EUTurbines

Overview of

Large Combustion Plants (LCP) BREF / BAT Conclusions and IED

Version 2
February 2018

Table of Contents

1. Introduction and purpose of the document

This document aims at providing a non-exhaustive overview of the most important areas of the LCP BREF and BAT Conclusions for gas turbines manufacturers, providing a quick compilation of the main categories and related key values for gas turbines.

This overview does not substitute the documents – and related values – that it makes reference to. While some explanations are provided, the document does not attempt to interpret the legal text.

The information presented is taken from the adopted BAT Conclusions of July 2017 (pdf English version) and the final LCP BREF of December 2017, as well as, for completeness, references to the IED 2010/75/EU are also made.

2. LCP BREF and BAT Conclusions

BAT Conclusions can be considered a "summary" of the BREF and are the legally binding part of the BREF. They are always part of the BREF (in this case of LCP BREF, in Chapter 10). The BAT Conclusions are always finalised and approved by Member States (IED Art. 75 Forum) and published in the Official Journal as an "implementing decision" – the LCP BAT Conclusions of 31 July 2017 were published in the Official Journal on 17 August 2017 (2017/1442/EU).

The formal definition of BAT Conclusions is available in the IED Art. 2 (12):

> *'BAT conclusions' means a document containing the parts of a BAT reference document laying down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures;*

2.1. Scope

Both the BAT Conclusions and the LCP BREF refer to the "Combustion of fuels in installations with a total rated thermal input of 50 MW or more, only when this activity takes place in combustion plants with a total rated thermal input of 50 MW or more" (BAT Conclusions p.3 / final LCP BREF p.727). The BAT Conclusions do not address "*combustion of fuels in units with a rated thermal input of less than 15 MW".*

Plants may therefore consist of units with less than 50 MWth (minimum of 15 MWth), as long as the rated total output is more than 50MWth. In such cases, the aggregation rules outlined in the IED, Art. 29 should be followed:

> ***Aggregation rules***
> *1. Where the waste gases of two or more separate combustion plants are discharged through a common stack, the combination formed by such plants shall be considered as a single combustion plant and their capacities added for the purpose of calculating the total rated thermal input.*
> *2. Where two or more separate combustion plants which have been granted a permit for the first time on or after 1 July 1987, or the operators of which have submitted a complete application for a permit on or after that date, are installed in such a way that, taking technical and economic factors into account, their waste gases could in the judgement of the competent authority, be discharged through a common stack, the combination formed by such plants shall be considered as a single combustion plant and their capacities added for the purpose of calculating the total rated thermal input.*
> *3. For the purpose of calculating the total rated thermal input of a combination of combustion plants referred to in paragraphs 1 and 2, individual combustion plants with a rated thermal input below 15 MW shall not be considered.*

Additionally, some explanatory slides to clarify the rules, including examples, have been published by the European Commission here.

The AELs set in the BAT Conclusions and LCP BREF may not apply in some cases – relevant for turbines:

*The BAT-AELs set out in these BAT conclusions may **not apply** to liquid-fuel-fired and gas-fired turbines and engines for emergency use operated less than 500 h/yr, when such emergency use is not compatible with the use of BAT (**Emission levels associated with the best available techniques (BAT-AELs) – BAT Conclusions p.10 / final LCP BREF p. 734)***

2.1.1. Definitions

Relevant definitions are available in BAT Conclusions from p.4 / LCP BREF from p. 729:

***CCGT** – A CCGT is a combustion plant where two thermodynamic cycles are used (i.e. Brayton and Rankine cycles). In a CCGT, heat from the flue-gas of a gas turbine (operating according to the Brayton cycle to produce electricity) is converted to useful energy in a heat recovery steam generator (HRSG), where it is used to generate steam, which then expands in a steam turbine (operating according to the Rankine cycle to produce additional electricity). For the purpose of these BAT conclusions, a CCGT includes configurations both with and without supplementary firing of the HRSG*

***OCGT** – Open-cycle gas turbine*

***Gas oil** – Any petroleum-derived liquid fuel falling within CN code 2710 19 25, 2710 19 29, 2710 19 47, 2710 19 48, 2710 20 17 or 2710 20 19. Or any petroleum-derived liquid fuel of which less than 65 vol-% (including losses) distils at 250 °C and of which at least 85 vol-% (including losses) distils at 350 °C by the ASTM D86 method*

***Combustion plant** - Any technical apparatus in which fuels are oxidised in order to use the heat thus generated. For the purposes of these BAT conclusions, a combination formed of:*

- *two or more separate combustion plants where the flue-gases are discharged through a common stack, or*
- *separate combustion plants which have been granted a permit for the first time on or after 1 July 1987, or for which the operators have submitted a complete application for a permit on or after that date, which are installed in such a way that, taking technical and economic factors into account, their flue-gases could, in the judgment of the competent authority, be discharged through a common stack is considered as a single combustion plant.*

For calculating the total rated thermal input of such a combination, the capacities of all individual combustion plants concerned, which have a rated thermal input of at least 15 MW, shall be added together

***Combustion unit** – Individual combustion plant*

***Net electrical efficiency** (combustion unit and IGCC) – Ratio between the net electrical output (electricity produced on the high-voltage side of the main transformer minus the imported energy – e.g. for auxiliary systems' consumption) and the fuel/feedstock energy input (as the fuel/feedstock lower heating value) at the combustion unit boundary over a given period of time*

***Net mechanical energy efficiency** – Ratio between the mechanical power at load coupling and the thermal power supplied by the fuel*

***Net total fuel utilisation** (combustion unit and IGCC) – Ratio between the net produced energy (electricity, hot water, steam, mechanical energy produced minus the imported electrical and/or thermal energy (e.g. for auxiliary systems' consumption)) and the fuel energy input (as the fuel lower heating value) at the combustion unit boundary over a given period of time*

2.2. Applicability

This part provides some information about when/how the BAT-AELs mentioned in the BAT Conclusions apply. It is important to remember that BAT-AELs are related to "normal operating conditions".

BAT-AELs IED Art. 2 (13)

'emission levels associated with the best available techniques' means the range of emission levels obtained under normal operating conditions using a best available technique or a combination of best available techniques, as described in BAT conclusions, expressed as an average over a given period of time, under specified reference conditions;

2.2.1. Minimum emission compliant load (MEL)

Differently to what is mentioned in the IED Annex V, references to >70% load are not consistent in the BAT Conclusions / LCP BREF.

The previously used term > 70% load has been replaced by footnote (2) in Table 24 (BAT-associated emission levels (BAT-AELs) for NOX emissions to air from the combustion of natural gas in gas turbines) of the BAT Conclusions p.55: “In the case of a gas turbine equipped with DLN, these BAT-AELs apply only when the DLN operation is effective”.

In Table 32 (BAT-associated emission levels (BAT-AELs) for NOX emissions to air from the combustion of gaseous fuels in open-cycle gas turbines on offshore platforms) of the BAT Conclusions (p.64), it is said that “These BAT-AELs are based on > 70 % of baseload power available on the day”.

Reference to >70% load when specifying the “Minimum monitoring frequency” – Continuous – for gas turbines (BAT 4, BAT Conclusions, p. 17 / final LCP BREF, p. 739):

(3) In the case of plants with a rated thermal input of < 100 MW operated < 1 500 h/yr, the minimum monitoring frequency may be at least once every six months. For gas turbines, periodic monitoring is carried out with a combustion plant load of > 70 %.

2.2.2. OTNOC

The IED Art. 14, 1(f) outlines some of what may be considered Other Than Normal Operating Conditions (OTNOC), *“such as start-up and shut-down operations, leaks, malfunctions, momentary stoppages and definitive cessation of operations”*

OTNOC are also specifically addressed in BAT 10 (BAT Conclusions, p. 21 / final LCP BREF, p. 747).

