EUROPEAN COMMISSION
DIRECTORATE-GENERAL JRC
JOINT RESEARCH CENTRE
Institute for Prospective Technological Studies
**Competitiveness and Sustainability Unit**
**European IPPC Bureau**

# Integrated Pollution Prevention and Control

## Reference Document on Best Available Techniques for

# Energy Efficiency

## June 2008

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# EXECUTIVE SUMMARY

This BAT (Best Available Techniques) Reference Document (BREF) reflects an information exchange on best available techniques, associated monitoring and developments in them, carried out under Article 17(2) of Directive 2008/1/EC (IPPC Directive). This executive summary describes the main findings, and provides a summary of the principal BAT conclusions. It should be read in conjunction with the preface, which explains this document's objectives; how it is intended to be used and legal terms. It can be read and understood as a standalone document but, as a summary, it does not present all the complexities of this full document. It is therefore not intended as a substitute for this full document as a tool in BAT decision making.

**Energy efficiency (ENE)**
Energy is a priority issue within the European Union (EU), for three related reasons:

- climate change: the burning of fossil fuels to release energy is the major anthropogenic source of greenhouse gases
- the continuing large scale use of irreplaceable fossil fuels, and the need to achieve sustainability
- security of supply: the EU imports over 50 % of its energy fuel supplies, and this is expected to rise to more than 70 % in the next 20 to 30 years.

There are therefore many important high level policy statements addressing these issues, such as:

*'We intend jointly to lead the way in energy policy and climate protection and make our contribution to averting the global threat of climate change.'* Berlin Declaration (Council of Ministers, 50th anniversary of the Treaty of Rome, Berlin, 25 March 2007).

Increased efficiency in the use of energy is the quickest, most effective and most cost-effective way to tackle these issues. There are legal instruments and other tools for implementing energy efficiency and this document has been prepared taking account of these other initiatives.

**Mandate of the work**
This document was specifically mandated by a special request from the Commission Communication on the implementation of the European Climate Change Programme (COM (2001)580 final) ECCP concerning energy efficiency in industrial installations. The ECCP asked that effective implementation of the energy efficiency provisions of the IPPC Directive are promoted and that a special horizontal BREF (BAT reference document) addressing generic energy efficiency techniques should be prepared.

**Scope of this document**
The IPPC Directive requires that all installations are operated in such a way that energy is used efficiently, and one of the issues to be taken into account in determining BAT for a process is its energy efficiency. For activities prescribed in the Emissions Trading Scheme Directive (Council Directive 2003/87/EC), Member States may choose not to impose requirements relating to energy efficiency in respect of combustion units or other units emitting carbon dioxide on the site. However, in such cases, energy efficiency requirements still apply to all other associated activities on the site.

This document therefore contains guidance and conclusions on techniques for energy efficiency that are considered to be compatible with BAT in a generic sense for all installations covered by the IPPC Directive. This document also gives references to BREFs where particular techniques for energy efficiency have already been discussed in detail, and can be applied to other sectors. In particular:

- the LCP BREF discusses energy efficiency relating to combustion and points out that these techniques may be applied to combustion plants with a capacity below 50 MW
- the ICS BREF discusses industrial cooling systems.

This document does not:

- include information specific to processes and activities in sectors covered by other BREFs
- derive sector-specific BAT.

However, a summary of sector-specific BAT for energy efficiency from other BREFs can be found for information in the EIPPCB workspace [283, EIPPCB].

This document was prepared in response to the request to promote the energy efficiency provisions of the IPPC Directive. It takes the efficient use of energy as the first priority, and therefore does not discuss renewable or sustainable energy resources, which are addressed elsewhere. However, it is important to note that the use of sustainable energy sources and/or 'wasted' or surplus heat may be more sustainable than using primary fuels, even if the energy efficiency in use is lower.

**Structure and contents of this document**

Energy efficiency is a horizontal issue in IPPC permitting, and as noted in the BREF outline and guide, this document does not completely follow the normal structure. In particular, because of the wide diversity of industries and activities addressed, there is no section dealing with consumptions and emissions. There are some guideline values for potential energy savings given for some techniques to consider for BAT, and a large number of examples are included in the annexes, to help users identify the most effective techniques to achieve energy efficiency in a specific situation.

