Horizontal Guidance Note
IPPC H2

Integrated Pollution Prevention and Control (IPPC)

Energy Efficiency

Environment Agency
Environment and Heritage Service
SEPA Scottish Environment Protection Agency

Commissioning Organisation
Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol. BS32 4UD

Tel 01454 624400   Fax 01454 624409

First Published 2002

ISBN 0 11 310154 X

Record of changes

Version	Date	Change
V1	1999	Limited consultation
V2	Jun 2001	External Consultation – rewrite taking into account the Climate Change Agreements.
V3	February 2002	Working version, taking into account external consultation responses. (Final publication version is awaiting finalisation of Secretary of State's Guidance under Regulation 37 to Regulators on the Treatment of Energy Efficiency)

Note:

Queries about the content of the document should be made to Maggie Dutton (0117 914 2821) or any member of the IPPC Project or Technical Guidance Teams.

Written comments or suggested improvements should be sent to Graham Winter, at the Environment Agency Technical Guidance Section by email at graham.winter@environment-agency.gov.uk or at:

Environmental Protection National Service
Environment Agency
Block 1, Government Buildings
Burghill Road
Westbury-on-Trym
Bristol BS10 6BF

Executive summary

This Guidance has been produced by the Environment Agency for England and Wales in collaboration with the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (EHS). Together these are referred to as "the Regulators" throughout this document. Its publication follows consultation with industry, government departments and non-governmental organisations.

What is IPPC?

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. It involves determining the appropriate controls for industry to protect the environment through a single permitting process. To gain a Permit, Operators will have to show that they have systematically developed proposals to apply the best available techniques (BAT) and meet certain other requirements, taking account of relevant local factors.

The Regulators intend to implement IPPC to:

- protect the environment as a whole
- promote the use of "clean technology" to minimise waste at source
- encourage innovation, by leaving significant responsibility for developing satisfactory solutions to environmental issues with industrial Operators
- provide a "one-stop shop" for administering Applications for Permits to operate.

Once a Permit has been issued, other parts of IPPC come into play. These include compliance monitoring, periodic Permit reviews, variation of Permit conditions and transfers of Permits between Operators. IPPC also provides for the restoration of industrial sites when the permitted activities cease to operate.

The aim of this Guidance

This document is a Horizontal IPPC Guidance Note, that provides cross-cutting information relevant to all IPPC sectors. The purpose of the horizontal guidance is to provide supplementary information to assist applicants in responding to the energy efficiency requirements described in the IPPC Sector Guidance Notes (or the General Sector Guidance Note).

In particular, this Note provides:

- further amplification of the interface between the regulatory requirements of IPPC and climate change or direct participant agreements (into the emissions trading scheme), noting that continuing effort will be made to ensure that as far as possible the two regimes are complementary, for example for reporting of energy information, and the like
- descriptions of the basic principles of energy efficiency and energy efficiency techniques
- information on the requirements for costs and benefits appraisal of energy efficiency options according to the Regulators' preferred methodology of using discounted cash flow techniques, with appropriate discount rates and project lifetimes
- conversion factors for assessing the environmental impact of the energy consumption.

Key Issues

Key issues of the guidance are summarised below.

- All installations under the scope of IPPC shall meet a set of basic energy requirements for energy efficiency as defined in sections 2.7.1 – 2.7.2 of Sector Guidance Notes. These include:
  - provision of information on energy consumed or generated by the activities within the permit and the associated direct and indirect carbon dioxide emissions
  - energy management provisions
  - a description of the proposed measures for the improvement of energy efficiency in operating and maintenance procedures, control of excessive heating and cooling losses and building services
  - provision of an energy efficiency plan that identifies energy efficiency techniques that are applicable to the operation of the activities.
- All installations under the scope of IPPC must also meet additional energy efficiency requirements either:
  - through participation in a Climate Change Agreement or Direct Participant Agreement in the Emissions Trading Scheme

  or

  - through compliance with further permit-specific requirements as determined with the regulator.

- The regulators will not enforce any part of a Climate Change Agreement or Direct Participant Agreement of the Emissions Trading Scheme.
- Where participating, the operator must provide evidence that the activities within the permit are covered by a Climate Change Agreement or Direct Participant Agreement in the Emissions Trading Scheme.
- The operator must notify the Regulator within 14 days in the case of any failure to obtain re-certification of a Climate Change Agreement or the termination of or withdrawal from an Emissions Trading Scheme Direct Participant Agreement, or if the permitted activities leave such an agreement.
- Many energy efficiency techniques result in a net cost-saving over the life of the technique. The Regulators consider such techniques to be Best Available Techniques (BAT).
- The Regulators intend to review the setting of an appropriate cost benchmark (e.g. £/tonne CO_2) in future, in the light of information arising from the Climate Change Agreements and Emissions Trading mechanisms.

CONTENTS

List of figures

Note that the section numbering above refers to the relevant sections that deal with energy efficiency requirements in the Sector and General Sector Guidance Notes.

1 Introduction

1.1 How to use this guidance

What is IPPC?

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities[1]. It involves determining the appropriate controls for industry to protect the environment through a single permitting process. To gain a Permit, Operators will have to show that they have systematically developed proposals to apply the best available techniques (BAT) and meet certain other requirements, taking account of relevant local factors.

The relationship of this Note to other Guidance

The IPPC Permit Application Form lists the legal requirements of the PPC Regulations. The UK Sector Guidance Notes explain, for each industrial sector, the information that the applicant must supply and the indicative standards that should normally be met in order to demonstrate compliance with each of those requirements. Where the EU has issued a BAT Reference (BREF) document for a sector, the information it contains is taken into account in the UK Sector Guidance Note.

Each IPPC **Sector** Guidance Note will detail, amongst other issues, BAT for energy efficiency for specific activities associated with that sector. The purpose of this IPPC **Horizontal** Guidance Note is to provide supplementary information, relevant to all sectors, to assist applicants in responding to the energy efficiency requirements described in the Sector Guidance Notes.

Taken together, these will ensure that all aspects necessary for the PPC Regulations, and other Regulations that need to be given effect by the IPPC Permit, are addressed adequately in the Application.

The table below summarises the relevant sections of the Sector Guidance Notes that deal with energy efficiency and how they apply to Applicants according to whether the activities are covered by a Climate Change Agreement (CCA) or a Direct Participant Agreement under the Emissions Trading Scheme (ETS).

Section	Title	Content	Applies to:
2.1	Management techniques	Energy management	All activities
2.7.1	Basic energy requirements (1)	Energy consumption	All activities
		Specific energy consumption	All activities
2.7.2	Basic energy requirements (2)	Operation and maintenance	All activities
		Basic physical measures	All activities
		Building services	All activities
		Energy efficiency plan	All activities
2.7.3	Further energy efficiency requirements	Energy efficiency measures	Non-CCA and non-ETS activities only
		Energy supply measures	Non-CCA and non-ETS activities only
3.1	Emissions inventory and benchmark comparison	Emissions associated with energy use	All activities

For ease of cross-reference to the requirements of the Sector and General Guidance Notes, the above section numbering sequence is used in this Guidance Note.

IPPC operates under the Pollution Prevention and Control (England and Wales) Regulations 2000 and the Pollution Prevention and Control (Scotland) Regulations 2000 [1]. These Regulations have been made under the Pollution Prevention and Control (PPC) Act 1999 and implement the EC Directive 96/61 on IPPC [2, 3]. Further information on the overall system of IPPC, together with Government policy and more detailed advice on the interpretation of the Regulations, can be found in the Department of the Environment, Transport and the Regions (DETR) document *IPPC: A Practical Guide* and the Scottish Executive/SEPA document *The Pollution Prevention and Control (Scotland) Regulations 2000: A Practical Guide* [4].

1.2 Key issues for energy efficiency

1.2.1 Environmental impacts of energy use

The predominant sources of energy used in industrial activities in the UK are based on conversion of fossil fuels. The conversion of these fuels into heat and power results in the release of a number of pollutants that can cause significant impacts on the environment. As many industrial activities falling under the PPC Regulations tend to be energy-intensive in nature, the direct and indirect environmental impacts associated with energy consumption in these activities can constitute a substantial proportion of the impact of emissions from the installation as a whole.

The use of fossil fuels to generate energy results, in particular, in the release of large amounts of carbon dioxide, a greenhouse gas, that is a major contributor to global warming and the threat of climate change. For this reason, emissions of carbon dioxide are generally used as the primary indicator when assessing the environmental impact of energy use.

Principles of BAT for energy efficiency

The environmental impact of carbon dioxide emissions is global and indirect in effect and there is no universally acceptable methodology that assesses this impact in terms of emissions concentrations. Therefore, the determination of BAT for energy efficiency by setting standards based on emission limit values (ELVs) is not considered appropriate. The approach adopted in place of ELVs is to replace these with equivalent technical measures as determined by appraisal of the appropriate balance between the costs of the techniques and the environmental benefits they deliver (see Appendix 4).

There is often a wide range of energy efficiency techniques available for a given activity, for which the costs and environmental benefits can vary significantly. **Many energy efficiency techniques result in a net cost saving over the life of the technique and the Regulators consider such techniques to be BAT.** However, the assessment of BAT should not be constrained by whether pollution control techniques result in a net cost saving over their life of operation. It is perfectly valid to consider techniques that result in a positive annual cost. One would expect to spend money to reduce other pollutants and it is reasonable to expect, if necessary, to spend money to reduce the pollutants resulting from energy use. **Therefore, the Regulators intend to review the setting of an appropriate cost benchmark (e.g. £/tonne CO_2) in future, in the light of information arising from the Government's Climate Change Agreements and Emissions Trading Scheme.**

The environmental impacts of energy use can be reduced by implementing technical measures to lower energy consumption, improve energy efficiency and use energy from renewable sources. The implementation of cost-effective, technically proven energy efficiency measures offers the potential to make a significant contribution to reduction of pollution and its global impacts. Other benefits from the efficient use of energy are reduced depletion of non-renewable resources and potential reductions in the use of other raw materials.

1.2.2 Other legislative influences

The aim of the energy efficiency requirement of the IPPC Directive is to minimise pollution arising from the consumption of energy in industrial processes and to reduce the associated environmental impacts. Under a United Nations Protocol, the "Kyoto Protocol", the EU has signed up to reduce emissions of greenhouse gases by 8% of 1990 levels, averaged over the years 2008 to 2012. As part of its contribution to this agreement, the UK has a target of 12.5% reduction. In addition, the UK Government has set a domestic target to reduce carbon dioxide emissions by 20% of 1990 levels by 2010.

In order to meet these targets, the UK Government is introducing other economic instruments to encourage energy efficiency, including:

- the **C*limate Change Levy,*** a tax on business energy use (with certain exemptions), designed to be revenue-neutral, commencing April 2001
- ***Climate Change Agreements,*** negotiated agreements, available to all IPPC installations to which the Climate Change Levy applies, which provide an 80% discount on the Climate Change Levy in return for achieving negotiated energy efficiency targets, commencing in April 2001
- ***Emissions Trading Scheme (ETS)***, a voluntary scheme that applies to all greenhouse gases, for the trading of allowances and credits equivalent to tonnes of carbon dioxide equivalent.

All the above schemes are administered by the UK Government and further information should be obtained from the Department for Environment, Food and Rural Affairs (DEFRA).

1.3 Energy efficiency regulatory requirements of IPPC

Regulation 11 (3) (b) of the Pollution Prevention and Control Regulations 2000, SI 1973, specifically requires that installations should be operated in such a way that energy is used efficiently. The Regulations also require a description of energy used in, or generated by, the installation to be included in the Application for a Permit. In addition, energy efficiency is one of several considerations to be taken into account when determining best available techniques for the prevention and minimisation of pollution.

As IPPC is an installation-specific form of regulation, each installation that falls within the scope of the Directive must comply with its requirements. However, the basis of the Government's economic instruments, described above, is to provide industry with the flexibility to make improvements at locations where this is most cost-effective on a company-wide basis. Therefore, a mechanism has been developed by DEFRA and the Regulators to enable the requirements of both systems to be met.