OTNOC – BAT 10

In order to reduce emissions to air and/or to water during other than normal operating conditions (OTNOC), BAT is to set up and implement a management plan as part of the environmental management system (see BAT 1), commensurate with the relevance of potential pollutant releases, that includes the following elements:

- *appropriate design of the systems considered relevant in causing OTNOC that may have an impact on emissions to air, water and/or soil (e.g. low-load design concepts for reducing the minimum start-up and shutdown loads for stable generation in gas turbines);*
- *set-up and implementation of a specific preventive maintenance plan for these relevant systems;*
- *review and recording of emissions caused by OTNOC and associated circumstances and implementation of corrective actions if necessary;*
- *periodic assessment of the overall emissions during OTNOC (e.g. frequency of events, duration, emissions quantification/estimation) and implementation of corrective actions if necessary.*

2.2.3. Start-up and shut-down operations

As stated above, start-up and shut-down operations are not considered part of “normal operation”, although they should be addressed separately in the permit. There is therefore a dedicated guideline saying the start-up and shutdown periods shall be minimised. Basically, the start-up and shut-down periods are set up based on the specific project settings.

There is additionally a Commission’s implementing decision on the determination of start-up and shut-down periods (2012/249/EU), which also refers to the need to minimise emissions (Article 4):

For the purposes of the determination of start-up and shut-down periods in the permit of the installation comprising the combustion plant, the measures referred to in Article 14(1)(f) of Directive 2010/75/EU shall include: […] (b) measures ensuring that the start-up and shut-down periods are minimised as far as practicable

Other points to consider:

IED Art. 3 (27) Definitions

(27) ‘operating hours’ means the time, expressed in hours, during which a combustion plant, in whole or in part, is operating and discharging emissions into the air, excluding start-up and shut-down periods;

IED Art. 14 (f) Permit conditions
(f) measures relating to conditions other than normal operating conditions such as start-up and shut-down operations, leaks, malfunctions, momentary stoppages and definitive cessation of operations;

2.2.4. Reference conditions

These are outlined throughout the BAT Conclusions, starting at p.10 /final LCP BREF, starting at p. 734. Below are some of the most relevant areas:

BAT-AELs for emissions to air
Emission levels associated with the best available techniques (BAT-AELs) for emissions to air given in these BAT conclusions refer to concentrations, expressed as mass of emitted substance per volume of flue-gas under the following standard conditions: dry gas at a temperature of 273.15 K, and a pressure of 101.3 kPa, and expressed in the units mg/Nm3, µg/Nm3 or ng I-TEQ/Nm3.

Activity	**Reference oxygen level** (OR)
Combustion of liquid and/or gaseous fuels when taking place in a gas turbine or an engine	15 vol-%

2.2.5. Referencing periods

BAT-AELs IED Art. 2 (13)
'emission levels associated with the best available techniques' means the range of emission levels obtained under normal operating conditions using a best available technique or a combination of best available techniques, as described in BAT conclusions, expressed as an average over a given period of time, under specified reference conditions;

There are some differences in the way the emission limit values were expressed in the past (also in the IED) and in the new LCP BREF: while the IED refers to monthly, daily and hourly referencing periods, the LCP BREF refers to yearly and daily averages (expressed in ranges).

The main purpose of daily averages is to avoid harmful peak emissions. Compliance is only demonstrated when both values are met.

Emission levels associated with the best available techniques (BAT-AELs) BAT Conclusions p.10
Where emission levels associated with the best available techniques (BAT-AELs) are given for different averaging periods, all of those BAT-AELs have to be complied with.

The averaging periods definitions are available in BAT Conclusions p.10-11 / final LCP BREF p. 735.

Averaging period	**Definition**
Daily average	Average over a period of 24 hours of valid hourly averages obtained by continuous measurements
Yearly average	Average over a period of one year of valid hourly averages obtained by continuous measurements
Average over the sampling period	Average value of three consecutive measurements of at least 30 minutes each (1)
Average of samples obtained during one year	Average of the values obtained during one year of the periodic measurements taken with the monitoring frequency set for each parameter
(1) For any parameter where, due to sampling or analytical limitations, 30-minute measurement is inappropriate, a suitable sampling period is employed.	

There is no definition (correlation) of operating mode related to the emission level. Therefore, all data collected for an hour, day and year count for the evaluation of emission compliance (see also point on monitoring).

Influence of load modes and load factors on the environmental performance of combustion plants (chap. 3.1.15)
For the purpose of this BREF, data related to the number of hours operated yearly (load mode) and to the way the plant is operated compared with its full capacity (load factor) have been collected and assessed together with the environmental parameters (emissions, consumption, efficiencies) and have been considered when setting the BAT-AELs.

2.2.6. Energy Efficiency

The IED 2010/75 does not specifically address Energy Efficiency levels. The final LCP BREF, however, address the topic in Chapter 10 (p. 735), BAT Conclusions p.11.

Energy efficiency levels associated with the best available techniques (BAT-AEELs)
An energy efficiency level associated with the best available techniques (BAT-AEEL) refers to the ratio between the combustion unit's net energy output(s) and the combustion unit's fuel/feedstock energy input at actual unit design. The net energy output(s) is determined at the combustion, gasification, or IGCC unit boundaries, including auxiliary systems (e.g. flue-gas treatment systems), and for the unit operated at full load.
In the case of combined heat and power (CHP) plants:
the net total fuel utilisation BAT-AEEL refers to the combustion unit operated at full load and tuned to maximise primarily the heat supply and secondarily the remaining power that can be generated;
the net electrical efficiency BAT-AEEL refers to the combustion unit generating only electricity at full load.
BAT-AEELs are expressed as a percentage. The fuel/feedstock energy input is expressed as lower heating value (LHV).
The monitoring associated with BAT-AEELs is given in BAT 2.

Energy efficiency is not expected to be part of the permit (in the sense of setting a threshold that needs to be met). This requirement is seen as a competitive advantage statement among manufacturers – something that is rather discussed with the customer.
Still, competent/local authorities may request the inclusion of energy efficiency levels in the permit. If this is the case, the values need to be met.

BAT 2 states that energy efficiency is established through testing after commissioning (if defined in the permit). While it is not defined how energy efficiency levels may be established, typically, it will be through the use of some international or national standards. The IED makes reference to the Emission Trading Scheme (ETS) Directive, giving the possibility for Member States not to impose requirements to energy efficiency.

BAT 2*, – BAT Conclusions p. 13 / final LCP BREF p. 739.*
BAT is to determine the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the gasification, IGCC and/or combustion units by carrying out a performance test at full load (1), according to EN standards, after the commissioning of the unit and after each modification that could significantly affect the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the unit. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.
(1) In the case of CHP units, if for technical reasons the performance test cannot be carried out with the unit operated at full load for the heat supply, the test can be supplemented or substituted by a calculation using full load parameters.

IED Art.9(2) – refers to the ETS Directive (2003/87/EC)
2. For activities listed in Annex I to 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.

2.2.7. Data evaluation / monitoring

References to associated monitoring are available on BAT2 (for efficiency, BAT Conclusions p. 13 / final LCP BREF, p.750) and BAT4 (to monitor emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality – see BAT Conclusions, p. 17 / final LCP BREF, p. 739-). Some generic EN standards for continuous measurements are mentioned as a footnote in BAT 4. These are EN 15267-1, EN 15267-2, EN 15267-3 and EN 14181.

See definitions of sampling periods above.

BAT 4 under the heading “Monitoring” contains some footnotes that should be considered, which are highlighted below (BAT Conclusions, p. 17 / final LCP BREF, p. 739)

(2) The monitoring frequency does not apply where plant operation would be for the sole purpose of performing an emission measurement.

(3) In the case of plants with a rated thermal input of < 100 MW operated < 1 500 h/yr, the minimum monitoring frequency may be at least once every six months. For gas turbines, periodic monitoring is carried out with a combustion plant load of > 70 %. For co-incineration of waste with coal, lignite, solid biomass and/or peat, the monitoring frequency needs to also take into account Part 6 of Annex VI to the IED.