Chapter 1 gives some background information on industrial energy consumption and energy efficiency issues in IPPC. It then gives a non-expert introduction to key issues such as: economics and cross-media issues, terms used in energy efficiency (such as energy, heat, work, power) and the important laws of thermodynamics: in particular, the first law states that energy can neither be created nor destroyed (it is transformed from one form to another): this means that energy can be accounted for in a process or installation, enabling efficiencies to be calculated. The second law shows that no energy transformation can result in 100 % useful work, and there are always some losses as low grade heat or energy; therefore, no process or machine can be 100 % efficient. The chapter then discusses energy efficiency indicators, the importance and problems of defining the energy efficiency and the boundaries of the systems and units they relate to. The chapter also demonstrates the need to optimise energy efficiency for systems and installations, and not at a component level.

Chapter 2 considers techniques to achieve ENE that can be applied at an installation level. It starts with discussing energy efficiency management systems (ENEMS), then discusses techniques which support the implementation of an ENEMS. These include: the importance of planning actions and investments in an integrated way to continuously minimise the environmental impact of an installation, the consideration of the installation and its systems as a whole, using energy efficiency design and selecting energy efficient process technologies for new and upgraded installations, increasing ENE by increasing process integration, and refreshing the ENEMS periodically. Other techniques supporting the ENEMS are maintaining sufficient staff expertise, communication of ENE issues, effective process control and

maintenance, monitoring and measuring energy usage, energy auditing, analytical tools such as pinch, exergy and enthalpy analyses and thermoeconomics, and monitoring and benchmarking ENE levels for installations and processes.

Chapter 3 considers techniques for energy efficiency in systems, processes and equipment using energy such as: combustion, steam, heat recovery, cogeneration, electrical power supplies, electric motor-driven subsystems, pumping systems, heating, air conditioning and ventilation, lighting, and drying and separation. When combustion is an important part of an IPPC process (such as melting furnaces), the techniques used are discussed in the appropriate vertical BREFs.

**Best available techniques**
The BAT chapter (Chapter 4) identifies those techniques considered to be BAT at a European level, based on the information in Chapters 2 and 3. The following text is a summary of this BAT chapter, and the full chapter remains the definitive text for BAT conclusions.

No associated energy savings or efficiency values could be derived and/or agreed for this horizontal document. Process-specific BAT for energy efficiency and associated energy consumption levels are given in the appropriate sector-specific (vertical) BREFs. BAT for a specific installation is therefore a combination of the specific BAT in the relevant sector BREFs, specific BAT for associated activities that may be found in other vertical BREFs (such as the LCP BREF for combustion and steam), and the generic BAT presented in this document.

The purpose of the IPPC Directive is to achieve integrated prevention and control of pollution, leading to a high level of protection of the environment as a whole, including the energy efficiency and the prudent use of natural resources. The IPPC Directive provides for a permitting system for specified industrial installations, requiring both operators and regulators to take an integrated, overall view of the potential of an installation to consume and pollute. The overall aim of such an integrated approach must be to improve the design and construction, management and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle given in Article 3 that operators should take all appropriate preventative measures against pollution, in particular through the application of **'best available techniques'**, enabling them to improve their environmental performance including energy efficiency.

Annex IV of the IPPC Directive contains a list of 'considerations to be taken into account generally or in specific cases when determining best available techniques bearing in mind the likely costs and benefits of a measure and the principles of precaution and prevention'. These considerations include the information published by the Commission to comply with Article 17(2) (BAT reference documents, or BREFs).

Competent authorities responsible for issuing permits are required to take account of the general principles set out in Article 3 when determining the conditions of the permit. These conditions must include emission limit values, supplemented or replaced, where appropriate, by equivalent parameters or technical measures. According to Article 9(4) of the Directive:

*(without prejudice to Article 10 on best available techniques and environmental quality standards, compliance with environmental quality standards), the emission limit values, equivalent parameters and technical measures shall be based on the best available techniques, without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. In all circumstances, the conditions of the permit shall include provisions on the minimisation of long-distance or transboundary pollution and must ensure a high level of protection for the environment as a whole.*

Member States have the obligation, according to Article 11 of the Directive, to ensure that competent authorities follow or are informed of developments in best available techniques.