The proposed approach is that the energy efficiency requirements of the IPPC Directive in the UK shall be met in the following way:

Regulatory requirements of PPC for energy efficiency

Regulatory Requirements for Energy Efficiency under IPPC

1. All installations falling under the scope of IPPC shall meet a set of defined ***basic energy requirements*** for energy efficiency. The basic energy requirements are based on the implementation of generic, low-cost measures designed to address gross inefficiencies only.

and

2. All installations falling under the scope of IPPC must meet additional energy efficiency requirements, either:
    - through participation in a ***Climate Change Agreement*** or ***Emissions Trading Scheme Direct Participant Agreement*** with the UK Government;

or

- through compliance with further permit-specific requirements as determined by the Regulator.

The Regulators and DEFRA believe that this approach is appropriate because it ensures that the installation-specific nature of IPPC is delivered, via the basic energy requirements, but allows industry the flexibility of delivering the additional requirements in the most cost-effective way.

The Regulators and DEFRA are also working to ensure that there is consistency in the common elements of these regimes, such as the use of emissions factors, and that duplication of information is avoided through complementary reporting requirements, e.g. for the reporting of energy consumption. Further efforts to harmonise common requirements will continue as the non-regulatory schemes are developed.

Further clarification of the requirements of IPPC in relation to the other economic instruments is provided below.

1.3.1 Regulatory requirements for activities covered by a Climate Change Agreement or Direct Participant Agreement

These activities will be required to comply with the following requirements as part of their Permit:

- the Operator must meet the basic energy requirements as described in Sections 2.7.1 and 2.7.2 of the IPPC Sector Guidance Notes
- the Operator must provide evidence that the activities in the Permit are covered by a Climate Change Agreement or Direct Participant Agreement (that covers energy-related CO_2 emissions)
- the Operator must notify the Regulator within 14 days in the case of any failure to obtain re-certification of a Climate Change Agreement or the termination of or withdrawal from an Emissions Trading Scheme Direct Participant Agreement, or if the permitted activities leave such an agreement.

Note that the Regulators' requirements and timescales for the PPC Regulations are independent of any obligations of Climate Change Agreements and Direct Particiant Agreements. The Regulators will not enforce any part of a Climate Change Agreement or Direct Participant Agreement.

1.3.2 Regulatory requirements for activities not covered by a Climate Change Agreement or Direct Participant Agreement

The following activities will be required to comply with all energy efficiency requirements listed in Section 2.7 of the IPPC Sector Guidance Notes, as part of their Permit:

- those exempt from the Climate Change Levy and who are not participating in the Emissions Trading Scheme for energy-related CO_2 emissions
- those that choose not to participate in a Climate Change Agreement or Direct Participant Agreement, or that leave a Climate Change Agreement or Direct Participant Agreement
- those participating in a Climate Change Agreement or Direct Participant Agreement, that fail to obtain re-certification of the Climate Change Agreement or withdraw from a Direct Participant Agreement or the Direct Participant Agreement is otherwise terminated.

1.3.3 Integration of energy efficiency with other requirements of IPPC

Energy efficiency and other environmental objectives

IPPC employs an integrated approach to control the environmental impacts of industrial activities. In the case of a trade-off between increased energy consumption and improvement of other environmental objectives, the Operator should undertake an environmental assessment, taking into account the costs and environmental benefits, to justify selection of the best available techniques for preventing and minimising pollution to the environment as a whole. Nothing in a Climate Change Agreement or Direct Participant Agreement will prejudice any other requirements of IPPC. The preferred methodology for this is provided in IPPC H1: Horizontal Guidance on Environmental Assessment, (see Ref. 5).

2 Techniques for pollution control

General information

The aim of the energy efficiency requirements of IPPC is to ensure that gross energy inefficiencies are eliminated and that the most effective energy saving opportunities are identified and implemented. There are usually many options that can be considered for optimising energy efficiency in new installations, or improving energy efficiency within an existing installation. Techniques range from simple measures such as good housekeeping, insulation or motor controls, to more complex measures such as process integrated heat recovery. In addition, effective energy management procedures are a vital component to inform cost–benefit appraisals and to ensure that continuous energy efficiency improvements are made.

In addition to the information in this Note, the Energy Efficiency Best Practice Programme (EEBPP) provides a valuable source of energy efficiency information. The EEBPP provides impartial, authoritative information and advice on energy efficiency techniques and technologies in industry, transport and buildings. The information is disseminated through publications, videos and software, together with seminars, workshops, a helpline (Environment and Energy Helpline 0800 585 794) and other events. A range of published literature is available free of charge and IPPC Applicants should make reference to these, or other relevant information, in establishing the approaches they will take to energy management systems and to the use of technology. Many of these documents can be downloaded from the EEBPP website (http://www.energy-efficiency.gov.uk).

Relevant guides are signposted throughout this Guidance Note wherever appropriate:

- ECG = Energy Consumption Guides – benchmarking guides
- GPG = Good Practice Guides – detailed ‘how to’ guides, identifying current best practice
- GPCS = Good Practice Case Studies – detailed examples of a real company’s experience
- GIR = General Information Reports – provide good background knowledge.

Descriptions of energy efficiency techniques specific to particular industrial sectors are provided in Section 2.7.3 of each Sector Guidance Note. These include any relevant information from the BREF documents and provide signposts to appropriate EEBPP literature for the sector. This Note provides general supporting information and guidance on the technical measures available.

2.1 Management techniques

INFORMATION IN THIS SECTION APPLIES TO ALL IPPC APPLICANTS

Cross-reference to requirement in Sector Guidance

2.1 Provide details of your proposed management techniques.

See Section 2.1 of the Sector and General Sector Guidance.

Section 2.1 of the main Guidance contains the above requirement for environmental management techniques as a whole. Within IPPC, an effective system of management is a key technique for ensuring that all appropriate pollution prevention and control techniques are delivered reliably and on an integrated basis. This includes the need to show how energy management is taken into account as part of the general, wider requirements for environmental management techniques.

Inclusion of energy with environmental management systems

It is considered practicable to incorporate energy management techniques within the requirements of an overall environmental management system for IPPC and reference should be made to Section 2.1 of the main Guidance for these general requirements. Supplementary information on energy management issues is provided here.

See EEBPP publications, for example:

GIR063 The energy management pathfinder

Supplementary information

Energy management policy

The production of a written and published energy policy is used to demonstrate the commitment of senior management to energy efficiency. Such a policy should provide targets and performance indicators and be integrated with the overall aims and policies of the installation.

The energy policy and its integration within the corporate management systems should provide the framework for a coherent and sustained approach to energy efficiency throughout the organisation and its staff. Senior management endorsement and demonstrable support for the energy policy and efficiency initiatives help to ensure that proper consideration is given to proposed efficiency projects and that the importance of energy efficiency is apparent at all levels of the organisation.

Activities that make up energy management are often dispersed within an organisation. For example, energy purchasing and bill payment is typically within the Finance Department, energy use within processes is often the responsibility of a Production Department, whilst specification of new or replacement plant may be down to Works or Maintenance Departments. An organisation's management system should establish links between different groups and responsibilities resulting in clear accountability for the proper management of energy as a resource.

See EEBPP publications, for example:

GPG186 Developing an effective energy policy

GPG119 Organising energy management

GPG217 Cutting energy losses through effective maintenance

GPG169 Putting energy into total quality

GPG200 A strategic approach to energy and environmental management

GPG214 Making use of business standards

GPG167 Organisational aspects of energy management: a self-assessment manual for managers.

Monitoring and targeting

In order to ensure ongoing improvement in energy efficiency, the Applicant should demonstrate that systems or procedures are in place for the continuous measurement and assessment of energy use within the installation. The prime function of such an energy management system is to support the overall energy policy. The system should enable the collection, analysis and reporting of data relating to energy performance as well as the setting, review and revision of energy performance targets. Collectively, these activities are often referred to as monitoring and targeting (M&T).

The starting point of monitoring and targeting is the measurement of energy consumption within the installation, (which is described in Section 2.7.1 of this Note). In addition, M&T is fundamental to good energy management, playing a key role in the following:

- identifying areas of energy wastage
- highlighting exceptions to normal performance
- evaluating the impact of energy saving actions or of faults in equipment and its operation

- setting realistic targets for improvement.

M&T provides the benefits of enhanced management control of energy use and expenditure, and a basis for assessing and justifying investment in energy efficiency projects. Many systems are currently available, ranging from simple metering and manual logging to sophisticated software trending systems. The appropriate system should be selected according to the requirements of the installation. Information is available from the sources listed below:

For example, general EEBPP publications:

GPG112 Monitoring and targeting in large companies

GPG231 Introducing information systems for energy management

GPG125 Monitoring and targeting in small and medium-sized companies

Sector-specific EEBPP guidance:

GPG111 Monitoring and targeting in foundries

GPG113 Monitoring and targeting in the semi-manufacture of non-ferrous metals

GPG147 Monitoring and targeting in the steel industry

GPG131 Monitoring and targeting in the glass manufacturing industries

GPG148 Monitoring and targeting in the textiles industry

Staff

As with all aspects of pollution control, energy management requires specific skills and competencies in technical, financial and managerial fields. It is essential that staff have the appropriate skills in the areas of energy management for which they have responsibility, and that these skills are maintained and developed through training and continuing professional development.

The National Vocational Standards for Managing Energy are a statement of national best practice in managing energy and can be used as a Code of Good Practice. This can be useful especially where the energy management function is not carried out by a single person, as the standards can be used to align individual units with organisational roles to ensure that the entire organisation is being addressed.

Good energy management also requires the awareness of and involvement in energy efficiency by all staff. Many simple, no-cost and low-cost energy saving measures are those that individual employees can take, such as switching off equipment and lighting. An important aspect of energy management, therefore, is making staff aware of why they should be energy-efficient and giving them the knowledge and understanding to know how to be energy-efficient. Ideas from staff to reduce wasted energy should be actively encouraged and such ideas responded to in a positive manner. Staff should be enabled to implement changes themselves where appropriate and once health and safety and business risks have been assessed.

See EEBPP publications, for example:

GPG84 Managing and motivating staff to save energy

GPG85 Energy efficiency training and development

GPG172 Marketing energy efficiency

GPG235 Managing people, managing energy

GPG251 Maintaining the momentum

[Note Sections 2.2–2.6 of Sector Guidance are not applicable to this document]

2.7.1 Basic energy requirements (1)

INFORMATION IN THIS SECTION APPLIES TO ALL IPPC APPLICANTS

Cross-reference to requirement in Sector Guidance

Provide a breakdown of the energy consumption and generation by source.

See Section 2.7.1 of the IPPC Sector or General Sector Guidance.

Section 2.7.1 of the Sector Guidance requires a description of the energy consumed in, or generated by, the activities covered in the Permit. An example format is shown in Table 2.1.

Table 2.1 Example breakdown of energy consumption

Energy source	Energy consumption	
	As delivered, MWh	At primary source*, MWh
Electricity (public supply)*		
Electricity (other supply)*		
Imported heat (steam, hot water)*		
Gas		Not applicable
Oil		Not applicable
Coal		Not applicable
Other**		Not applicable

*For electricity from the public supply a factor of 2.6 should be used to convert from delivered to primary energy. Operator to specify appropriate factors for other supply sources.

**Specify additional fuels, including recovery of energy from wastes or other materials.

Information about energy consumption is required because the measurement and monitoring of energy use within the installation is fundamental to identifying where the most cost-effective and environmentally beneficial improvements can be made. Provision of energy consumption information is the basis for demonstrating that the installation is operated in an efficient manner, that energy efficiency improvements are made in the most appropriate areas and that a realistic implementation plan is developed.

The Operator is also required to submit, with the Application, the specific energy consumption of the activities covered in the Permit. This should be related to the raw material or product that most closely matches the primary purpose of the activities. Specific energy consumption provides an ongoing performance-monitoring tool which takes into account variation in production capacity.