(5) In the case of natural-gas-fired turbines with a rated thermal input of < 100 MW operated < 1 500 h/yr, or in the case of existing OCGTs, PEMS[1] may be used instead.

2.2.8. Additional information

Further information is available in IED Art. 15 – Emission limit values, equivalent parameters and technical measures.

*1.The emission limit values for polluting substances shall apply **at the point where the emissions leave the installation**, and any dilution prior to that point shall be disregarded when determining those values.*
With regard to indirect releases of polluting substances into water, the effect of a water treatment plant may be taken into account when determining the emission limit values of the installation concerned, provided that an equivalent level of protection of the environment as a whole is guaranteed and provided this does not lead to higher levels of pollution in the environment.
*2.Without prejudice to Article 18, the **emission limit values** and the equivalent parameters and technical measures referred to in Article 14(1) and (2) shall **be based on the best available techniques**, without prescribing the use of any technique or specific technology.*
*3. The competent authority shall set emission limit values that ensure that, **under normal operating conditions**, emissions do not exceed the emission levels associated with the best available techniques as laid down in the decisions on BAT conclusions referred to in Article 13(5) through either of the following:*
(a) setting emission limit values that do not exceed the emission levels associated with the best available techniques. Those emission limit values shall be expressed for the same or shorter periods of time and under the same reference conditions as those emission levels associated with the best available techniques; or
(b) setting different emission limit values than those referred to under point (a) in terms of values, periods of time and reference conditions.
Where point (b) is applied, the competent authority shall, at least annually, assess the results of emission monitoring in order to ensure that emissions under normal operating conditions have not exceeded the emission levels associated with the best available techniques.
4. By way of derogation from paragraph 3, and without prejudice to Article 18, the competent authority may, in specific cases, set less strict emission limit values. Such a derogation may apply only where an assessment shows that the achievement of emission levels associated with the best available techniques as described in BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to:
(a) the geographical location or the local environmental conditions of the installation concerned; or
(b)the technical characteristics of the installation concerned.
The competent authority shall document in an annex to the permit conditions the reasons for the application of the first subparagraph including the result of the assessment and the justification for the conditions imposed.
The emission limit values set in accordance with the first subparagraph shall, however, not exceed the emission limit values set out in the Annexes to this Directive, where applicable.
The competent authority shall in any case ensure that no significant pollution is caused and that a high level of protection of the environment as a whole is achieved.
On the basis of information provided by Member States in accordance with Article 72(1), in particular concerning the application of this paragraph, the Commission may, where necessary, assess and further clarify, through guidance, the criteria to be taken into account for the application of this paragraph.
The competent authority shall re-assess the application of the first subparagraph as part of each reconsideration of the permit conditions pursuant to Article 21.
5. The competent authority may grant temporary derogations from the requirements of paragraphs 2 and 3 of this Article and from Article 11(a) and (b) for the testing and use of emerging techniques for a total period of time not exceeding 9 months, provided that after the period specified, either the technique is stopped or the activity achieves at least the emission levels associated with the best available techniques.

---

[1] Predictive Emission Monitoring System

2.3. Use of BAT Conclusions

The use of the BAT conclusions as basis to set up permit conditions (e.g. setting Emission Limit Values (ELVs)) is mandatory:

> *3. BAT conclusions shall be the reference for setting the permit conditions (IED Art.14 (3))*

It is always up to the competent authority to agree/set up specific ELVs for a plant (on the basis of the BAT Conclusions). Deviations may be possible in some specific cases, which need to be very well documented.

The BAT conclusions are applicable to new installations since their publication. In the case certain areas are not covered by the BAT conclusions (e.g. fuel oil gas turbines > 500 operating hrs/year), the IED continues to be applicable. Competent authorities, hence, have to consider both – the BAT conclusions and the IED as applicable.

One may also expect that some countries will have to adapt their national emission regulations based on the published BAT Conclusions.

Application of BAT Conclusions to existing plants

Now that BAT Conclusions are published, the permits for existing plants will need to be re-assessed, taking into account the BAT Conclusions ranges provided for existing installations. Member States (competent authorities) have a maximum of 4 years to ensure that existing installations are compliant with the new values – this should be done on a case-by-case basis. (IED Art. 21 (3))

> *3. Within 4 years of publication of decisions on BAT conclusions in accordance with Article 13(5) relating to the main activity of an installation, the competent authority shall ensure that:*
> *(a) all the permit conditions for the installation concerned are reconsidered and, if necessary, updated to ensure compliance with this Directive, in particular, with Article 15(3) and (4), where applicable;*
> *(b) the installation complies with those permit conditions.*
> *The reconsideration shall take into account all the new or updated BAT conclusions applicable to the installation and adopted in accordance with Article 13(5) since the permit was granted or last reconsidered.*

Range values and determination of (hard) limits

The BAT Conclusions and the LCP BREF provide a range of values from reference plants in the EU which have implemented certain BATs. They do not provide a single (hard) limit – it is up to the competent authority to determine which value will need to apply to a given plant.

As mentioned above, the implementation of the BAT Conclusions falls under the Member States. There is little guidance within the BAT Conclusions on how to address this. Different approaches among Member States may be expected.

Competent authorities are expected to check BAT for NOx and other relevant values and look for air quality in the area to be permitted and to set the limits accordingly. In certain countries, additional requirements may be also requested, e.g. nitrogen levels in protected areas, such as Natura 2000.

In the case of existing plants, it would be expected that any plant currently emitting within the range of the new BAT Conclusions may be re-permitted as it is or there may be a discussion on emission improvement prior to re-permit.

3. Combustion of natural gas in gas turbines

3.1. BAT-AELs

It is important to remember that the BAT-AELs may not apply to liquid-fuel-fired and gas-fired turbines and engines for emergency use operated less than 500 h/yr, when such emergency use is not compatible with the use of BAT (BAT Conclusions p.10 / final LCP BREF p. 734)

The values in this chapter have been extracted from **Table 24** of the BAT Conclusions p. 54-55 / Table 10.24 final draft LCP BREF (p. 784).

3.1.1. Open Cycle Gas Turbines – NOx

Type of combustion plant		Total rated thermal input (MWth)	BAT-AELs (mg/Nm³) (1) (2)	
			Yearly average (3) (4)	Daily average or average over sampling period
OCGTs (5)(6)	New OCGT	≥ 50	15-35	25-50
	Existing OCGT	≥ 50	15-50	25-55 (7)

These BAT-AELs do not apply to existing turbines for mechanical drive applications or to plants operated <500 h/yr

(1) These BAT-AELs also apply to the combustion of natural gas in dual-fuel-fired turbines.

(2) In the case of a gas turbine equipped with DLN, these BAT-AELs apply only when the DLN operation is effective.

(3) These BAT-AELs do not apply to existing plants operated <1500h/yr

(4) Optimising the functioning of an existing technique to reduce NOX emissions further may lead to levels of CO emissions at the higher end of the indicative range for CO emissions given after this table.

(5) These BAT-AELs do not apply to existing turbines for mechanical drive applications or to plants operated <500h/yr.

(6) For plants with a net electrical efficiency (EE) greater than 39%, a correction factor may be applied to the higher end of the range, corresponding to [higher end] x EE/39, where EE is the net electrical energy efficiency or net mechanical energy efficiency of the plant determined at ISO baseload conditions.

(7) The higher end of the range is 80 mg/Nm3in the case of plants which were put into operation no later than 27 November 2003 and are operated between 500h/ yr and 1500 h/yr.