The information provided in this document is intended to be used as an input to the determination of BAT for energy efficiency in specific cases. When determining BAT and setting BAT-based permit conditions, account should always be taken of the overall goal to achieve a high level of protection for the environment as a whole including energy efficiency.

The BAT chapter (Chapter 4) presents the techniques that are considered to be compatible with BAT in a general sense. The purpose is to provide general indications about energy efficiency techniques that can be considered as an appropriate reference point to assist in the determination of BAT-based permit conditions or for the establishment of general binding rules under Article 9(8). It should be stressed, however, that this document does not propose energy efficiency values for permits. It is foreseen that new installations can be designed to perform at or even better than the general BAT levels presented here. It is also considered that existing installations could move towards the general BAT levels or do better, subject to the technical and economic applicability of the techniques in each case. In the case of existing installations, the economic and technical viability of upgrading them also needs to be taken into account.

The techniques presented in this BAT chapter will not necessarily be appropriate for all installations. On the other hand, the obligation to ensure a high level of environmental protection including the minimisation of long-distance or transboundary pollution implies that permit conditions cannot be set on the basis of purely local considerations. It is therefore of the utmost importance that the information contained in this document is fully taken into account by permitting authorities.

It is important to bear in mind the importance of energy efficiency. However, *'even the single objective of ensuring a high level of protection for the environment as a whole will often involve making trade-off judgements between different types of environmental impact, and these judgements will often be influenced by local considerations'*. As a consequence:

- it may not be possible to maximise the energy efficiencies of all activities and/or systems in the installation at the same time
- it may not be possible to both maximise the total energy efficiency and minimise other consumptions and emissions (e.g. it may not be possible to reduce emissions such as those to air without using energy)
- the energy efficiency of one or more systems may be de-optimised to achieve the overall maximum efficiency for an installation
- it is necessary to keep the balance between maximising energy efficiency and other factors, such as product quality, the stability of the process, etc.
- the use of sustainable energy sources and/or 'wasted' or surplus heat may be more sustainable than using primary fuels, even if the energy efficiency in use is lower.

**Energy efficiency techniques are therefore proposed as 'optimising energy efficiency'**
The horizontal approach to energy efficiency in all IPPC sectors is based on the premise that energy is used in all installations, and that common systems and equipment occur in many IPPC sectors. Generic options for energy efficiency can therefore be identified independently of a specific activity. On this basis, BAT can be derived that embrace the most effective measures to achieve a high level of energy efficiency as a whole. Because this is a horizontal BREF, BAT need to be determined more broadly than for a vertical BREF, such as considering the interaction of processes, units and systems within a site.

Process-specific BAT for energy efficiency and associated energy consumption levels are given in the appropriate 'vertical' sector BREFs. As the first series of the BREFs has been completed, these have been broadly summarised in [283, EIPPCB].

Neither the BAT Chapter (Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**), nor Chapters 2 and 3 give exhaustive lists of techniques which may be considered, and therefore other techniques may exist or may be developed which may be equally valid within the framework of IPPC and BAT.

The implementation of BAT in new or significantly upgraded plants or processes is not usually a problem. In most cases, it makes economic sense to optimise energy efficiency. Within an existing installation, the implementation of BAT is not generally so easy, because of the existing infrastructure and local circumstances: the economic and technical viability of upgrading these installations needs to be taken into account. In Chapters 2 and 3, the applicability of the techniques is considered, and this is summarised for each BAT in Chapter 4.

Nevertheless, this document does not generally distinguish between new and existing installations. Such a distinction would not encourage the operators of industrial sites to move towards adopting BAT. There is generally a payback associated with energy efficiency measures and due to the high importance attached to energy efficiency, many policy implementation measures, including financial incentives, are available. Some of these are referred to in the annexes.

Some techniques are very desirable, and often implemented, but may require the availability and cooperation of a third party (e.g. cogeneration), which is not considered in the IPPC Directive. It should be noted that the cooperation and agreement of third parties may not be within the control of an operator, and therefore may not be within the scope of an IPPC permit.