Supplementary information

Energy consumption

Energy consumption information should be provided in the Application for all of the activities included within an IPPC Permit. This should be done by using figures of delivered energy consumption for all energy sources used over a recent 12 month period. The information should be broken down by energy source, to include fuels converted to energy at the installation, heat or power imported directly from external sources (such as the national grid or other direct supplier) and renewable energy sources. Where energy is exported in the form of heat or power from an installation, this information should also be provided.

Energy consumption information should be reported in the same units, MWh, for all fuels to enable ease of comparison. The energy contents of fossil fuel, waste and other residues are often reported on a gross calorific value basis, e.g. GJ/tonne or MJ/m^3. Actual calorific values should be reported where available. These values can be converted to MWh using the following conversion factors:

1 MWh	=	3.6 GJ
	=	3,600 MJ
	=	3,600,000 kJ
	=	1,000 kWh

Electricity data should be presented as delivered energy and also converted to primary energy, in order to take into account differences in the efficiency of conversion, generation, supply and transmission by source. For example, electricity imported from the national grid has an overall efficiency of about 40%, due to heat losses from thermal generation, whereas the efficiency of electricity supplied directly from non-public suppliers may be much higher. Conversion to primary energy ensures that a common basis is used across all IPPC installations and that the advantages of the more efficient conversion systems are taken into account. For conversion of fossil fuel, waste and other residues to energy, no correction is applied to account for energy used in extraction, processing and delivery to the installation.

Electricity conversion factor to primary consumption

Units of electricity from the public supply should be multiplied by a factor of 2.6 to account for the energy loss in generation. This factor is consistent with that used by the Government for the purposes of administering energy programmes, including the Climate Change Agreements.

Other factors may be used where heat or power is imported directly from a supplier, or power is generated at the installation, as appropriate. Where this is done, the Operator is required to state the factors assumed, according to the guidelines below.

- Where electricity is imported from a dedicated electricity generation plant, allocate energy input to the plant to the activities in the Permit on a pro rata basis according to proportion of electricity consumed by the activities in the Permit.
- Where energy from a combined heat and power (CHP) plant is used, calculate the units of energy used on the basis of the units of energy input to the CHP plant, not the units of energy produced by the CHP plant. Where all the energy from a CHP is used within the activities in the Permit, all the units of energy input to the CHP are allocated to the Permit. Where the permitted activities use only part of the output of a CHP, allocate the energy input to the CHP to each user according to the guidelines in Appendix 1.

Imported or exported steam should be accounted for by taking the enthalpy (heat content) of the steam and dividing by the efficiency of the system that generates the steam and distributes it to the user's facility boundary, in order to account for the total energy used to produce the steam. Account should also be taken of steam pressure – for example, where sites import high-pressure steam and return it at a lower pressure.

It is useful to supplement energy consumption information with energy balances (e.g. "Sankey" diagrams, other flow diagrams or descriptions) to illustrate how energy is used throughout the process (see Figure 2.1). This is particularly relevant where energy conversion is highly integrated within the activities, in order to illustrate any inter-dependencies between energy use and selection of other operational or environmental control measures. This type of information is fundamental to the description of the main activities, and should in most cases be provided in response to Section 2.3 of the IPPC Application.

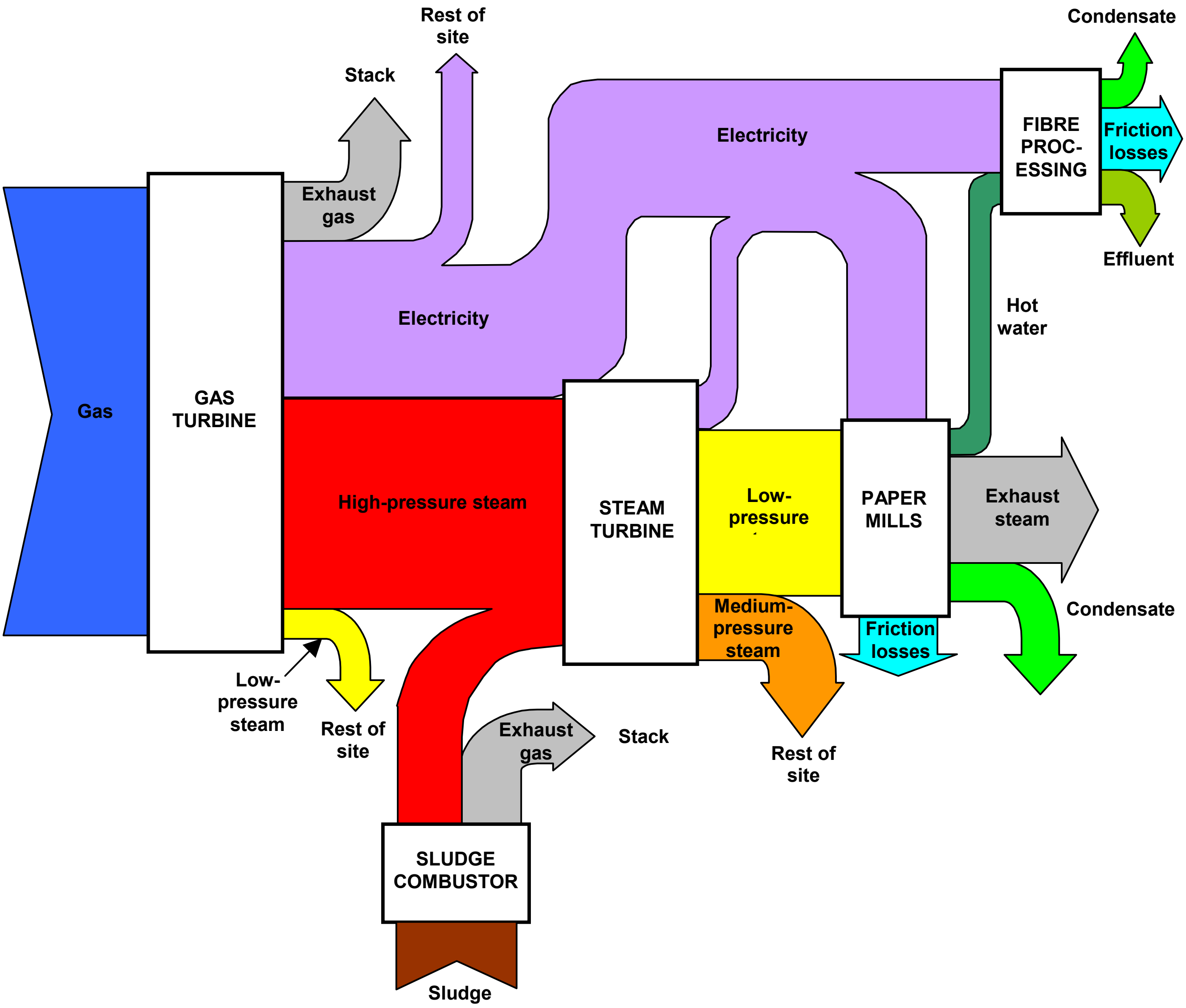

Figure 2.1 Example "Sankey diagram" for a typical paper mill

Supplementary information

Specific energy consumption

Specific energy consumption (SEC) is a benchmark for how much energy is consumed per unit of raw material processed or product output. It is a useful tool for managing energy efficiency, as it takes into account variations in production capacity at an installation, and can be used in an ongoing way to monitor improvements in efficiency within an installation. Some benchmarks are available, for example from the IPPC BREF documents, for industry sectors or specific industrial processes that may be used as a comparison of the efficiency of installations within a sector. Where available, these will be provided within Section 2.7.3 of the appropriate sector-specific Guidance Notes. Some indicative examples of SEC are given in Table 2.2 which may be used for comparative purposes or to examine trends.

Table 2.2 Examples of specific energy consumption

Sector	Sub-sector/product	Specific energy consumption		
		Range	Units	Source
Metals	copper	1.5–3.2	MWh/tonne product	BREF ref. 6
	aluminium	17.8–20.0	MWh/tonne product	
Minerals	cement	0.9–1.8	MWh/tonne product	BREF ref. 7
	lime	1.5	MWh/tonne product	
Other industries	pulping: raw pulp	5.5–5.9	MWh/tonne paper	BREF ref. 8
	pulping: recycled fibre	2.4–2.6	MWh/tonne paper	
	papermaking	2.9	MWh/tonne paper	

Guidelines for calculating SEC are given below:

- SEC is usually expressed in terms of energy, by simply dividing energy consumption by an appropriate production unit to provide a direct measure of the efficiency of energy consumed. The time periods over which energy consumption and production levels are measured must be the same. It is good practice to calculate SEC for both the main activity and the installation as a whole to demonstrate that installation efficiency is increasing. For activities with seasonal variations in product output, it may be most appropriate to present SEC on a monthly and annual basis.
- The SEC is usually based on primary energy consumption, denoted SEC_p. There is no fixed rule on the unit of production that should be used as the basis for SEC, but it should be whatever unit most closely mirrors the primary purpose and level of production at the installation, for example tonnes of product or of a key raw material. IPPC Sector Guidance may provide further information of appropriate units, in relation to any available benchmarks for the sector.

2.7.2 Basic energy requirements (2)

INFORMATION IN THIS SECTION APPLIES TO ALL IPPC APPLICANTS

Cross-reference to requirement in Sector Guidance

Describe the proposed measures for the improvement of energy efficiency.

See Section 2.7.2 of Sector or General Sector Guidance.

Section 2.7.2 of the Sector Guidance requires that the Operator describe the proposed measures to improve energy efficiency. This includes the following aspects:

- operating and maintenance procedures
- basic physical measures
- building services
- appraisal of all applicable measures in an energy efficiency plan.

1. Operating and maintenance procedures

Supplementary information

The manner in which individual processes and services within an installation are operated can have a significant impact on energy consumption. Optimisation of operating procedures and equipment schedules, as well as maintenance and general housekeeping procedures, can lead to significant energy efficiency improvements.

Some of these techniques may be sector-specific and will be addressed in the relevant Sector Guidance Notes, but the general principles apply to most installations. To demonstrate compliance with Section 2.7.2 of the Sector Guidance requires that opportunities to improve the energy efficiency of operating and maintenance measures should be implemented. These include the more common aspects listed below, where applicable to the activities within the installation, and any other site-specific operating and maintenance techniques.

Optimised warm-up procedures to reduce supplementary energy use
This will be applicable to many industrial processes, including combustion plant, ovens, furnaces and other thermal treatment processes. The Operator should demonstrate that operating procedures have been optimised, within the constraints of recommended heating rates, to ensure that the use of start-up fuel or energy is not wasted through over-extended warm-up periods or periods of supplementary firing. The Operator should, however, ensure that this does not compromise any other conditions relating to minimum operational temperatures and associated impacts on environmental emissions.

Management and scheduling of furnaces and heated vessels to reduce holding time
This is applicable to many batch processes, especially in the metals and chemicals sectors. The Operator should demonstrate that operating procedures have been integrated with upstream and downstream activities to minimise unnecessary holding of materials at high temperatures.

Minimisation of compressed air leakage through regular checks and maintenance
Compressed air is used as a transmitting medium in a wide range of industrial applications. Generation of compressed air is energy-intensive and wastage should be minimised where possible. Leakage is the single biggest area of wastage in the generation and use of compressed air, and can often be addressed by simple, low-cost maintenance checks. The Operator should demonstrate that basic, low-cost steps have been undertaken to minimise leakage. Further guidance in the form of an indicative checklist is presented in Appendix 2A.

Maintenance of steam distribution systems to reduce leaks and heat losses
Steam is used as a heating medium or direct feedstock in many industrial processes, and efficiency gains can often be made by improving efficiency of steam distribution from generation to the point of use. The most common areas for improvement at low cost (other than physical measures described elsewhere) are through repairs to leaks and improved steam traps. The operator should demonstrate that basic, low-cost steps to reduce leaks and heat losses have been undertaken. Further guidance in the form of an indicative checklist is given in Appendix 2B.

Regular servicing of refrigeration condensers and evaporators
Refrigeration systems are commonly used for process cooling and storage. To comply with the basic energy requirements, the Operator should demonstrate that procedures are in place for the regular servicing of refrigeration components to avoid poor heat transfer and reduced efficiency. Further guidance in the form of an indicative checklist is provided in Appendix 2C.