3.1.2. Combined Cycle Gas Turbines – NOx

Type of combustion plant		Total rated thermal input (MWth)	BAT-AELs (mg/Nm³) (1) (2)	
			Yearly average (3) (4)	Daily average or average over sampling period
CCGTs (5) (8)	New CCGT	≥ 50	10-30	15-40
	Existing CCGT with a net total fuel utilisation of < 75	≥ 600	10-40	18-50
	Existing CCGT with a net total fuel utilisation of ≥ 75	≥ 600	10-50	18-55 (9)
	Existing CCGT with a net total fuel utilisation of < 75	50-600	10-45	35-55
	Existing CCGT with a net total fuel utilisation of ≥ 75	50-600	25-50 (10)	35-55 (11)

These BAT-AELs do not apply to existing turbines for mechanical drive applications or to plants operated < 500 h/yr *1) These BAT-AELs also apply to the combustion of natural gas in dual-fuel-fired turbines.* *(2) In the case of a gas turbine equipped with DLN, these BAT-AELs apply only when the DLN operation is effective.* *(3) These BAT-AELs do not apply to existing plants operated <1500h/yr* *(4) Optimising the functioning of an existing technique to reduce NOX emissions further may lead to levels of CO emissions at the higher end of the indicative range for CO emissions given after this table.* *(5) These BAT-AELs do not apply to existing turbines for mechanical drive applications or to plants operated <500h/yr.* *(8) For plants with a net electrical efficiency (EE) greater than 55%, a correction factor may be applied to the higher end of the BAT-AEL range, corresponding to [higher end] xEE/55, where EE is the net electrical efficiency of the plant determined at ISO baseload conditions* *(9) For existing plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is 65 mg/Nm3.* *(10) For existing plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is 55 mg/Nm3.* *(11) For existing plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is 80mg/Nm3.*

3.1.3. Others – NOx

Type of combustion plant	Total rated thermal input (MWth)	**BAT-AELs (mg/Nm³)** (1) (2)	
		Yearly average (3) (4)	**Daily average or average over sampling period**
Gas turbine put into operation no later than 27 November 2003, or existing gas turbine for emergency use and operated < 500 h/yr	≥ 50	No BAT-AEL	60-140 (12) (13)
Existing gas turbine for mechanical drive applications – All but plants operated < 500 h/yr	≥ 50	15-50 (14)	25-55 (15)

(1) These BAT-AELs also apply to the combustion of natural gas in dual-fuel-fired turbines.
(2) In the case of a gas turbine equipped with DLN, these BAT-AELs apply only when the DLN operation is effective
(3) These BAT-AELs do not apply to existing plants operated <1500h/yr
(4) Optimising the functioning of an existing technique to reduce NOX emissions further may lead to levels of CO emissions at the higher end of the indicative range for CO emissions given after this table.
(12) The lower end of the BAT-AEL range for NOX can be achieved with DLN burners.
(13) These levels are indicative.
(14) For existing plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is 60mg/Nm3.
(15) For existing plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is 65mg/Nm3

3.1.4. Indicative CO emission levels

As the name indicates, CO levels provided are considered indicative, which may be used by national authorities to set up their own levels. Different approaches among Member States in this regard may be expected.

> ***BAT Conclusions p. 55 / final LCP BREF p. 785***
> *As an **indication**, the yearly average CO emission levels for each type of existing combustion plant operated ≥ 1 500 h/yr and for each type of new combustion plant will generally be as follows:*
> *— New OCGT of ≥ 50 MWth: < 5–40 mg/Nm3. For plants with a net electrical efficiency (EE) greater than 39 %, a correction factor may be applied to the higher end of this range, corresponding to [higher end] × EE/39, where EE is the net electrical energy efficiency or net mechanical energy efficiency of the plant determined at ISO baseload conditions.*
> *— Existing OCGT of ≥ 50 MWth (excluding turbines for mechanical drive applications): < 5–40 mg/Nm3. The higher end of this range will generally be 80 mg/Nm3 in the case of existing plants that cannot be fitted with dry techniques for NOX reduction, or 50 mg/Nm3 for plants that operate at low load.*
> *— New CCGT of ≥ 50 MWth: < 5–30 mg/Nm3. For plants with a net electrical efficiency (EE) greater than 55 %, a correction factor may be applied to the higher end of the range, corresponding to [higher end] × EE/55, where EE is the net electrical energy efficiency of the plant determined at ISO baseload conditions.*
> *— Existing CCGT of ≥ 50 MWth: < 5–30 mg/Nm3. The higher end of this range will generally be 50 mg/Nm3 for plants that operate at low load.*
> *— Existing gas turbines of ≥ 50 MWth for mechanical drive applications: < 5–40 mg/Nm3. The higher end of the range will generally be 50 mg/Nm3 when plants operate at low load.*
> *In the case of a gas turbine equipped with DLN burners, these indicative levels correspond to when the DLN operation is effective.*

3.2. BAT-AEELs

Values extracted from **Table 23**: BAT-associated energy efficiency levels (BAT-AEELs) for the combustion of natural gas (BAT Conclusions p.51 / Table 10.23, final LCP BREF, p. 780).

3.2.1. Open Cycle Gas Turbines

Type of combustion unit	**BAT-AEELs (1) (2)**				
	Net electrical efficiency (%)		**Net total fuel utilisation (%)** (3) (4)	**Net mechanical energy efficiency (%)** (4) (5)	
	New unit	**Existing unit**		New unit	Existing unit
Open Cycle Gas turbine ≥ 50 MWth	36-41.5	33-41.5	No BAT-AEEL	36.5-41	33.5-41

(1) These BAT-AEELs do not apply to units operated <1500h/yr.
(2) In the case of CHP units, only one of the two BAT-AEELs 'Net electrical efficiency' or 'Net total fuel utilisation' applies, depending on the CHP unit design (i.e. either more oriented towards electricity generation or heat generation).
(3) Net total fuel utilisation BAT-AEELs may not be achievable if the potential heat demand is too low.
(4) These BAT-AEELs do not apply to plants generating only electricity.
(5) These BAT-AEELs apply to units used for mechanical drive applications.

3.2.2. Combined Cycle Gas Turbines

Type of combustion unit	**BAT-AEELs (1) (2)**				
	Net electrical efficiency (%)		**Net total fuel utilisation (%)** (3) (4)	**Net mechanical energy efficiency (%)** (4) (5)	
	New unit	**Existing unit**		**New unit**	**Existing unit**
CCGT, 50-600 MWth	53-58.5	46-54	No BAT-AEEL	No BAT-AEEL	
CCGT, ≥ 600 MWth	57-60.5	50-60	No BAT-AEEL	No BAT-AEEL	
CHP CCGT, 50-600 MWth	53-58.5	46-54	65-95	No BAT-AEEL	
CHP CCGT, ≥ 600 MWth	57-60.5	50-60	65-95	No BAT-AEEL	

(1) These BAT-AEELs do not apply to units operated <1500h/yr.
(2) In the case of CHP units, only one of the two BAT-AEELs 'Net electrical efficiency' or 'Net total fuel utilisation' applies, depending on the CHP unit design (i.e. either more oriented towards electricity generation or heat generation).
(3) Net total fuel utilisation BAT-AEELs may not be achievable if the potential heat demand is too low.
(4) These BAT-AEELs do not apply to plants generating only electricity.
(5) These BAT-AEELs apply to units used for mechanical drive applications.

4. Combustion of Gas oil (Liquid fuels)

4.1. BAT-AELs

It is important to remember that the BAT-AELs may not apply to liquid-fuel-fired and gas-fired turbines and engines for emergency use operated less than 500 h/yr, when such emergency use is not compatible with the use of BAT (BAT Conclusions p.10 / final LCP BREF p. 734)

4.1.1. Gas turbines (including dual fuel) – SO2

BAT-AELS as available in **Table 22** BAT-associated emission levels for SO2 and dust emissions to air from the combustion of gas oil in gas turbines, including dual fuel gas turbines (BAT Conclusions p. 50 / Table 10.22, final LCP BREF p. 779)

Type of Combustion plant	BAT-AELs (mg/Nm3)			
	SO2		Dust	
	Yearly average (1)	Daily average or average over the sampling period (2)	Yearly average (1)	Daily average or average over the sampling period (2)
New and existing	35–60	50–66	2-5	2-10

(1) These BAT-AELs do not apply to existing plants operated <1500h/yr.
(2) For existing plants operated < 500 h/yr, these levels are indicative.