**General BAT for achieving energy efficiency at an installation level**

A key element to deliver energy efficiency at an installation level is a formal management approach. The other BAT applied at a site level support the management of energy efficiency, and give more detail of techniques needed to achieve this. These techniques are applicable to all installations. The scope (e.g. level of detail, frequency of optimisation, systems to be considered at any one time) and techniques used depend on the scale and complexity of the installation, and the energy requirements of the component systems.

***Energy efficiency management***

- BAT is to implement and adhere to an energy efficiency management system (ENEMS) that incorporates, as appropriate to the local circumstances, the following features:
  - commitment of top management
  - definition of an energy efficiency policy for the installation by top management
  - planning and establishing objectives and targets
  - implementation and operation of procedures paying particular attention to:
    - staff structure and responsibilities; training, awareness and competence; communication; employee involvement; documentation; efficient control of processes; maintenance programmes; emergency preparedness and response; safeguarding compliance with energy efficiency related legislation and agreements (where such agreements exist)
  - benchmarking
  - checking performance and taking corrective action paying particular attention to:
    - monitoring and measurement; corrective and preventive action; maintenance of records; independent (where practicable) internal auditing to determine whether or not the ENEMS conforms to planned arrangements and has been properly implemented and maintained
  - review of the ENEMS and its continuing suitability, adequacy and effectiveness by top management
  - when designing a new unit, taking into account the environmental impact from the eventual decommissioning
  - development of energy efficient technologies and to follow developments in energy efficiency techniques.

An ENEMS may optionally include the following steps:

- preparation and publication (with or without external validation) of a regular energy efficiency statement, allowing for year-by-year comparison against objectives and targets
- having the management system and audit procedure examined and validated externally
- implementation and adherence to a nationally or internationally accepted voluntary management system for energy efficiency.

***Continuous environmental improvement***

- BAT is to continuously minimise the environmental impact of an installation by planning actions and investments on an integrated basis and for the short, medium and long term, considering the cost benefits and cross-media effects.

This is applicable to all installations. 'Continuously' means the actions are repeated over time, i.e. all planning and investment decisions should consider the overall long term aim to reduce the environmental impacts of the operation. Improvement may be step-wise, and not linear, and needs to take account of the cross-media effects, such as increased energy usage to reduce air pollutants. Environmental impacts can never be reduced to zero, and there will be times when there is little or no cost-benefit to further actions. However, over time, the viability may also change.

***Identification of energy efficiency aspects of an installation and opportunities for energy saving***

- BAT is to identify the aspects of an installation that influence energy efficiency by carrying out an audit. It is important that an audit is coherent with a systems approach.

This is applicable to all existing installations and prior to planning upgrades or rebuilds. An audit may be external or internal.

- When carrying out an audit, BAT is to ensure that an audit identifies the following aspects:
  - energy use and type in the installation and its component systems and processes
  - energy-using equipment, and the type and quantity of energy used in the installation
  - possibilities to minimise energy use, such as:
    - controlling/reducing operating times, e.g. switching off when not in use
    - ensuring insulation is optimised
    - optimising utilities, associated systems and processes (see BAT for energy-using systems)
  - possibilities to use alternative sources or use of energy that is more efficient, in particular energy surplus from other processes and/or systems
  - possibilities to apply energy surplus to other processes and/or systems
  - possibilities to upgrade heat quality.

- BAT is to use appropriate tools or methodologies to assist with identifying and quantifying energy optimisation, such as:
  - energy models, databases and balances
  - a technique such as pinch methodology, exergy or enthalpy analysis or thermoeconomics
  - estimates and calculations.

The choice of the appropriate tools depends on the sector and complexity of the site, and is discussed in the relevant sections.

- BAT is to identify opportunities to optimise energy recovery within the installation, between systems within the installation and/or with a third party (or parties).

This BAT depends on the existence of a suitable use for the surplus heat of the type and quantity that may be recovered.