Regular cleaning of heat transfer surfaces prone to fouling
Heat transfer equipment is used extensively in industrial applications and includes that used for heat exchange between process fluids, direct heating and cooling of fluids, and in boilers. The fouling of heat transfer surfaces through deposition of dirt or corrosion products reduces their efficiency significantly, as deposited material usually has a relatively low conductivity.

To satisfy the basic energy requirements, the Operator should demonstrate that procedures are in place for the regular cleaning of heat transfer surfaces, particularly in applications most prone to fouling.

Switching off equipment when not in use
This is a basic housekeeping measure that applies to all industrial applications. To satisfy the basic energy requirements, Operators should demonstrate that procedures are in place to minimise inefficiencies caused by unnecessary running of equipment when not in use.

Operation and maintenance of motors and drives
Motors and drives are used to operate many mechanical systems in industrial processes. To reduce the load on motors and drives, the Operator should demonstrate that basic maintenance steps such as lubrication of machinery have been undertaken. To comply with the basic energy requirements, the Operator should demonstrate that procedures are in place for the regular servicing of motors and drives. An indicative checklist is provided in Appendix 2D.

Optimised cleaning of filtration equipment
Filtration equipment used for screening solid material from gaseous or liquid streams should be regularly cleaned and maintained in order to reduce the operating pressure drop and load on fans and pumps. These procedures should also take into consideration, where relevant, the optimisation of automatic cleaning systems, e.g. using compressed air, which may be significant consumers of energy themselves.

2. Basic physical measures

Supplementary information

Section 2.7.2 of the Sector Guidance requires the Operator to describe and provide evidence that basic, low-cost, physical energy efficiency techniques have been undertaken to avoid gross inefficiencies relating to excessive heating or cooling losses.

This includes identification and elimination of all excessive heating or cooling losses from steam systems, hot water pipes, heated vessels, ovens, chillers and other temperature-controlled zones or equipment through implementation of basic insulation and containment methods. For example:

- Insulation of steam and hot water systems, to ensure that all steam and condensate pipework and fittings are insulated sufficiently. Well-insulated pipes typically have heat losses 10–20 times lower than those from uninsulated pipes. Each uncovered flange on a steam line is roughly equivalent to 0.6 m of bare pipe, so a single, uninsulated 150 mm (6 inch) flange can result in a typical annual energy loss of almost 6 MWh
- Provision of hoods, lids, air-tight seals and self-closing doors to maintain temperature
- Avoidance of unnecessary discharge of heated water or air by fitting simple timers or sensors.

3. Building services

Section 2.7.2 of the Sector Guidance requires the Operator to optimise the energy efficiency of services in buildings that are included within the permitted activities, e.g. process buildings, control rooms, etc. This includes energy-consuming services such as space heating, cooling and hot water, ventilation and lighting.

Supplementary information

The energy consumption associated with industrial buildings is often overlooked, yet space heating, ventilation, air-conditioning, associated pumps and fans, lighting and office equipment can be a significant proportion of overall consumption in the less energy-intensive installations. Furthermore, low-cost measures can save up to half of the buildings-related energy use. For energy intensive industries, buildings energy use may have a relatively minor impact and should not distract effort from more major energy issues. Buildings should nonetheless form part of the assessment of energy saving opportunities, particularly where they constitute more than 5% of the total energy consumption, or where there is little scope for energy improvements to the process, making attention to building services more worth while.

Note that the assessment of appropriate energy efficiency techniques should also have due regard to any implications on health and safety at work.

Section 2.7.2 of the Sector Guidance requires the Operator to identify which of the following energy measures are applicable to the activities within the installation and the extent to which they have been implemented. This includes the following elements:

Lighting

- Provide evidence that an assessment of the efficiency of lighting has been undertaken, including:
  - estimation of lighting level;
  - comparison with appropriate benchmarks.

A method for assessing efficiency and indicative benchmarks is given in Appendix 2E.

- Demonstrate that the following measures have been considered or implemented:
  - use of efficient lighting systems, lamps and luminaires
  - installing lighting systems to provide appropriate lighting density;
  - using effective controls so that lighting is only used when required

Further guidance on lighting systems and lighting density is provided in Appendix 2E.

Also see EEBPP publications:

GPG160 Electric lighting controls – a guide for designers, installers and users

GPG303 The designer's guide to energy efficient buildings for industry.

Heating, cooling and ventilation

- Describe proposed measures to improve energy efficiency in the design and operation of climate control systems, including use of the following techniques:
  - use of waste process heat for space heating
  - selection of high-efficiency heating equipment
  - selection of point-of-use water heaters
  - temperature control: use of thermostats, time switches, etc.
  - use of natural ventilation
  - draught-proofing measures.

Further guidance and an indicative checklist is provided in Appendix 2E.

4. Energy efficiency plan

Section 2.7.2 of the Sector Guidance requires the Operator to produce an energy efficiency plan that identifies and appraises energy efficiency techniques applicable to the activities covered by the Permit. This is not limited to measures covered under basic energy requirements, but should include all technically available measures, such as those identified in all the previous sections, in Sector Guidance or signposted in EEBPP publications. In the case of Permits that are covered by a Climate Change or Direct Participant Agreement, no techniques beyond the basic energy requirements will be enforced by the Regulator. However, if the Permit ceases to be covered by a Climate Change or Direct Participant Agreement, then further energy efficiency measures will be required to meet the PPC Regulations. The energy efficiency plan submitted as part of the Application will then be used as a basis for determining the scope of these further requirements.

To comply with the requirements of Section 2.7.2 of the Sector Guidance, the Operator should provide an energy efficiency plan which:

- identifies **all techniques** described in Section 2 of this Guidance that are applicable to the installation but that have not yet been implemented (this should include basic energy requirements in Section 2.7.2 and further energy efficiency techniques in Section 2.7.3 of this Note and the relevant Sector Guidance)
- estimates the annual carbon dioxide savings of each technique
- identifies any techniques that lead to adverse environmental impacts.

In addition, those Applicants which do not hold a CCA or DPA should meet the further requirement to:

- prioritise the applicable techniques according to their costs in relation to the environmental benefit delivered.

An example of an energy efficiency plan is shown in Table 2.3.

Supplementary information

The aim of the energy efficiency plan is to provide the basis for an ongoing energy efficiency improvement programme. The production of a Permit-specific energy efficiency plan enables the Operator to demonstrate that basic good energy management principles are in place and that the key energy saving opportunities for the installation have been identified and appraised in terms of their costs and benefits. This enables the Operator to identify the scope of measures which should be implemented and to prioritise the order of their implementation. (Note that it is likely that this type of appraisal would need to be carried out in any case for the purposes of any targets negotiated under a CCA.)

The appraisal of candidate energy efficiency techniques requires a cost–benefit assessment. The Regulators' preferred method for conducting cost–benefit appraisals, based on discounted cash flow techniques, is described in Appendix 4. This method is applicable in cases where the energy efficiency measures do not affect any other environmental releases from the installation. However, in cases where there is a trade-off between energy efficiency and worsening of any other environmental emissions, an appraisal should be conducted according to the H1 environmental assessment methodology for the assessment of BAT [5].

For Operators without a Climate Change Agreement (including those that have failed to meet the obligations of their CCA), a detailed assessment of all technically available energy efficiency measures should be undertaken according to the methodologies described above. This will then form part of an implementation programme.

In the case of Operators with a CCA, the energy efficiency plan should include estimates of carbon dioxide savings for all technically available options. Should the Operator fail to meet the obligations of their CCA at any stage, then the options identified in this energy plan should be subject to further detailed costs–benefits appraisal according to the methodologies described above, in order to develop an implementation programme.

Table 2.3 Example format of energy efficiency plan

ALL APPLICANTS			ONLY APPLICANTS WITHOUT A CCA		
Energy efficiency measure	CO_2 savings (tonnes)		Equivalent annual cost ✻ (EAC) £k	EAC/CO_2 saved £/tonne	Date for implementation
	Annual	Lifetime			
CHP plant	1,948	29,220	(35.7)	(18.32)	
High efficiency motor	4	20	(0.4)	(87.30)	
Variable speed drive	1,456	7,280	(49.4)	(33.95)	

✻. Refer to Appendix 4 for preferred appraisal methodology. Where other appraisal methodologies have been used, state the method, and provide evidence that appropriate discount rates, asset life and expenditure (£/tonne) criteria have been employed. Bracketed figures are cost savings.

2.7.3 Further energy efficiency techniques

INFORMATION ON TECHNIQUES IN THIS SECTION APPLIES TO ALL APPLICANTS, BUT IMPLEMENTATION OF TECHNIQUES IN THIS SECTION APPLIES ONLY TO ACTIVITIES NOT COVERED BY A CLIMATE CHANGE AGREEMENT OR DIRECT PARTICIPANT AGREEMENT

Cross-reference to requirement in Sector Guidance

The Operator should describe proposed measures for improvement of energy efficiency.

See Section 2.7.3 of Sector or General Sector Guidance.

Section 2.7.3 of the Sector Guidance requires the Operator to describe proposals for further, process related energy efficiency measures for any activities in the Permit that are not covered by a Climate Change Agreement. The energy efficiency measures described in this section go beyond the low-cost basic physical measures described in Section 2.7.2, to consider the full range of energy efficiency techniques available to industrial installations. Such techniques include design considerations, the selection of energy-efficient equipment, the use of process optimisation and integrated techniques and options for energy supply.

1. Energy efficiency techniques

Supplementary information

The most effective energy efficiency improvements can usually be made at the design stage in new installations and refurbishments, or in the specification for procurement of equipment and buildings. At this stage, integrated energy efficiency techniques such as heat recovery, water minimisation, heat and power demand can be optimised by consideration of energy consumption and recovery opportunities for the installation as a whole. There are also components and controls of larger equipment or process plant which can be upgraded or optimised to improve energy efficiency without the need for major refurbishment or redesign.

The techniques available for energy efficiency are strongly dependent on the particular site, activity and industrial process. There is a vast array of information and advice concerning energy efficiency available commercially, and under the EEBPP run by DEFRA. It is the aim of this Guidance not to attempt to summarise and reproduce this mass of information here, but to ensure that the Applicant has considered all relevant techniques for energy efficiency within the installation and identified those that are most effective.

In many cases, the most appropriate energy efficiency techniques will be described in IPPC Sector Guidance Notes.

Section 2.7.3 of the Sector Guidance requires the Operator to identify which of the following techniques are applicable to the activities within the installation and the extent to which they have implemented.

- ***Motors and drives*** Motive power in particular can make a significant contribution to energy consumption in industrial processes. The capital cost of a higher efficiency motor is no more than a standard quality motor but the efficiency gain of 2–3% makes significant savings over the motor's life. In addition, use of variable speed drives to reduce the load on fans and pumps is a much more energy-efficient method of regulating flow than throttles, dampers or recirculation systems. Phase optimisation of electronic control motors should also be considered.
- ***Heat recovery*** Significant savings can be made through the recovery of waste heat in many industrial sectors. Opportunities for heat recovery from gaseous and liquid effluent streams should be explored for use in applications such as direct process heat exchange, pre-heating of combustion and drying air, flue gas re-heating, etc.
- ***Water minimisation*** The use of mechanical de-watering equipment such as presses and centrifuges will minimise drying energy requirements. Use of closed circulating water systems to minimise water treatment is also recommended good practice.
- ***Low-energy technology*** Process routes or equipment with inherently low energy consumption, such as electro-technologies, may be appropriate for particular applications. A key feature of these technologies is that they give highly targeted and controlled delivery of energy at the end-stage, which can lead to an overall reduction in primary energy consumption. For example, microwave heating has a high efficiency of heat transfer by generating heat directly in the product, instead of heating the space around the product to a high enough temperature to cause sufficient heat to transfer into the product. Other techniques that can, in appropriate applications, deliver net savings include induction heating, ultraviolet curing, air-knife drying, desiccant drying, infrared heating, radio frequency heating and a range of other specialised low-energy processes.
- ***Optimised design and layout*** For example, reduced pipe runs, minimised pressure losses, location of buildings, etc.