4.1.2. Dual fuel gas turbines (indicative) – NOx

BAT Conclusions p. 50 / final LCP BREF p. 778 present the indicative NOx values for dual fuel gas turbines.

> *As an indication, the emission level for NOX emissions to air from the combustion of gas oil in dual fuel gas turbines for emergency use operated < 500 h/yr will generally be 145–250 mg/Nm3 as a daily average or average over the sampling period.*

4.2. BAT-AEELs

BAT-AELS as available in **Table 21** BAT-associated energy efficiency levels (BAT-AEELs) for gas-oil-fired gas turbines (BAT Conclusions p. 50 / Table 10.21**,** final LCP BREF p. 778)

Type of combustion unit	BAT-AEELs (1)	
	Net electrical efficiency (%) (2)	
	New unit	Existing unit
Gas-oil-fired open-cycle gas turbine	> 33	25–35.7
Gas-oil-fired combined cycle gas turbine	> 40	33–44

1) These BAT-AEELs do not apply to units operated < 1500 h/yr.
(2) Net electrical efficiency BAT-AEELs apply to CHP units whose design is oriented towards power generation, and to units generating only power.

5. Combustion of iron and steel process gases

5.1. BAT-AELs

5.1.1. Combined Cycle Gas Turbines – NOx

NOX emissions to air from the combustion of 100 % iron and steel process gases (**Table 29**, BAT Conclusions p. 60 / Table 10.29, final LCP BREF, p.789)

Type of combustion plant	**O2 reference level (vol-%)**	**BAT-AELs (mg/Nm3) (1)**	
		Yearly average	**Daily average or average over the sampling period**
New CCGT	15	20–35	30–50
Existing CCGT	15	20–50 (2)(3)	30–55 (5) (6)

(1) Plants combusting a mixture of gases with an equivalent LHV of > 20 MJ/Nm3 are expected to emit at the higher end of the BAT-AEL ranges.
(2) The lower end of the BAT-AEL range can be achieved when using SCR[2].
(3) For plants operated <1500h/yr, these BAT AELs do not apply.
(5) For plants operated <500h/yr, these levels are indicative.
(6) In the case of plants put into operation no later than 7 January 2014, the higher end of the BAT-AEL range is70 mg/Nm3

5.1.2. Combined Cycle Gas Turbines – SOx

SO2 emissions to air from the combustion of 100 % iron and steel process gases (**Table 30**, BAT Conclusions, p. 61 / Table 10.30**,** final LCP BREF, p. 790)

Type of combustion plant	**O2 reference level (vol-%)**	**BAT-AELs for SO2 (mg/Nm3)**	
		Yearly average (1)	Daily average or average over the sampling period (2)
New or existing CCGT	15	10–45	20–70

(1) For existing plants operated <1500 h/yr, these BAT AELs do not apply
(2) For existing plants operated <500h/yr, these levels are indicative.

5.1.3. Combined Cycle Gas Turbines – Indicative CO

As an indication, the yearly average CO emission levels for CCGTs they will generally be < 5–20 mg/Nm3for existing CCGTs operated ≥1 500 h/yr or new CCGTs. (BAT Conclusions p. 60 / final LCP BREF, p.789)

5.1.4. Combined Cycle Gas Turbines – Dust

Dust emissions to air from the combustion of 100 % iron and steel process gases (**Table 31**, BAT Conclusions p. 62 / Table 10.31, final LCP BREF, p.801)

[2] Selective Catalytic Reduction

Type of combustion plant	BAT-AELs for dust (mg/Nm3)	
	Yearly average (1)	Daily average or average over the sampling period (2)
CCGT	2–5	2–5

(1) For existing plants operated < 1 500 h/yr, these BAT-AELs do not apply.
(2) For existing plants operated < 500 h/yr, these levels are indicative

5.2. BAT-AEELs

BAT-associated energy efficiency levels (BAT-AEELs) for the combustion of iron and steel process gases in CCGTs (**Table 28**, BAT Conclusions p.57 / Table 10.28, final LCP BREF, p. 787)

Type of combustion unit	BAT-AEELs (1) (2)		
	Net electrical efficiency (%)		Net total fuel utilisation (%) (3)
	New unit	Existing unit	
CHP CCGT	> 47	40–48	60–82
CCGT	> 47	40–48	No BAT-AEEL

(1) These BAT-AEELs do not apply in the case of units operated < 1500 h/yr.
(2) In the case of CHP units, only one of the two BAT-AEELs 'Net electrical efficiency' or 'Net total fuel utilisation' applies, depending on the CHP unit design (i.e. either more oriented towards electricity generation or towards heat generation).
(3) These BAT-AEELs do not apply to plants generating only electricity.

6. Combustion of gaseous and/or liquid fuels on offshore platforms

6.1. BAT-AELs

6.1.1. Open Cycle Gas Turbines – NOx

NOX emissions to air from the combustion of gaseous fuels in open-cycle gas turbines on offshore platforms (**Table 32**, BAT Conclusions p. 64 / Table 10.32, final LCP BREF, p. 792)

Type of combustion unit	BAT-AELs (mg/Nm3) (1)
	Average over the sampling period
New gas turbine combusting gaseous fuels (2)	15–50 (3)
Existing gas turbine combusting gaseous fuels (2)	< 50–350 (4)

(1) These BAT-AELs are based on > 70 % of baseload power available on the day.
(2) This includes single fuel and dual fuel gas turbines.
(3) The higher end of the BAT-AEL range is 250 mg/Nm3 if DLN burners are not applicable.
(4) The lower end of the BAT-AEL range can be achieved with DLN burners.

6.1.2. Open Cycle Gas Turbines – Indicative CO

As an indication, the average CO emission levels over the sampling period for new and existing gas turbines combusting gaseous fuels on offshore platforms will generally be < 75 mg/Nm3 and < 100 mg/Nm3 respectively. (BAT Conclusions p. 64 / final LCP BREF, p. 792)

7. Best Available Techniques

This Annex contains the Best Available Techniques (BATs) mentioned in the BAT Conclusions / final LCP BREF. To facilitate the reading and ease the search of information, the technique's descriptions (Section 8 in the BAT Conclusions or Section 10.8 in the final LCP BREF "Description Techniques") have been copied in each table as relevant.

7.1. Combustion of natural gas turbines

7.1.1. Addressing NOx emissions

To prevent and/or reduce NOX emissions to air from the combustion of natural gas in gas turbines, BAT is to use one or a combination (**BAT 42:** BAT Conclusions p.52, final LCP BREF p. 782-83)

Technique		Description	Applicability
a.	Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring This technique is often used in combination with other techniques or may be used alone for combustion plants operated < 500 h/yr	The applicability to old combustion plants may be constrained by the need to retrofit the combustion system and/or control command system
b.	Water/steam addition	Water or steam is used as a diluent for reducing the combustion temperature in gas turbines, engines or boilers and the thermal NOX formation. It is either premixed with the fuel prior to its combustion (fuel emulsion, humidification or saturation) or directly injected in the combustion chamber (water/steam injection)	The applicability may be limited due to water availability
d.	Low-load design concept	Adaptation of the process control and related equipment to maintain good combustion efficiency when the demand in energy varies, e.g. by improving the inlet airflow control capability or by splitting the combustion process into decoupled combustion stages	The applicability may be limited by the gas turbine design
e.	Low-NOX burners (LNB)	The technique (including ultra- or advanced low-NOX burners) is based on the principles of reducing peak flame temperatures; boiler burners are designed to delay but improve the combustion and increase the heat transfer (increased emissivity of the flame). The air/fuel mixing, reduces the availability of oxygen and reduces the peak flame temperature, thus retarding the conversion of fuel-bound nitrogen to NOX and the formation of thermal NOX, while maintaining high combustion efficiency. It may be associated with a modified design of the furnace combustion chamber. The design of ultra-low-NOX burners (ULNBs) includes combustion staging (air/fuel) and firebox gases' recirculation (internal flue-gas recirculation). The performance of the technique may be influenced by the boiler design when retrofitting old plants	Generally applicable to supplementary firing for heat recovery steam generators (HRSGs) in the case of combined-cycle gas turbine (CCGT) combustion plants
f.	Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NOX to nitrogen in a catalytic bed by reaction with ammonia (in general aqueous solution) at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several layers of catalyst. The technique design can be modular, special catalyst can be used and/or preheating can be used to cope with low loads or with a wide flue-gas temperature window. 'In-duct' or 'slip' SCR is a technique that combines SNCR with downstream SCR which reduces ammonia slip from the SNCR unit	Not applicable in the case of combustion plants operated < 500 h/yr. Not generally applicable to existing combustion plants of < 100 MWth. Retrofitting existing combustion plants may be constrained by the availability of sufficient space. There may be technical and economic restrictions for retrofitting existing combustion plants operated between 500 h/yr and 1500 h/yr