***A systems approach to energy management***

- BAT is to optimise energy efficiency by taking a systems approach to energy management in the installation. Systems to be considered for optimising as a whole are, for example:
  - process units (see sector BREFs)
  - heating systems such as:
    - steam
    - hot water
  - cooling and vacuum (see the ICS BREF)
  - motor driven systems such as:
    - compressed air
    - pumping
  - lighting
  - drying, separation and concentration.

***Establishing and reviewing energy efficiency objectives and indicators***

- BAT is to establish energy efficiency indicators by carrying out all of the following:
  - identifying suitable energy efficiency indicators for the installation, and where necessary, individual processes, systems and/or units, and measure their change over time or after the implementation of energy efficiency measures
  - identifying and recording appropriate boundaries associated with the indicators
  - identifying and recording factors that can cause variation in the energy efficiency of the relevant processes, systems and/or units.

Secondary or final energies are usually used for monitoring ongoing situations. In some cases, more than one secondary or final energy indicator may be used for each process (e.g. both steam and electricity). When deciding on the use (or change) in energy vectors and utilities, the indicator may also be the secondary or final energy. However, other indicators such as primary energy or carbon balance may be used to take account of the efficiency of production of any secondary energy vector and its cross-media effects, depending on local circumstances.

***Benchmarking***

- BAT is to carry out systematic and regular comparisons with sector, national or regional benchmarks, where validated data are available.

The period between benchmarking is sector-specific and is usually several years, as benchmark data rarely change rapidly or significantly in a short time period.

***Energy efficient design (EED)***

- BAT is to optimise energy efficiency when planning a new installation, unit or system or a significant upgrade by considering all of the following:
  - energy efficient design (EED) should be initiated at the early stages of the conceptual design/basic design phase, even though the planned investments may not be well-defined, and should be taken into account in the tendering process
  - the development and/or selection of energy efficient technologies
  - additional data collection may need to be carried out as part of the design project or separately to supplement the existing data or fill gaps in knowledge
  - the EED work should be carried out by an energy expert
  - the initial mapping of energy consumption should also address which parties in the project organisations influence the future energy consumption and optimise the EED of the future plant with them. For example, the staff in the existing installation who may be responsible for specifying operational parameters.

Where relevant in-house expertise on energy efficiency is not available (e.g. non-energy intensive industries), external ENE expertise should be sought.

***Increased process integration***

- BAT is to seek to optimise the use of energy between more than one process or system within the installation or with a third party.

***Maintaining the impetus of energy efficiency initiatives***

- BAT is to maintain the impetus of the energy efficiency programme by using a variety of techniques, such as:
  - implementing a specific energy management system
  - accounting for energy based on real (metered) values, which places the obligation and credit for energy efficiency on the user/bill payer
  - the creation of financial profit centres for energy efficiency
  - benchmarking
  - a fresh look at existing management systems
  - using techniques to manage organisational change.

Techniques such as the first three are applied according to the data in the relevant sections. Techniques such as the last three should be applied far enough apart for the progress of the ENE programme to be assessed, i.e. several years.

***Maintaining expertise***

- BAT is to maintain expertise in energy efficiency and energy-using systems by using techniques such as:
  - recruitment of skilled staff and/or training of staff. Training can be delivered by in-house staff, by external experts, by formal courses or by self-study/development
  - taking staff off-line periodically to perform fixed term/specific investigations (in their original installation or in others)
  - sharing in-house resources between sites
  - use of appropriately skilled consultants for fixed term investigations
  - outsourcing specialist systems and/or functions.

***Effective control of processes***

- BAT is to ensure that the effective control of processes is implemented by techniques such as:
  - having systems in place to ensure that procedures are known, understood and complied with
  - ensuring that the key performance parameters are identified, optimised for energy efficiency and monitored
  - documenting or recording these parameters.

***Maintenance***

- BAT is to carry out maintenance at installations to optimise energy efficiency by applying all of the following:
  - clearly allocating responsibility for the planning and execution of maintenance
  - establishing a structured programme for maintenance based on technical descriptions of the equipment, norms, etc. as well as any equipment failures and consequences. Some maintenance activities may be best scheduled for plant shutdown periods
  - supporting the maintenance programme by appropriate record keeping systems and diagnostic testing
  - identifying from routine maintenance, breakdowns and/or abnormalities, possible losses in energy efficiency, or where energy efficiency could be improved
  - identifying leaks, broken equipment, worn bearings, etc. that affect or control energy usage, and rectifying them at the earliest opportunity.