- ***Process control and instrumentation*** For example, the use of control and instrumentation to optimise process conditions such as temperature, pressure, flow-rate and humidity.
- ***Specification of equipment*** Energy consumption should be taken into account in the specification and selection of new equipment and buildings.

2. Energy supply techniques

Section 2.7.3 of the Sector Guidance requires Operators to demonstrate that they have considered alternative, more efficient forms of the supply of electricity and heat, according to the guidelines below. All energy use constitutes an environmental burden and Operators are required to demonstrate that it is not only consumed efficiently at point of use, but also produced in as efficient a manner as possible. There may be instances where the use of certain low-energy technologies determines the form of energy supply used; in such cases the aim should be to demonstrate that the overall efficiency is maximised compared to alternatives.

Supplementary information

To comply with Section 2.7.3 of the Sector Guidance, the Applicant should carry out the following.

- Demonstrate that the alternative options for the supply of process heat have been appraised, and provide information on the combustion and thermal efficiency of heat supply systems. Thermal energy is a requirement for many IPPC installations, often produced in the form of hot gases, steam or hot water from the combustion of fossil fuels. This is most often generated on-site, but options for the import of steam or "waste" heat from neighbouring installations should also be considered. The energy efficiency of such systems is dependent on type of fuel, combustion equipment, steam-raising boiler and distribution system. Specific energy efficiency guidance for combustion plant is provided in the Sector Guidance Notes for those processes.

  See EEBPP publications:

  GPG030 Energy efficient operation of industrial boilers

  GPG197 Energy efficient heat distribution

  ECG066 Steam generation costs

  ECG067 Steam distribution costs

- Identify whether CHP is feasible for heat and power supply for the installation. CHP is the simultaneous generation and use of heat and electricity on-site or nearby. A turbine or engine is connected to a generator to produce electricity, while the exhaust heat is used to raise steam or hot water or provide absorption chilling. Making use of this "waste" heat makes the system inherently efficient, and therefore financially attractive. CHP can save 20–30% of a site's primary energy and is therefore one of the most important energy saving technologies. However, CHP plant requires a simultaneous demand for electricity and heat (or cooling for absorption chillers) and a feasibility study is usually undertaken to determine whether a scheme is suitable for an installation. Appendix 3 provides further information on the principles of CHP feasibility appraisals.

  Reasons why CHP may not be applicable are: the unavailability of a suitable fuel (gas is most common); the use of a waste-to-energy scheme instead; that the installation is too small for the available gas turbines or engines; that the projected life of the plant is too short; or, that existing systems are more efficient.

  The balance of steam demand and electricity consumption is another important factor. If the steam demand becomes too low, then the economics can become less attractive. This leads to the important conclusion that energy techniques must be viewed as a whole across the installation. DEFRA has published guidelines regarding criteria that should be used for good quality CHP schemes [9].

  See Appendix 3 *for general information on CHP and EEBPP's CHP club at* htttp://www.chpclub.com

  Also see EEBPP publications:

  GIR82 The manager's guide to custom built CHP

  GIR83 The manager's guide to packaged CHP

- Identify opportunities and describe the feasibility of using on-site renewable energy sources or purchasing energy generated from renewable sources. Using renewable energy sources clearly produces a reduction in environmental impact. Although renewable energy schemes must be carefully designed for each application, there are several examples where companies have incorporated renewable energy into industrial applications such as:
  - biomass conversion for heat and power generation
  - use of fuel gas derived from landfill, e.g. in brick kilns
  - fuel gas production from anaerobic digestion of sludges in sewage treatment works.

Other promising technologies such as fuel cells have yet to reach full commercial status but may be considered in future. The use of other renewable technologies such as wind and hydropower is much more dependent on location and will not be appropriate to every installation. However, many public energy supply companies are now offering tariffs and contracts for “Green Electricity”, which is generated wholly or partly from renewable energy sources, has a much lower environmental impact and can dramatically reduce an installation’s carbon dioxide releases.

For more information, contact electricity suppliers and the New and Renewable Energy Enquiries Bureau (tel 01235 432450/433601)

- Demonstrate that the option of energy recovery from incineration of process waste has been considered and justify any decision not to recover energy. Combustion or other thermal conversion of on-site generated wastes to provide heat and power should be considered where appropriate. Co-incineration with other fuels, or joint schemes with other local Operators, should also be considered. This can be a valuable way of recovering energy from wastes which would otherwise be disposed to landfill, provided that emissions are tightly controlled to minimise other environmental impacts. In determining whether such waste-to-energy schemes are likely to produce an overall environmental benefit, a full analysis including consideration of alternative options should be carried out. The Operator should also refer to the relevant Guidance Notes for waste combustion and incineration processes for information on relevant standards and obligations for these processes.

  Reasons for not being able to justify a waste-to-energy plant might be that the waste is already being put to more beneficial use, that the waste has a low combustible content, or that a gas-powered CHP plant offers better overall performance even though it is using fossil fuels. Combustion of waste also has considerable impact on other pollutants, and the assessment should take these into account against the costs.

3 Emissions benchmarks

3.1 Emissions inventory and benchmark comparison

INFORMATION IN THIS SECTION APPLIES TO ALL IPPC APPLICANTS

Cross-reference to requirement in Sector Guidance

Describe the nature, quantities and sources of foreseeable emissions into each medium (which will result from the techniques proposed in Section 2).

See Section 3.1 of Sector or General Sector Guidance.

Section 3.1 of the Application requires the Operator to list significant emissions of all substances that will result from the proposals in Section 2 of the Sector Guidance. The reporting of direct and indirect emissions of carbon dioxide resulting from the consumption or generation of energy by the activities covered in the Permit is included as part of this overall reporting of environmental emissions. A suitable table on which to record this information is provided in the electronic (Applicant) version of the Sector Guidance Note, based on the format in Table 3.1.

Table 3.1 Example format: emissions of carbon dioxide from energy use

Energy source	Annual emissions of CO_2 to environment (tonnes)
Electricity (public supply)*	
Electricity (other supply)*	
Imported heat*	
Gas	
Oil	
Other	
Total	

- Emissions should be based on primary energy source.

Note that there are no emission concentration benchmarks for carbon dioxide for comparison, unlike other environmental pollutants.

Supplementary information

Energy consumption results in the release of a number of polluting substances. The primary indicator in the assessment of energy efficiency is emission of carbon dioxide generated through the production of energy from fuels. Reporting of direct and indirect emissions of carbon dioxide is required in order to ensure that the environmental benefits of using efficient on-site energy conversion systems over the average national grid efficiency are taken into account. Direct releases occur where primary energy is converted to heat and/or electricity at the installation, e.g. through steam-raising boilers, combined heat and power plant or gas combustion turbines. Indirect releases are those associated with the consumption of electricity or heat generated elsewhere.

Direct and indirect emissions of carbon dioxide can be calculated using the factors provided in Table 3.2, or, where applicable, by the use of factors derived from on-site heat and/or power generation. In the latter case, Section 3.1 of the Sector Guidance requires that the Operator provides details of such factors. Emissions for electricity and imported heat should be based on primary energy. The values in Table 3.2 are consistent with factors used for Climate Change Levy and negotiated agreements, but Operators may propose actual factors for fuels of variable composition, where available.

Table 3.2 Emissions factors for various fuels

Fuel	Emission factor: carbon		Emission factor: carbon dioxide	
	kg/MWh	kg/GJ	kg/MWh	kg/GJ
Electricity*	45.3	12.6	166	46.2
Coal	81.7	22.7	300	83.2
Coke	117	32.5	430	119.2
Gas oil	68	18.9	250	69.3
Heavy fuel oil	70.9	19.7	260	72.2
Petrol	65.5	18.2	240	66.7
Liquid petroleum gas	62.7	17.4	230	63.8
Jet kerosene	65.5	18.2	240	66.7
Ethane	54.5	15.2	200	55.7
Naphtha	70.9	19.7	260	72.2
Refinery gas	54.5	15.2	200	19.1
Petroleum coke	92.7	25.8	340	94.6
Natural gas	51.8	14.4	190	52.8

1 tonne carbon = 44/12 tonnes of CO_2 **1 MWh = 3.6 GJ**

* Emissions factor for public supply, based on primary energy consumption. The Operator should specify appropriate emissions factor for other supplies, e.g. direct supplies or "green" tariffs.

References

1. The Pollution Prevention and Control Regulations (SI 1973 2000) (http://www.click-tso.com)
2. The Pollution Prevention and Control Act (1999) (http://www.click-tso.com)
3. EC Directive 96/61/EC, Integrated Pollution Prevention and Control (OJ No. L 257, 10/10/1996, p.26)
4. IPPC – A Practical Guide (for England and Wales) (or equivalents in Scotland and Northern Ireland) (http://www.click-tso.com)
5. IPPC H1: Horizontal Guidance on Environmental Impact Assessment and BAT Appraisal (Environment Agency, in draft)
6. Non-Ferrous Metal BREF, EIPPCB, 2000 (http://eippcb.jrc.es)
7. Cement and Lime BREF, EIPPCB, 2000 (http://eippcb.jrc.es)
8. Pulp and Paper BREF, EIPPCB, 2000 (http://eippcb.jrc.es)
9. Good Quality CHP Guidelines, DEFRA (then DETR) (http://www.defra.gov.uk)
10. Guidelines for Defining and Documenting Data on the Costs of Possible Environmental Protection Measures, European Environment Agency Technical Report No 27, 1999.

Definitions

BAT	best available techniques
BREF	BAT Reference (document)
CCA	Climate Change Agreement
CCL	Climate Change Levy
CHP	combined heat and power
COP	coefficient of performance
DCF	discounted cash flow
DPA	Direct Participant Agreement (in the Emissions Trading Scheme)
DEFRA	Department for Environment, Food and Rural Affairs
ECG	Energy Consumption Guide (EEBPP)
EEBPP	Energy Efficiency Best Practice Programme
EHS	Environment and Heritage Service (Northern Ireland)
ELV	emission limit value
EMS	Environmental Management System
ETS	Emissions Trading Scheme
GIR	General Information Report (EEBPP)
GPCS	Good Practice Case Study (EEBPP)
GPG	Good Practice Guide (EEBPP)
HEM	high efficiency motor
IPPC	Integrated Pollution Prevention and Control
PPC	Pollution Prevention and Control
M&T	monitoring and targeting
SEC	specific energy consumption
SEPA	Scottish Environment Protection Agency

Appendix 1 - Allocation of energy inputs from CHP

This appendix provides guidelines for apportioning energy supplied from combined heat and power units, depending on the proportion of output supplied to the permitted activities. These guidelines are extracted from those provided for DEFRA's Climate Change Agreements.

Where all of the energy from a CHP plant is used within the facility, the facility shall be treated as using all of the units of energy input to the plant. Where this is not the case, the energy input to the CHP plant shall be allocated to each user of the heat or electricity as follows:

(1) First, allocate energy input to the CHP plant to the heat and electricity produced using the following formulae

$$\text{Heat Energy} = \frac{\text{Fuel Input}}{(2 \times \text{Electricity Output}) + \text{Heat Output}} \times \text{Heat Output}$$

$$\text{Electricity Energy} = \frac{2 \times \text{Fuel Input}}{(2 \times \text{Electricity Output}) + \text{Heat Output}} \times \text{Electricity Output}$$

where

"Heat Energy" is the energy allocated to the heat produced

"Electricity Energy" is the energy allocated to the electricity produced

"Fuel Input" is the fuel supplied to the CHP plant

"Heat Output" is the quantity of heat produced

"Electricity Output" is the quantity of electricity produced.

(Fuel and heat units should be expressed on a gross calorific value basis. Energy units should be consistent throughout (ideally kWh). Where absorption cooling is used to produce a cooling supply, the cooling output should be metered and divided by the average coefficient of performance (COP) of the cooling system to estimate the heat used.)

(2) Then apportion the energy input to each user of the heat and electricity as follows:

- allocate the heat energy to each user of the heat in proportion to the quantity of heat from the CHP plant which each consumes
- allocate the electricity energy to each user of the electricity in proportion to the quantity of electricity from the CHP plant which each consumes.