7.1.2. Addressing CO emissions

To prevent and/or reduce CO emissions to air from the combustion of natural gas, BAT is to use one or both of the techniques (**BAT 44:** BAT Conclusions p.54, final LCP BREF p. 783)

Technique		Description
a.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and/or use of an advanced control system
b.	Oxidation catalysts	The use of catalysts (that usually contain precious metals such as palladium or platinum) to oxidise carbon monoxide and unburnt hydrocarbons with oxygen to form CO2 and water vapour

7.1.3. Addressing energy efficiency

To increase the energy efficiency of natural gas combustion, BAT is to use one or an appropriate combination of the techniques in BAT 12 and below (**BAT 40:** BAT Conclusions p.51, final LCP BREF p. 780)

Technique		Description	Applicability
a.	Combined cycle	Combination of two or more thermodynamic cycles, e.g. a Brayton cycle (gas turbine/combustion engine) with a Rankine cycle (steam turbine/boiler), to convert heat loss from the flue-gas of the first cycle to useful energy by subsequent cycle(s)	Generally applicable to new gas turbines and engines except when operated < 1500 h/yr. Applicable to existing gas turbines and engines within the constraints associated with the steam cycle design and the space availability. Not applicable to existing gas turbines and engines operated < 1500 h/yr. Not applicable to mechanical drive gas turbines operated in discontinuous mode with extended load variations and frequent start-ups and shutdowns. Not applicable to boilers

BAT 12 (BAT Conclusions p.21, final LCP BREF p. 748 -49)

Technique		Description	Applicability
a.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and/or use of an advanced control system (Section 10.8.2) Optimising the combustion minimises the content of unburnt substances in the flue-gases and in solid combustion residues	Generally applicable
b.	Optimisation of the working medium conditions	Operate at the highest possible pressure and temperature of the working medium gas or steam, within the constraints associated with, for example, the control of NOX emissions or the characteristics of energy demanded	Generally applicable
d.	Minimisation of energy consumption	Minimising the internal energy consumption (e.g. greater efficiency of the feed-water pump)	Generally applicable
f.	Fuel preheating	Preheating of fuel using recovered heat	Generally applicable within the constraints associated with the boiler design and the need to control NOX emissions

g.	Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring Computerised control of the main combustion parameters enables the combustion efficiency to be improved	Generally applicable to new units. The applicability to old units may be constrained by the need to retrofit the combustion system and/or control command
l.	Heat accumulation	Heat accumulation storage in CHP mode	Only applicable to CHP plants. The applicability may be limited in the case of low heat load demand
j.	CHP readiness	The measures taken to allow the later export of a useful quantity of heat to an off-site heat load in a way that will achieve at least a 10 % reduction in primary energy usage compared to the separate generation of the heat and power produced. This includes identifying and retaining access to specific points in the steam system from which steam can be extracted, as well as making sufficient space available to allow the later fitting of items such as pipework, heat exchangers, extra water demineralisation capacity, standby boiler plant and back-pressure turbines. Balance of Plant (BoP) systems and control/ instrumentation systems are suitable for upgrade. Later connection of back-pressure turbine(s) is also possible	Only applicable to new units where there is a realistic potential for the future use of heat in the vicinity of the unit
o.	Fuel pre-drying	The reduction of fuel moisture content before combustion to improve combustion conditions	Applicable to the combustion of biomass and/or peat within the constraints associated with spontaneous combustion risks (e.g. the moisture content of peat is kept above 40 % throughout the delivery chain). The retrofit of existing plants may be restricted by the extra calorific value that can be obtained from the drying operation and by the limited retrofit possibilities offered by some boiler designs or plant configurations
q.	Advanced materials	Use of advanced materials proven to be capable of withstanding high operating temperatures and pressures and thus to achieve increased steam/combustion process efficiencies	Only applicable to new plants

7.2. Combustion of Gas oil (liquid fuels)

7.2.1. Addressing NOx emissions

To prevent and/or reduce NOX emissions to air from the combustion of gas oil in gas turbines, BAT is to use one or a combination of the techniques (**BAT 37:** BAT Conclusions p.49, final LCP BREF p. 778)

Technique		Description	Applicability
a.	Water/steam addition	Water or steam is used as a diluent for reducing the combustion temperature in gas turbines, engines or boilers and the thermal NOX formation. It is either premixed with the fuel prior to its combustion (fuel emulsion, humidification or saturation) or directly injected in the combustion chamber (water/steam injection)	The applicability may be limited due to water availability
c.	Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NOX to nitrogen in a catalytic bed by reaction with ammonia (in general aqueous solution) at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several layers of catalyst. The technique design can be modular, special catalyst can be used and/or preheating can be used to	Not applicable to combustion plants operated < 500 h/yr. There may be technical and economic restrictions for retrofitting existing combustion plants operated between 500 h/yr and 1500 h/yr. Retrofitting existing combustion plants may be constrained by the availability of sufficient space

		cope with low loads or with a wide flue-gas temperature window. 'In-duct' or 'slip' SCR is a technique that combines SNCR with downstream SCR which reduces ammonia slip from the SNCR unit	

7.2.2. Addressing CO emissions

To prevent and/or reduce CO emissions to air from the combustion of gas oil in gas turbines, BAT is to use one or a combination of the techniques (**BAT 38:** BAT Conclusions p.50, final LCP BREF p. 778)

Technique		Description	Applicability
a.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and/or use of an advanced control system	Generally applicable
b.	Oxidation catalysts	The use of catalysts (that usually contain precious metals such as palladium or platinum) to oxidise carbon monoxide and unburnt hydrocarbons with oxygen to form CO2 and water vapour	Not applicable to combustion plants operated < 500 h/yr. Retrofitting existing combustion plants may be constrained by the availability of sufficient space

7.2.3. Addressing SOx and dust emissions

To prevent and/or reduce SOX and dust emissions to air from the combustion of gas oil in gas turbines, BAT is to use the technique (**BAT 39:** BAT Conclusions p.50, final LCP BREF p. 779)

Technique		Description	Applicability
a.	Fuel choice	The use of fuel with a low content of potential pollution-generating compounds (e.g. low sulphur, ash, nitrogen, mercury, fluorine or chlorine content)	Applicable within the constraints associated with the availability of different types of fuel, which may be impacted by the energy policy of the Member State

7.3. Combustion of iron and steel process gases

7.3.1. Addressing NOx emissions

To prevent and/or reduce NO_x emissions to air from the combustion of iron and steel process gases in CCGTs, BAT is to use one or a combination of the techniques given below (**BAT 48:** BAT Conclusions p. 58, final LCP BREF p. 788)