Carrying out repairs promptly has to be balanced with maintaining the product quality and process stability, as well as with health and safety issues.

***Monitoring and measurement***

- BAT is to establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristics of operations and activities that can have a significant impact on energy efficiency. Some suitable techniques are given in this document.

**Best available techniques for achieving energy efficiency in energy-using systems, processes, activities or equipment**

The general BAT, above, identify the importance of seeing the installation as a whole, and assessing the needs and purposes of the various systems, their associated energies and their interactions. They also include:

- analysing and benchmarking the system and its performance
- planning actions and investments to optimise energy efficiency considering the cost-benefits and cross-media effects
- for new systems, optimising energy efficiency in the design of the installation, unit or system and in the selection of processes
- for existing systems, optimising the energy efficiency of the system through its operation and management, including regular monitoring and maintenance.

The following BAT therefore assume that these general BAT are also applied to the systems listed below, as part of their optimisation. ***BAT for ENE for the commonly found associated activities, systems and processes in IPPC installations can be summarised as:***

- BAT is to optimise:
  - combustion
  - steam systems

by using relevant techniques such as:

  - those specific to sectors given in vertical BREFs
  - those given in the LCP BREF and this (ENE) document.

- BAT is to optimise the following, using techniques such as those described in this document:
  - compressed air systems
  - pumping systems
  - heating, ventilation and air conditioning (HVAC) systems
  - lighting
  - drying, concentration and separation processes. For these processes, it is also BAT to seek opportunities to use mechanical separation in conjunction with thermal processes.

Other BAT for systems, processes or activities are:

***Heat recovery***

- BAT is to maintain the efficiency of heat exchangers by both:
  - monitoring the efficiency periodically
  - preventing or removing fouling.

Techniques for cooling and associated BAT can be found in the ICS BREF, where the primary BAT is to seek to use surplus heat, rather than dissipate it through cooling. Where cooling is required, the advantages of free cooling (using ambient air) should be considered.

***Cogeneration***

- BAT is to seek possibilities for cogeneration, inside and/or outside the installation (with a third party).

In many cases, public authorities (at local, regional or national level) have facilitated such arrangements or are the third party.

***Electrical power supply***

- BAT is to increase the power factor according to the requirements of the local electricity distributor by using techniques such as those described in this document, according to applicability
- BAT is to check the power supply for harmonics and apply filters if required
- BAT is to optimise the power supply efficiency by using techniques described in this document, according to applicability.

***Electric motor driven sub-systems***

Replacement by electrically efficient motors (EEMs) and variable speed drives (VSDs) is one of the easiest measures when considering energy efficiency. However, this should be done in the context of considering the whole system the motor sits in, otherwise there are risks of:

- losing the potential benefits of optimising the use and size of the systems, and subsequently optimising the motor drive requirements
- losing energy if a VSD is applied in the wrong context.

- BAT is to optimise electric motors in the following order:
  - optimise the entire system the motor(s) is part of (e.g. cooling system)
  - then optimise the motor(s) in the system according to the newly-determined load requirements, by applying one or more of the techniques described, according to applicability
  - when the energy-using systems have been optimised, then optimise the remaining (non-optimised) motors according the techniques described and criteria such as:

    i) prioritising the remaining motors running more than 2000 hrs per year for replacement with EEMs
    ii) electric motors driving a variable load operating at less than 50 % of capacity more than 20 % of their operating time and operating for more than 2000 hours a year should be considered for equipping with variable speed drives.

**Degree of consensus**

A high degree of consensus was achieved. No split view was recorded.

**Research and technical development**

The EC is launching and supporting, through its RTD programmes, a series of projects dealing with clean technologies, emerging effluent treatment and recycling technologies and management strategies. Potentially these projects could provide a useful contribution to future BREF reviews. Readers are therefore invited to inform the EIPPCB of any research results which are relevant to the scope of this document (see also the preface of this document).