Thus, if the heat is distributed to a number of users such that

$$\text{Heat Output} = \text{Heat}_1 + \text{Heat}_2 + \text{Heat}_n$$

or the electricity is distributed to a number of users such that

$$\text{Electricity Output} = \text{Electricity}_1 + \text{Electricity}_2 + \text{Electricity}_m$$

then

$$\text{Heat Energy}_1 = \frac{\text{Heat}_1}{\text{Heat Output}} \times \text{Heat Energy}$$

and

$$\text{Electricity Energy}_1 = \frac{\text{Electricity}_1}{\text{Electricity Output}} \times \text{Electricity Energy}$$

where "Heat Energy$_1$" and "Electricity Energy$_1$" are the quantities of energy allocated to user 1, and likewise for the other users.

(3) If some of the electricity is exported to the public supply (and not directly to a known user), allocate credit for this electricity to each of the heat users as follows:

- multiply the quantity of exported electricity by 2.6
- subtract from this the energy apportioned to the exported electricity from the CHP plant, which gives the saving that has been made
- divide this saving amongst each of the users of the heat from the CHP plant on a pro-rata basis to the quantity of heat which each uses
- subtract the pro-rata saving from each of the heat figures calculated in accordance with step (2) above, to get a revised heat figure.

Thus, if electricity were exported to the public supply instead of being supplied to user *m* in step (2) above, the revised heat figures would be:

Revised Heat Energy$_1$ =

$$\text{Heat Energy}_1 - \frac{[(\text{Exported Electricity x 2.6}) - \text{Electricity Energy}_m]}{\text{Heat Output}} \text{ x Heat}_1$$

Revised Heat Energy$_2$ =

$$\text{Heat Energy}_2 - \frac{[(\text{Exported Electricity x 2.6}) - \text{Electricity Energy}_m]}{\text{Heat Output}} \text{ x Heat}_2$$

Revised Heat Energy$_n$ =

$$\text{Heat Energy}_n - \frac{[(\text{Exported Electricity x 2.6}) - \text{Electricity Energy}_m]}{\text{Heat Output}} \text{ x Heat}_n$$

where “Exported Electricity” is the quantity of exported electricity expressed as the number of units of electricity exported.

(If there were no electricity exports to the public supply, then user 1 would report total energy from the plant or generator as Heat Energy$_1$ plus Electricity Energy$_1$. If there were electricity exports, user 1 would report total energy from the plant or generator as Revised Heat Energy$_1$ plus Electricity Energy$_1$.)

Appendix 2 - Energy efficiency checklists

A - Checklist for compressed air

1. Good housekeeping

- Consider turning off compressors during non-productive hours.
- Review the level to which air is pressurised. You may be able to reduce it, which reduces consumption and leakage.
- Related to the previous two points, if there are applications which require higher pressures or have longer operating hours than the rest of the system, investigate whether it might be worth installing a dedicated compressor.
- Check that the air inlet to the compressor is not taken from inside the building. Compressors operate more efficiently using cool air.
- Control/sequence compressors to operate on a "demand-controlled" basis. Compressors use as much as 70% of on-load power when they are idling. Seek professional advice.
- Initiate an effective system for reporting leaks. Carry out an "out of hours" survey, to listen for leaks, locate them and tag.
- Make sure all redundant piping is isolated – it is often a source of leaks.
- Check that the condensate collection system is working correctly, and that there is no constant bleed of air. Condensate traps may be jammed open or have been bypassed. Consider fitting electronically operated condensate traps, which are more reliable.

2. Treatment

- Investigate treating the bulk of the air to the minimum level possible, then improving the quality for specific appliances.
- Regularly inspect and maintain the air treatment system. Check the pressure drop across the pre- and after-filters. If it is above 0.4 bar the filter may need replacing. It is cheaper to replace the filters than to pay for the loss in air pressure when they become clogged.
- Measure the dryer inlet temperature. This should not exceed 35°C with the compressors on full load.
- Measure the temperature of the dryer room. It should be within 5°C of the outside ambient temperature. If the room is too hot, there is a loss of performance.

3. Use of compressed air

- Over 90% of energy used by a compressor is turned into heat, so consider whether you can fit a heat recovery system to the compressor(s) and use this heat elsewhere in your buildings.
- Use of higher efficiency nozzles (which entrain free air) can maintain performance, yet reduce the distribution pressure and hence energy consumption.
- Make sure that air tools are not left running when not in use.
- Check that compressed air is not used for ventilation or cleaning purposes, such as blowing off swarf.
- Look at alternatives to compressed air tools. Electrically powered tools are much cheaper.
- When purchasing a new compressor, take into account its energy efficiency, since electricity will be the major running cost.

4. **Calculating compressed air leakage**

The best way to establish the amount of leakage in a system is by measurement. In the absence of suitable measuring devices, a no-load test should be carried out to establish the percentage leakage from the system (see GPG126, p. 5). Two possible methods are as follows.

(a) For compressors in on/off mode

This applies to compressors that are operated in an on/off load, i.e. when the compressor is on-load it produces a known amount of air.

- Close down all the air-operated equipment.
- Start the compressor and operate it to full line pressure, when it will off-load. Air leaks will cause the pressure to fall and the compressor will come on-load again.
- Over a number of cycles, make a note of the average on-load time (T) and average off-load time (t).
- Total leakage can then be calculated as follows:

$$\text{Leakage (litres/second)} = \frac{Q \times T}{T + t}$$

where Q = air capacity of the compressor (litres/second), T is the average on-load time (s) and t is the average off-load time (s).

(b) For modulating compressors

This test is more difficult, as the compressor output is unknown. The following method can be used if you have a pressure gauge downstream of the receiver.

- Calculate the system volume of air (V) in litres. This can be estimated as the volume of air mains downstream of the receiver isolating valve, including all the pipework (25 mm and above) and the receivers.
- Pump up the system to operating pressure (P_1) and then close the isolating valve.
- Record the time (T) for pressure to drop to P_2.
- Leakage can then be calculated as follows:

$$\text{Leakage (litres/second)} = \frac{V \times (P_1 - P_2)}{T}$$

where V is in litres, P_1 and P_2 are in bar_g, and T is in seconds.

B - Checklist for steam systems

1. Maximise condensate return

- Hot condensate that is not returned to the boilerhouse has to be replaced by treated cold make-up water and wastes some 20% of the energy absorbed in the generation of the steam from which the condensate is derived. This may be the greatest single energy loss in steam utilisation. The additional make-up water also adds to water treatment costs.
- If condensate is being discharged to drain because of the risk of contamination, it may be possible to return the condensate to a break tank via an analyser to detect the presence of any contaminant. Alternatively, recover useful heat from contaminated condensate before discharging it to drain.
- The energy in any steam used for direct injection to process may be considered to be fully utilised.

2. Avoid loss of flash steam from condensate return

- When condensate is discharged from steam traps and flows along the return piping, some flash steam is formed.
- Try to find a new use for the flash steam – it will typically contain some 40% of the energy in the original pressurised condensate. All too often flash steam is simply vented to atmosphere.
- If the condensate and associated steam cannot be accommodated in the boilerhouse hot well, flash the collected condensate down to a low or atmospheric pressure local to the point of use of the steam and pump the residual condensate back to the hot well. This practice is also preferred where there are long runs of condensate piping.

3. Isolate unused piping

- Check all pipework is used. There may be branches of the steam distribution system that are no longer used and can be removed from the system.
- Use valves or slip-plates to isolate piping that supplies steam to infrequently used items of plant. Such piping imposes a disproportionate standing loss on the system and is likely to receive less maintenance attention.
- If you remove part of a redundant section of piping and fit a blank flange, check that the remaining piping is adequately supported.

4. Improve steam trapping

- Inspect steam traps routinely.
- Make sure that the replacement of defective traps is given high priority.

5. Repair steam leaks

- Consider keeping a documented system for reporting and rectifying of steam leaks.
- Make sure that the repair of steam leaks is given high priority. Costs can soon mount up with only a few leaking valve glands.

C - Checklist for air conditioning and refrigeration

1. Around the refrigeration plant

- Keep the condensers clean. Blocked condensers increase the condensing temperature, and a 1°C increase in condensing temperature increases running costs by 2–4%. The cooling capacity also drops and the required temperature may not be achieved. Get the condensers cleaned regularly and budget to replace badly corroded ones.
- Make sure air entering the condensers is as cold as possible. The warmer the air onto the condenser, the higher the condensing temperature. Shade the condensers if necessary and ensure warm air is not recirculated – remove anything obstructing the airflow.
- Check the refrigerant sight glass for bubbles. Bubbles in the sight glass usually mean a system is leaking. (NB: it is illegal to knowingly vent certain refrigerants.) Find the leaks and repair them before the system is recharged with refrigerant.
- Check that the oil in the compressor sight glass(es) is at the right level. The compressor will be more likely to fail if the oil level is too low (or too high).
- Report and repair any pipework that is vibrating. Vibrating pipework is more likely to fracture, causing a major refrigerant leak. Get the pipework fixed more securely, but make sure it is not too rigid.
- Keep the plant room as cool as possible. Otherwise, the plant will be running hotter than necessary, reducing reliability and performance. Ventilate the plant room, preferably with an extractor fan that is switched on when the temperature gets too high. Make sure air can get in as well as out of the plant room.

2. In cooled rooms

- Keep the door closed as much as possible. Ice around the door indicates poor sealing, with a consequent increase in the heat load. Avoid loading product in the doorway and improve the sealing on the door. If the door has to be used regularly, fit a strip curtain.
- Do not stack product directly under the evaporators This impedes the airflow over the cold store.
- Check your evaporators defrost properly. Evaporators that operate below 0^{o}C should be completely defrosted when the ice starts to cover the fins – this may be every few hours or every few days. If the frost does not clear, or if the drain pan/lines are blocked, then the frost build-up on the evaporator will get worse.
- Report ice on the floor and walls of the store. This indicates that a lot of air is entering the room, bringing with it moisture, which is condensing on the evaporator and the structure. It could also indicate a defrost problem.
- Do not keep the store colder than necessary. Cold stores are often held at lower temperatures than necessary because of worries about failure. In fact, having a cold store at a lower temperature than necessary makes it more likely that failure will occur.

3. In other areas

Refrigeration systems have to remove the heat from many places other than the product or space you are cooling. Most of these heat gains are unavoidable, but they should always be minimised. Common examples are:

- *Pumps and fans* that circulate cold air, chilled water, or an antifreeze solution generate heat, contributing most of the power they consume to the cooling load – switch them off when not required.
- *Lights in a cold store or cooled room* also contribute most of the power they consume to the cooling load – switch them off when not required.
- *Cold refrigerant pipes (particularly the larger gas pipes)* will pick up heat from their surroundings – they should be insulated, and avoid hot areas.

D - Checklist for motors and drives

1. Is the equipment still needed?

- Check that changing operational requirements have not eliminated the need for the equipment altogether.

2. Switching the motor off

- Time the switching according to a fixed programme or schedule.
- Monitor system conditions, e.g. high or low temperatures, and switch off the motor when it is not needed.
- Sense the motor load so that the motor is switched off when idling.

3. Reducing the load on the motor

- There is no point in optimising the drive if what the motor is driving is fundamentally inefficient.
- Is the system doing a useful and necessary job?
- Is the transmission between motor and driven equipment efficient?
- Is the driven machine efficient?
- Are maintenance programmes adequate?
- Have losses due to the pipework, ducting, insulation, etc. been minimised?
- Is the control system effective?

4. Minimising motor losses

- Always specify higher efficiency motors where feasible.
- When a motor fails, ensure that proper care and attention are given in the repair process so as to minimise energy losses.
- Avoid using greatly oversized motors.
- Consider permanent reconnection of the motor electrical supply in star-phase, as a no-cost way of reducing losses from lightly loaded motors.
- Check that voltage imbalance, low or high supply voltages, harmonic distortion or a poor power factor is not causing excessive losses.

5. Slowing down the load

- In pump or fan applications where the cube law applies, even a small reduction in speed can produce substantial energy savings.
- For belt drives only, a low-cost option is to change the pulley ratio.