Technique		Description	Applicability
a.	Process gas management system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring	Generally applicable within the constraints associated with the availability of different types of fuel
b.	Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring This technique is used in combination with other techniques	The applicability to old combustion plants may be constrained by the need to retrofit the combustion system and/or control command system

c.	Water/steam addition	Water or steam is used as a diluent for reducing the combustion temperature in gas turbines, engines or boilers and the thermal NOX formation. It is either premixed with the fuel prior to its combustion (fuel emulsion, humidification or saturation) or directly injected in the combustion chamber (water/steam injection) In dual fuel gas turbines using DLN for the combustion of iron and steel process gases, water/steam addition is generally used when combusting natural gas	The applicability may be limited due to water availability
d.	Dry low-NOX burners (DLN)	Gas turbine burners that include the premixing of the air and fuel before entering the combustion zone. By mixing air and fuel before combustion, a homogeneous temperature distribution and a lower flame temperature are achieved, resulting in lower NOX emissions DLN that combust iron and steel process gases differ from those that combust natural gas only	Applicable within the constraints associated with the reactiveness of iron and steel process gases such as coke oven gas. The applicability may be limited in the case of turbines where a retrofit package is not available or when steam/water addition systems are installed
f.	Selective catalytic reduction (SCR)	Selective reduction of nitrogen oxides with ammonia or urea in the presence of a catalyst. The technique is based on the reduction of NOX to nitrogen in a catalytic bed by reaction with ammonia (in general aqueous solution) at an optimum operating temperature of around 300–450 °C. Several layers of catalyst may be applied. A higher NOX reduction is achieved with the use of several layers of catalyst. The technique design can be modular, special catalyst can be used and/or preheating can be used to cope with low loads or with a wide flue-gas temperature window. 'In-duct' or 'slip' SCR is a technique that combines SNCR with downstream SCR which reduces ammonia slip from the SNCR unit	Retrofitting existing combustion plants may be constrained by the availability of sufficient space

7.3.2. Addressing CO emissions

To prevent and/or reduce CO emissions to air from the combustion of iron and steel process gases, BAT is to use one or a combination of the techniques (**BAT 49:** BAT Conclusions p. 59, final LCP BREF p. 788)

Technique		Description	Applicability
a.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and/or use of an advanced control system	Generally applicable
b.	Oxidation catalysts	The use of catalysts (that usually contain precious metals such as palladium or platinum) to oxidise carbon monoxide and unburnt hydrocarbons with oxygen to form CO2 and water vapour	Only applicable to CCGTs. The applicability may be limited by lack of space, the load requirements and the sulphur content of the fuel

7.3.3. Addressing dust emissions

To prevent and/or reduce SO_X and dust emissions to air from the combustion of gas oil, BAT is to use the technique given below. (**BAT 51:** BAT Conclusions p. 61, final LCP BREF p. 790)

Technique		Description	Applicability
a.	Fuel choice/management	Use of a combination of process gases and auxiliary fuels with a low averaged dust or ash content	Generally applicable within the constraints associated with the

			availability of different types of fuel
b.	Blast furnace gas pretreatment at the iron- and steel-works	Use of one or a combination of dry dedusting devices (e.g. deflectors, dust catchers, cyclones, electrostatic precipitators) and/or subsequent dust abatement (venturi scrubbers, hurdle-type scrubbers, annular gap scrubbers, wet electrostatic precipitators, disintegrators)	Only applicable if blast furnace gas is combusted
c.	Basic oxygen furnace gas pretreatment at the iron- and steel-works	Use of dry (e.g. ESP or bag filter) or wet (e.g. wet ESP or scrubber) dedusting. Further descriptions are given in the Iron and Steel BREF	Only applicable if basic oxygen furnace gas is combusted
d.	Electrostatic precipitator (ESP)	Electrostatic precipitators operate such that particles are charged and separated under the influence of an electrical field. Electrostatic precipitators are capable of operating under a wide range of conditions. Abatement efficiency may depend on the number of fields, residence time (size), catalyst properties, and upstream particle removal devices. They generally include between two and five fields. The most modern (high-performance) ESPs have up to seven fields	Only applicable to combustion plants combusting a significant proportion of auxiliary fuels with a high ash content
e.	Bag filters	Bag or fabric filters are constructed from porous woven or felted fabric through which gases are passed to remove particles. The use of a bag filter requires the selection of a fabric suitable for the characteristics of the flue-gas and the maximum operating temperature	Only applicable to combustion plants combusting a significant proportion of auxiliary fuels with a high ash content

7.3.4. Addressing energy efficiency

To increase the energy efficiency of the combustion of iron and steel process gases, BAT is to use an appropriate combination of the techniques in BAT 12 and below (**BAT 46:** BAT Conclusions p.57, final LCP BREF p. 786)

Technique		Description	Applicability
a.	Process gases management system	A system that enables the iron and steel process gases that can be used as fuels (e.g. blast furnace, coke oven, basic oxygen furnace gases) to be directed to the combustion plants, depending on the availability of these fuels and on the type of combustion plants in an integrated steelworks	Only applicable to integrated steelworks

BAT 12 (BAT Conclusions p.21, final LCP BREF p. 748 -49)

Technique		Description	Applicability
b.	Optimisation of the working medium conditions	Operate at the highest possible pressure and temperature of the working medium gas or steam, within the constraints associated with, for example, the control of NOX emissions or the characteristics of energy demanded	Generally applicable
g.	Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring Computerised control of the main combustion parameters enables the combustion efficiency to be improved	Generally applicable to new units. The applicability to old units may be constrained by the need to retrofit the combustion system and/or control command
o.	Fuel pre-drying	The reduction of fuel moisture content before combustion to improve combustion conditions	Applicable to the combustion of biomass and/or peat within the constraints associated with spontaneous combustion risks (e.g. the moisture content of peat is kept above 40 % throughout the delivery chain).

			The retrofit of existing plants may be restricted by the extra calorific value that can be obtained from the drying operation and by the limited retrofit possibilities offered by some boiler designs or plant configurations
f.	Fuel preheating	Preheating of fuel using recovered heat	Generally applicable within the constraints associated with the boiler design and the need to control NOX emissions
m.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and residence time in the combustion zone, and/or use of an advanced control system (Section 10.8) Optimising the combustion minimises the content of unburnt substances in the flue-gases and in solid combustion residues	Generally applicable
l.	Heat accumulation	Heat accumulation storage in CHP mode	Only applicable to CHP plants. The applicability may be limited in the case of low heat load demand
q.	Advanced materials	Use of advanced materials proven to be capable of withstanding high operating temperatures and pressures and thus to achieve increased steam/combustion process efficiencies	Only applicable to new plants
p.	Minimisation of energy consumption	Minimising the internal energy consumption (e.g. greater efficiency of the feed-water pump)	Generally applicable
j.	CHP readiness	The measures taken to allow the later export of a useful quantity of heat to an off-site heat load in a way that will achieve at least a 10 % reduction in primary energy usage compared to the separate generation of the heat and power produced. This includes identifying and retaining access to specific points in the steam system from which steam can be extracted, as well as making sufficient space available to allow the later fitting of items such as pipework, heat exchangers, extra water demineralisation capacity, standby boiler plant and back-pressure turbines. Balance of Plant (BoP) systems and control/ instrumentation systems are suitable for upgrade. Later connection of back-pressure turbine(s) is also possible	Only applicable to new units where there is a realistic potential for the future use of heat in the vicinity of the unit

7.4. Combustion of gaseous and/or liquid fuels on offshore platforms

To improve the general environmental performance in offshore platforms (**BAT 52:** BAT Conclusions p. 62, final LCP BREF p. 791)

Techniques		Description	Applicability
a.	Process optimisation	Optimise the process in order to minimise the mechanical power requirements	Generally applicable
b.	Control pressure losses	Optimise and maintain inlet and exhaust systems in a way that keeps the pressure losses as low as possible	Generally applicable
c.	Load control	Operate multiple generator or compressor sets at load points which minimise pollution	Generally applicable
d.	Minimise the 'spinning reserve'	When running with spinning reserve for operational reliability reasons, the number of additional turbines is minimised, except in exceptional circumstances	Generally applicable

e.	Fuel choice	Provide a fuel gas supply from a point in the topside oil and gas process which offers a minimum range of fuel gas combustion parameters, e.g. calorific value, and minimum concentrations of sulphurous compounds to minimise SO2 formation. For liquid distillate fuels, preference is given to low-sulphur fuels	Generally applicable
g.	Heat recovery	Utilisation of gas turbine/engine exhaust heat for platform heating purposes	Generally applicable to new combustion plants. In existing combustion plants, the applicability may be restricted by the level of heat demand and the combustion plant layout (space)
h.	Power integration of multiple gas fields / oilfields	Use of a central power source to supply a number of participating platforms located at different gas fields / oilfields	The applicability may be limited depending on the location of the different gas fields / oilfields and on the organisation of the different participating platforms, including alignment of time schedules regarding planning, start-up and cessation of production