E – Checklist for building services

1. Lighting systems checklist

(a) Assessment of lighting level

Lighting levels in industrial processes should be appropriate for the tasks. It is possible to show that general lighting conforms to good energy efficiency practice by calculating the installed lighting load in watts per square metre. A simple estimate can be made for each general processing area by:

- counting the number of lamps installed in the given area (where a fitting has more than one lamp, count the total number of lamps,)
- adding up the circuit watts using table A2.1,
- dividing the total circuit wattage by the floor area.

Table A2.1 gives typical circuit watts for most types of single lamp light fittings.

Table A2.1 Circuit wattages for commonly used lamps

Lamp type	Description *	Total circuit wattage (W)
Fluorescent	2400mm, Ø38mm, 125W tube	137
	2400mm, Ø38mm, 100W tube	112
	1800mm, Ø38mm, 75W tube	91
	1800mm, Ø26mm, 70W tube	80
	1800mm, Ø26mm, 70W tube, EB	66
	1500mm, Ø38mm, 65W tube	78
	1500mm, Ø26mm, 58W tube	71
	1500mm, Ø26mm, 58W tube, EB	54
	1200mm, Ø38mm, 40W tube	51
	1200mm, Ø26mm, 36W tube	47
	1200mm, Ø26mm, 36W tube, EB	37
High-pressure mercury	50	62
	80	94
	125	142
	250	275
	400	430
	700	720
	1,000	1,040
Metal halide	125	172
	250	288
	400	410
	1,000	1,080
High-pressure sodium	50	62
	70	86
	100	114
	150	172
	250	280
	400	432
	1,000	1,090
Low-pressure sodium	18	26
	35	52
	55	68
	90	105
	135	175

* (note: EB = electric ballast)

(b) Benchmarks for lighting levels

The installed lighting load depends on the lighting intensity, which should be appropriate for the task in hand. Table A2.2 gives good practice benchmarks for tasks that are moderately easy (large details) of 300 lux and tasks that are moderately difficult (medium-sized detail) of 500 lux. The range of benchmarks quoted are consistent with the latest guidance from CIBSE to be found in “Society of Light and Lighting – Code for Lighting 2002”.

Table a2.2 also gives the corresponding luminaire-lumens/circuit-watt ratio which shows that by adopting good practice it is possible to achieve a performance better than the minimum required by the building regulations of not less than 40 luminaire-lumens/circuit-watt averaged over the whole building.

Table A2.2 Targets for installed lighting load

Level of discrimination of detail	Recommended lighting level (lux)	Target for installed lighting load (circuit-watts/m^2)	Luminaire-lumens /circuit-watt
None	300	6 to 7	50 to 43
Medium	500	10 to 12	50 to 42

2. Climate control systems checklist

- Where waste process heat is available, consider practicality of recovering heat for space heating using partial air recirculation or heat exchangers.
- Provide independent control of the internal climate for each activity area, e.g.:
  - ensure thermostats in each activity area are set to maintain a temperature appropriate to the activity;
  - ensure heating and cooling systems are controlled through time switches and/or occupancy sensors to operate only when required by the occupants or the process;
  - optimum start, optimum shut-down and weather compensation of heating system;
  - where cooling is required, first consider reducing the internal heat gains, and then use the least energy-intensive cooling technique that will maintain the required temperature (see GPG303 for more details);
  - in production areas, locate thermostats controlling heaters so that they respond by turning down the heating system as process gains raise the temperature.
- Select high-efficiency heating equipment, e.g.:
  - where centralised heating system is installed, consider replacing with efficient warm air or radiant heaters;
  - for small quantities of hot water, consider point-of-use water heaters.
- Minimise ingress of cold air through:
  - improving air-tightness of fabric;
  - minimising the length of time access doors are open;
  - installing plastic strip curtains, fast acting roller doors or entrance lobbies at main access points.
- Use natural ventilation where possible. But where mechanical ventilation is required, consider time control, or temperature control, or air flow rate control, and introduce make-up air in such a way as to avoid cold draughts and running the building at negative pressure.

Appendix 3 - Feasibility of CHP for energy supply

In the last few years, there have been major developments in the market for CHP, both in technology and also in financing packages. Such innovations include using energy supply companies to completely finance the investment and using CHP for cooling. Thus even if you have examined the use of CHP in the past, changes in the energy and CHP markets justify re-evaluating the opportunity. The following information provides an overview of the main principles in evaluating feasibility of CHP. Further information may be found via the Environment and Energy Helpline (0800 585 794).

Benefits

1. Cost savings

Evidence shows that, in many industrial sectors, CHP can reduce total site energy bills significantly.

2. Secure supplies of energy

Secure electricity and heat supplies are of critical importance for both commercial and safety reasons. The impact of any temporary loss of mains electricity can be minimised by configuring your CHP system to supply essential site loads. This maintains safety and can avoid production losses, disappointed customers and ultimately lost business.

3. Better control

Modern CHP equipment is likely to require less effort to operate and maintain than many older boiler systems, as CHP systems are equipped with automatic control and monitoring systems.

4. Environmental benefits

CHP has a very high energy efficiency. This optimises the use of fossil fuels and reduces the production of CO_2. Furthermore, gas-fired CHP schemes can eliminate SO_2 emissions, while NO_x can be controlled to meet environmental legislation.

Risks

1. Technical risks

CHP is a well-established technology but it is vital that the right design decisions are made. In simple terms, the key to maximising efficiency is to have a good match between heat required and the heat available. However, optimisation of economic and environmental performance does not always coincide.

2. Finance

Over half the companies installing CHP in the last two years have chosen not to finance the plant themselves. In a typical Energy Services contract, a third party provides the capital for the CHP plant and then installs, operates and maintains the equipment. Both parties agree on who should bear the different costs and risks, and on how the savings should be shared. A contract will normally run for 10 to 15 years with the host site buying electricity and heat produced by the plant at preferential rates.

3. Fluctuations in the energy market

The economics of CHP depend on using one fuel, normally gas, to generate electricity and heat. Hence if electricity prices fall or gas prices rise, the financial return from CHP will fall. As the market for gas and electricity prices becomes fully liberalised, it is likely that the only certainty is that there will be continuing changes. Both energy and CHP suppliers recognise that businesses need price stability to enable decisions to be made. Hence, these companies are moving into the financial markets so that they can offer price stability as an element of longer-term contracts for energy supplies.

Appendix 4 - Appraisal of energy efficiency techniques

There are often a wide range of energy efficiency measures available for a given activity, for which the financial and environmental implications can vary significantly. The aim of this appendix is to provide guidance for the appraisal of energy efficiency measures, in order to select and prioritise implementation of those that represent the best available techniques for energy efficiency by providing the greatest environmental protection at reasonable cost. In the appraisal of best available techniques for IPPC, the Regulator adopts the principle of balancing the overall environmental benefits of pollution control techniques against the costs of their implementation.

Some energy efficiency techniques can lead to adverse implications for other environmental releases, such as increased emissions to air or generation of waste. In these cases, the wider environmental impacts need to be taken into account in the appraisal to determine what is the best available technique. In addition, there are many techniques used for the control of other environmental releases from an installation that consume significant amounts of energy. In the case of a trade-off between energy consumption and other environmental objectives, the Operator should undertake an environmental assessment, taking into account the costs and environmental benefits, to justify selection of the best available techniques for preventing and minimising pollution to the environment as a whole. The preferred methodology for this is provided in IPPC H1: Horizontal Guidance on Environmental Impact Assessment and BAT Appraisal ([5]).

However, many techniques aimed at reducing the environmental impact of energy use have no effect on other polluting emissions associated with the installation. Such measures could be considered as "stand-alone" techniques and appraised according to their individual environmental benefits. Examples of such "stand-alone" techniques might include housekeeping measures, improved motors and drives, installation of low-energy lighting or upgrading of insulation on a steam system. A simplified methodology for the appraisal of stand-alone energy efficiency techniques is provided below. This is based on balancing the environmental impact of the energy efficiency technique, in terms of global warming potential of releases of carbon dioxide, against the costs of implementing the technique.

Appraisal method

Evaluate the costs of the techniques by following the procedure below:

1. **For each option to be considered in the appraisal, provide estimates of the following costs:**
   - capital costs of equipment purchase and installation (note 1),
   - average change in annual operating and maintenance costs (note 2).

   The information for capital and operating costs should be provided according to the templates overleaf, broken down into sufficient detail to allow the major cost influences of each option to be clearly demonstrated (note 3).

2. **Calculate the annualised cost for each option according to the method in Table A4.1** (note 4).

Table A4.1 Calculating equivalent annual cost

Step	Result	Unit
Discount rate, *r* (note 5)	=	decimal
Assumed life of the option, *n* (note 6)	=	years
Equivalent annual cost factor = $\frac{r}{(1+r)^n - 1} + r$	=	
Present value factor = 1 / equivalent annual cost factor	=	
Present value cost of the option = (Annual average operating costs x **present value factor)** + capital costs (note 1)	=	£
Equivalent annual cost **= Present value cost of the option** x **equivalent annual cost factor**	=	£

3. **Estimate the annual average carbon dioxide savings over the assumed life of the technique.**

4. Present the information according to Table A4.2.

Table A4-2 Cost–benefit appraisal summary

Equivalent annual costs		
	Technique 1	**Technique 2, etc.**
Capital cost (£000s)		
Operating costs (£000s/year)		
Life of option (*n*) (years)		
Discount rate (*r*)		
Equivalent annual cost (saving)*		
Average annual CO_2 savings		
Cost (saving)*/tonne CO_2		

*A positive value indicates an equivalent annual cost, a negative value an equivalent annual saving.

5. **List the measures to be implemented, justifying any prioritisation in the order of their implementation.** Section 2.7.3 of the Sector Guidance requires Operators to implement all measures which are considered cost-effective according to this methodology. Operators may use the following guidelines to justify the implementation and prioritisation of energy efficiency measures:
   - To assist in ranking of techniques in order of priority for implementation, divide equivalent annual savings by average annual CO_2 savings to provide a relative ranking of cost effectiveness of techniques in reducing environmental pollution (note 7).
   - All options which result in a net cost saving should be considered for implementation. Note that this should not exclude techniques which result in a positive annualised cost, as cost effective options are judged to be those where the costs are not excessive in relation to the environmental protection they provide (note 8).

A worked example is provided at the end of this appendix.

Notes

Note 1 Capital costs (see Table A4.3 for a template) include all costs required to purchase equipment needed for the pollution control techniques, the costs of labour and materials for installing that equipment, costs of site preparation (including dismantling) and buildings, and certain other indirect installation costs. Capital costs should include not only those associated with stand-alone pollution control equipment, but also costs of making integrated process changes or installing control and monitoring systems.

The limits of the activity or components to which the costs apply should be described. For example, choice of one type of technology that is inherently less polluting would require all components of that technology to be included in this limit.

“Engineering” estimates of costs are generally satisfactory for cost submissions. However, any significant uncertainties should be described, especially for components that could have a major influence on a decision between different options. Where available, the cost of each major piece of equipment within the limit should be documented with data supplied by an equipment vendor or a referenced source.

Note 2 The recurring annual change in operating costs (see Table A4.4 for a template) for options consists of the additional costs, minus any cost savings, resulting from the implementation of that option. This should include any changes in production capacity. The recurring annual costs for pollution control systems consist of three elements:

- direct (variable and semi-variable) costs,
- indirect (fixed) costs, and
- recovery credits

Direct costs are those which tend to be proportional or partially proportional to the quantity of releases processed by the control system per unit time or, in the case of cleaner processes, the amount of material processed or manufactured per unit time. They include costs for raw materials, utilities (steam, electricity, process and cooling water, etc.), waste treatment and disposal, maintenance materials, replacement parts, and operating, supervisory and maintenance labour.

Indirect, or “fixed”, annual costs are those whose values are totally independent of the release flow rate and which would in fact be incurred even if the pollution control system were shut down. They include such categories as overhead, administrative charges, insurance and business rates.

Direct and indirect annual costs may be offset by recovery credits, taken for materials or energy recovered by the control system, which may be sold, recycled to the process, or re-used elsewhere at the site. These credits, in turn, should be offset by the costs necessary for their processing, storage, transportation, and any other steps required to make the recovered materials or energy reusable or resaleable. They also include reduced labour requirements, enhanced production efficiencies or improvements to product quality.

Note 3 In order that cost appraisals can be assessed on a consistent basis between installations and sectors, a standard methodology for the reporting of costs has been developed. This is based on guidelines issued by the European Environment Agency "Guidelines for Defining and Documenting Data on Costs of Possible Environmental Protection Measures" [10] .

The templates in Tables A4.3 and A4.4 present a detailed breakdown of the components that contribute to capital and operating costs. The Operator is required to provide sufficient cost breakdown information to allow comparison of the contribution of component techniques within each option, particularly where components differ significantly between options. The components listed are based on a general format, but, where relevant, the Operator may present a cost breakdown based on components more appropriate to the particular industrial sector of the activity. In addition, not all of the cost components listed will be applicable to all energy efficiency techniques, especially the simpler techniques. In these cases the Operator should state which of the breakdown components are not applicable.

If the exact cost figures are not available for the detailed breakdown, and are not required for the purposes of clarification of differences between options, the Operator should at the very least indicate which cost elements are included in the total by placing a tick against the relevant component. This ensures consistency in the determination of Applications.

In certain cases, the Operator may wish to apply for confidentiality of cost information. This must be done on a case-by-case basis. In any event, the Regulator may require access to actual cost information in order to determine the Application. However, subject to the satisfaction of the Regulator, cost information may ultimately be submitted as part of this BAT assessment in the form of relative costs.

Note 4 The preferred technique for appraisal of options is based on conventional discounted cash flow (DCF) analysis, which allows options of different timescales and cost profiles to be compared on the same basis. In DCF the future cash flows over the lifetime of an option are converted or "discounted" to annualised values or "equivalent annual costs". Unlike many other environmental improvements, investments in energy efficiency usually result in significant revenue savings, such that the investment cost is recovered over a period of time.

Note 5 An appropriate discount rate should be selected by the Operator. This usually reflects the cost of capital to the Operator, and discount rates applicable to industrial activities in the UK vary typically from 6 to 12%. This varies depending on the risk associated with the company, industrial sector or project. The Operator should ensure that the appropriate discount rate is used for all options.

Note 6 The assumed life of the option should be based on asset life. Typical values for asset life are given below, although these will vary by industrial process:

buildings	20 years
major components	15 years (e.g. steam and power generating plant)
intermediate components	10 years (e.g. heat exchangers)
minor components	5 years (e.g. motors, drives)

Note 7 The realities of cash restrictions, business cycles, the economic health of industries and the age of plant should be taken into account in determining an implementation timetable. These constraints will inevitably mean that not all measures can be implemented at an early stage. In such circumstances, it may be appropriate for improvement projects having a high CO_2 saving and lower capital cost to be implemented first. The cash savings that these produce as a result of reduced energy consumption can then be used to finance other projects. It is recognised that some improvements will be less cost-effective as retrofits to existing plant, but will be more cost-effective for new plant or when substantial modifications are being planned. It will be for the Operator to demonstrate when this is the case.

Note 8 The approach to determining BAT for pollution control under IPPC is to ensure that the cost of applying techniques is not disproportionate to the environmental benefits they achieve. Therefore, it is proposed that the methodology presented in this section, based on calculating annualised costs per tonne of CO_2 saved for different energy efficiency techniques, is used to determine the level of energy efficiency performance needed to meet IPPC.

The costs of implementing different energy efficiency techniques varies, but unlike most other environmental control techniques, they often result in a net cost saving over the life of the technique. The Regulators consider that all energy efficiency measures that result in a net cost saving should be implemented, preferably in order of highest savings of CO_2.

However, the assessment of BAT should not be constrained by whether pollution control techniques result in a net cost saving over their life of operation. It is perfectly valid to consider techniques that result in a positive annual cost. One would expect to spend money to reduce other pollutants and it is reasonable to expect, if necessary, to spend money to reduce the pollutants resulting from energy use.

However, there are insufficient data at present to confirm an appropriate figure for the net cost up to which it would be reasonable to implement energy efficiency measures. The Regulators therefore intend to review the setting of an appropriate cost benchmark in future, in the light of information arising from the Government's Climate Change Agreements and Emissions Trading mechanisms. At present there are ample measures that can be taken in most sectors if a benchmark of zero cost is used to determine which techniques should be implemented.

Table A4.3 Template for presentation of capital costs

<table>
<tr><th colspan="4">CAPITAL/INVESTMENT COSTS</th></tr>
<tr><td colspan="2"></td><td>Costs
£000s/Other
(please specify units)</td><td>Year</td></tr>
<tr><td colspan="2">Total Capital Costs</td><td></td><td></td></tr>
<tr><td>Breakdown:</td><td>Included in Capital Costs
✓ = Yes
✗ = No</td><td>Costs
£000s/% of total capital cost/Other
(please specify units)</td><td>Year</td></tr>
<tr><td>Equipment costs
• Primary equipment
• Auxiliary equipment
• Instrumentation
• Modifications to existing equipment</td><td></td><td></td><td></td></tr>
<tr><td>Installation costs
• Land costs
• General site preparation
• Buildings and civil works (e.g. foundations/supports, electrical, piping, insulation, etc.)
• Labour and materials (engineering, construction and field expenses)</td><td></td><td></td><td></td></tr>
<tr><td>Other capital costs
• Project definition, design and planning
• Testing and start-up costs
• Contingency
• Working Capital
• End-of-Life clean-up costs (note: this cost would be typically discounted to a present value)</td><td></td><td></td><td></td></tr>
</table>

Table A4.4 Template for presentation of operating costs

OPERATING COSTS & REVENUES					
				Costs £000s per year/Other (please specify units)	Year
			Total Operating Costs		
Breakdown:	Included in Operating Costs ✓ = Yes ✗ = No	Quantity (please specify units, e.g. number of Full time staff*, tonnes, etc.)	Cost/ value per unit	Total Cost/ £000' per year/% of total operating cost/Other (please specify units)	Year
Additional costs • Additional labour for operation and maintenance • Water/Sewage • Fuel/Energy costs (please specify energy/ fuel type) • Waste treatment and disposal • Other materials and parts (Provide details) • Costs of any additional pollution abatement equipment operation (provide details) • Insurance • Taxes on property • Other general overheads		[not obligatory – just as an example]			
Cost savings/revenues: • Energy savings • By-products recovered/ sold • Environmental tax/ charge savings • Other					

Worked example - Installation of a combined heat and power plant

CAPITAL/INVESTMENT COSTS			
		Costs £000s/Other (please specify units)	Year
	Total Capital Costs	1,000	2003
Breakdown:	Included in Capital Costs ✓ = Yes ✗ = No	Costs £000s/% of total capital cost/Other (please specify units)	Year
Equipment costs			2003
• Primary equipment	✓	500 (50%)	
• Auxiliary equipment	✓	50 (5%)	
• Instrumentation	✓	n/a	
• Modifications to existing equipment	✓	50 (5%)	
Installation costs			
• Land costs	✗	N/a	
• General site preparation	✓	10 (1%)	
• Buildings and civil works (e.g. foundations/supports, electrical, piping, insulation, etc.)	✓	15 (1.5%)	
• Labour and materials (engineering, construction and field expenses)	✓	150 (15%)	
Other capital costs			
• Project definition, design and planning		125(12.5)	
• Testing and start-up costs		50(5%)	
• Contingency		50(5%)	
• Working Capital		N/A	
• End-of-Life clean-up costs (note: this cost would be typically discounted to a present value)		N/A	

OPERATING COSTS & REVENUES

				Costs £000s per year/Other (please specify units)	Year
			Total Operating Costs		
Breakdown:	Included in Operating Costs ✓= Yes ✗ = No	Quantity (please specify units, e.g. number of Full time staff*, tonnes, etc.)	Cost/ value per unit	Total Cost/ £000' per year/% of total operating cost/Other (please specify units)	Year
Additional costs		[not obligatory – just as an example]			
• Additional labour for operation and maintenance	✓			56.450	
• Water/Sewage	✗			N/A	
• Fuel/Energy costs (please specify energy/ fuel type)	✓			80.640	
• Waste treatment and disposal	✗			N/A	
• Other materials and parts (Provide details)	✗			N/A	
• Costs of any additional pollution abatement equipment operation (provide details)	✗			N/A	
• Insurance	✗			N/A	
• Taxes on property	✗				
• Other general overheads	✗				
Cost savings/revenues:					
• Energy savings	✓	See below		322.560 (90%)	
• By-products recovered/ sold	✗				
• Environmental tax/ charge savings	✓	See below		77,011 (10%)	
• Other	✗				

Equivalent annual cost factor = $r/[(1 + r)^n - 1)] + r$

Substituting a discount rate of 12% for *r* and an expected life of 15 years for *n*:

Equivalent annual cost factor = $0.12/[(1 + 0.12)^{15} - 1] + 0.12$

= 0.12/[(5.4736 - 1)] + 0.12

= 0.12/(4.4736) + 0.12

= 0.0268 + 0.12

= 0.147 (rounded to three decimal places)

Present value factor = **1/*r***

which in this instance = 1/0.1468

= 6.811 (rounded to three decimal places)

Annual operating costs

The change in annual operating costs involves a combination of the following:

(a) Generated electricity = 8,064 hours x 1,000 kW

= 8,064,000 kWh

@ 4.0 p/kWh = *£322,560*

(b) Reduction in CCL on electricity generated, i.e. electricity not imported

= 8,064,000 kWh

@ 0.43 p/kWh = *£34,675*

(c) Increased cost of gas is that used in the CHP unit minus the saving in gas which was used for process heating, now substituted by heat from the CHP

= 8,064 hours x (3,500 - 2,500) kW

= 8,064,000 kWh

@ 1.0 p/kWh = £80,640

(d) Reduction in CCL on gas, which, since the fuel used by a CHP unit is exempt from CCL in any case, will be the saving on CCL on gas used for process heating

= (8,064,000 kWh x 2,500) x 0.15 p/kWh

= *£42,336*

(e) Increase in maintenance costs = 8,064,000 x 0.7 p/kWh

= £56,450

Annual saving in operating cost = (a) saving from generated electricity + (b) reduction in electricity CCL charges - (c) increase in gas costs + (d) reduction in gas CCL charges - (e) increase in maintenance

= £*322,560* + £*34,675* - £80,640 + £*42,336* - £56,450

= £262,481

Present value cost = capital cost + present value of the savings over the life of the scheme

= £1,000,000 + (*262,481* x 6.811)

= £787,758

Equivalent annual cost = present value cost x equivalent annual cost factor

= *£242,878* x 0.147

= £115, 800

Carbon dioxide emissions

The average annual savings in carbon dioxide (CO_2) are calculated by multiplying together the annual savings in energy and the appropriate emission factor. There are no savings in overall energy consumed downstream of the CHP, but electricity is now generated by a more efficient process than that previously imported from the public supply. A greater quantity of gas will be burnt at the installation, which also has to be taken into account.

For imported electricity, average annual savings in energy must be first converted into primary energy.

Generated electricity = 8,064,000 kWh x 2.6

= 20,966,400 kWh

Annual reduction in carbon dioxide resulting from displacement of imported electricity

$$= \frac{(20{,}966{,}400 \text{ kWh} \times 166 \text{ kg/MWh})}{1{,}000}$$

= 3,480,422 kg

Annual release of carbon dioxide resulting from gas used to generate heat and power on site

$$= \frac{(8{,}064{,}000 \text{ kWh} \times 190 \text{ kg/MWh})}{1{,}000}$$

= 1,532,160 kg

Total annual savings in CO_2 = 3,480,422 - 1,532,160

= 1,948,262 kg

= 1,948 tonnes

Cost per tonne of CO_2 is equal to the annual equivalent financial savings divided by the annual savings in CO_2

$$= \frac{£115{,}800}{1{,}948}$$

= £*59.45* per tonne equivalent CO_2