7.4.1. Addressing NOx emissions

To prevent and/or reduce NO_X emissions to air from the combustion of gaseous and/or liquid fuels on offshore platforms (**BAT 53:** BAT Conclusions p. 63, final LCP BREF p. 792)

Techniques		Description	Applicability
a.	Advanced control system	The use of a computer-based automatic system to control the combustion efficiency and support the prevention and/or reduction of emissions. This also includes the use of high-performance monitoring	The applicability to old combustion plants may be constrained by the need to retrofit the combustion system and/or control command system
b.	Dry low-NOX burners (DLN)	Gas turbine burners that include the premixing of the air and fuel before entering the combustion zone. By mixing air and fuel before combustion, a homogeneous temperature distribution and a lower flame temperature are achieved, resulting in lower NOX emissions	Applicable to new gas turbines (standard equipment) within the constraints associated with fuel quality variations. The applicability may be limited for existing gas turbines by: availability of a retrofit package (for low-load operation), complexity of the platform organisation and space availability

7.4.2. Addressing CO emissions

To prevent and/or reduce CO emissions to air from the combustion of gaseous and/or liquid fuels in gas turbines on offshore platforms (**BAT 54:** BAT Conclusions p. 62, final LCP BREF p. 792)

Techniques		Description	Applicability
a.	Combustion optimisation	Measures taken to maximise the efficiency of energy conversion, e.g. in the furnace/boiler, while minimising emissions (in particular of CO). This is achieved by a combination of techniques including good design of the combustion equipment, optimisation of the temperature (e.g. efficient mixing of the fuel and combustion air) and	Generally applicable

		residence time in the combustion zone, and/or use of an advanced control system	
b.	Oxidation catalysts	The use of catalysts (that usually contain precious metals such as palladium or platinum) to oxidise carbon monoxide and unburnt hydrocarbons with oxygen to form CO2 and water vapour	Not applicable to combustion plants operated < 500 h/yr. Retrofitting existing combustion plants may be constrained by the availability of sufficient space and by weight restrictions

8. Industrial Emissions Directive

8.1. General

Chapter III (with Annex V) of the IED sets out special provisions for certain pollutant emissions from combustion plants with a total rated thermal input equal to or greater than 50 MW.
They represent the EU-wide "minimum requirements" for large combustion plants, which have replaced the LCP Directive (2001/80/EC) since 1 January 2016. These limits will only apply when there are no replacement figures within the LCP BREF BAT conclusions. (such as for liquid fuel emissions)

IED Art. 73
Chapter III and Annex V of this Directive shall be considered to represent the Union-wide minimum requirements in the case of large combustion plants.

Art. 13(2) provides guidance on the areas that need to be addressed with the so-called exchange of information and the preparation of BAT reference documents (through the Sevilla process and finalised with the Art.13 Forum):

IED Art. 13(2)
2. The exchange of information shall, in particular, address the following:
(a) the performance of installations and techniques in terms of emissions, expressed as short- and long-term averages, where appropriate, and the associated reference conditions, consumption and nature of raw materials, water consumption, use of energy and generation of waste;
(b) the techniques used, associated monitoring, cross-media effects, economic and technical viability and developments therein;
(c) best available techniques and emerging techniques identified after considering the issues mentioned in points (a) and (b).

Part 3 (Emission monitoring) and 4 (Assessment of compliance with emission limit values) of Annex V may be amended by the Commission, as needed, based on scientific and technical progress. This would be done in form of delegated acts.
IED Art. 74 - Amendments of Annexes
In order to allow the provisions of this Directive to be adapted to scientific and technical progress on the basis of best available techniques, the Commission shall adopt delegated acts in accordance with Article 76 and subject to the conditions laid down in Articles 77 and 78 as regards the adaptation of Parts 3 and 4 of Annex V, Parts 2, 6, 7 and 8 of Annex VI and Parts 5, 6, 7 and 8 of Annex VII to such scientific and technical progress.

The European Commission has a Q&A section for questions related to the implementation of the IED:
http://ec.europa.eu/environment/industry/stationary/ied/faq.htm#ch3_3

8.2. Annex V – Part 1

Emission limit values for combustion plants referred to in Article 30(2)
Article 30(2), first paragraph
2. All permits for installations containing combustion plants, which have been granted a permit before 7 January 2013, or the operators of which have submitted a complete application for a permit before that date, provided that such plants are put into operation no later than 7 January 2014, shall include conditions ensuring that emissions into air from these plants do not exceed the emission limit values set out in Part 1 of Annex V.

The values refer to existing plants, which were in operation by 7 January 2014. Most of the values outlined in Annex V part 1 are now to be replaced by the values outlined in the 2017 BAT Conclusions / LCP BREF. In this sense, usually, reference to this type of installations is made in footnotes, where the higher end of the BAT-AEL range is modified (being higher).

8.2.1. Emission limit values

The applicable values have been extracted from the IED Annex V part 1 – see IED text copied below:

***IED Annex V, Part 1 (5 & 6)**– p. 44-45*
5. Gas turbines (including combined cycle gas turbines (CCGT)) using light and middle distillates as liquid fuels shall be subject to an emission limit value for NOx of 90 mg/Nm3 and for CO of 100 mg/Nm3.

Gas turbines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

6. Emission limit values (mg/Nm3) for NOx and CO for gas fired combustion plants

	NOx	**CO**
Gas turbines (including CCGT), using other gases as fuel	120	—

For gas turbines (including CCGT), the NOx and CO emission limit values set out in the table contained in this point apply only above 70 % load.

For gas turbines (including CCGT) which were granted a permit before 27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003, and which do not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, the emission limit value for NOx is 150 mg/Nm3 when firing natural gas and 200 mg/Nm3 when firing other gases or liquid fuels.

A part of a combustion plant discharging its waste gases through one or more separate flues within a common stack, and which does not operate more than 1 500 operating hours per year as a rolling average over a period of 5 years, may be subject to the emission limit values set out in the preceding paragraph in relation to the total rated thermal input of the entire combustion plant. In such cases the emissions through each of those flues shall be monitored separately.

Gas turbines and gas engines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.

8.3. Annex V – Part 2

Emission limit values for combustion plants referred to in Article 30(3)

Article 30(3)
3. All permits for installations containing combustion plants not covered by paragraph 2 shall include conditions ensuring that emissions into the air from these plants do not exceed the emission limit values set out in Part 2 of Annex V.

Article 30(2), second paragraph
All permits for installations containing combustion plants which had been granted an exemption as referred to in Article 4(4) of Directive 2001/80/EC and which are in operation after 1 January2016, shall include conditions ensuring that emissions into the air from these plants do not exceed the emission limit values set out in Part 2 of Annex V.

The values are applicable to plants in operation after 1 January 2016. Most of the values outlined in Annex V part 2 are now to be replaced by the values outlined in the 2017 BAT Conclusions / LCP BREF as relevant.

8.3.1. Emission limit values

The applicable values have been extracted from the IED Annex V part 2 – see IED text copied below:

IED Annex V, Part 2 (5), p. 47
5. Gas turbines (including CCGT) using light and middle distillates as liquid fuels shall be subject to an emission limit value for NOx of 50 mg/Nm3 and for CO of 100 mg/Nm3

Gas turbines for emergency use that operate less than 500 operating hours per year are not covered by the emission limit values set out in this point. The operator of such plants shall record the used operating hours.