Final Meeting of the Technical Working Group (TWG) for the review of the BAT reference document for Large Combustion Plants (LCP BREF)

Preliminary draft conclusions – Day 2

Natural gas in boilers

BAT 46 in Revised Draft 1

Techniques to reduce NO_x emissions (1/5) – BP 1.6.2

- Specify in the BREF chapter on 'Concluding remarks and recommendations for future work' that more information on the use of SCR when combusting natural gas in boilers should be collected during the next BREF review in order to review the applicability.

Natural gas in boilers

BAT 46 in Revised Draft 1

Techniques to reduce NO_X emissions (2/5) – BP 1.6.2

BAT 46 In order to prevent and/or reduce NO_X emissions to air from the combustion of natural gas in boilers, BAT is to use one or a combination of the techniques given below.

	Technique	Description	Applicability
a	Air and/or fuel staging	See descriptions in Section 10.8. Air staging is often associated with low-NO_X burners	Generally applicable
b	Flue-gas recirculation	See description in Section 10.8	Generally applicable

Natural gas in boilers

BAT 46 in Revised Draft 1

Techniques to reduce NO_X emissions (3/5) – BP 1.6.2

	Technique	Description	Applicability
c	Low-NO_X burners (LNB)	See description in Section 10.8	Generally applicable
d	Selective catalytic reduction (SCR)	See description in Section 10.8	Not applicable in the case of combustion plants operated in emergency-load mode. Not generally applicable to combustion plants of < 100 MW_{th}. There may be technical and economic restrictions for retrofitting existing plants operated in peak-load mode

Natural gas in boilers

BAT 46 in Revised Draft 1

Techniques to reduce NO_X emissions (4/5) – BP 1.6.2

	Technique	Description	Applicability
e	Selective non-catalytic reduction (SNCR)	See description in Section 10.8	Not applicable to combustion plants operated in emergency-load mode with highly variable loads. The applicability may be limited in the case of combustion plants operated in peak-load mode with highly variable boiler loads

Natural gas in boilers

BAT 46 in Revised Draft 1

Techniques to reduce NO_x emissions (5/5) – BP 1.6.2

	Technique	Description	Applicability
f	Advanced control system	See description in Section 10.8. This technique is often used in combination with other techniques or may be used alone for plants operated in emergency-load mode	~~Generally applicable to new plants.~~ The applicability to old combustion plants may be constrained by the need to retrofit the combustion and/or control command system(s)
g	Reduction of the combustion air temperature	See description in Section 10.8	Generally applicable within the constraints associated with the process needs

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_X emissions (1/6) – BP 1.6.3

- Specify in the BREF chapter on 'Concluding remarks and recommendations for future work' that more information on the use of SCR when combusting natural gas in turbines should be collected during the next BREF review in order to review the applicability.

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_X emissions (2/6) – BP 1.6.3

BAT 47 In order to prevent and/or reduce NO_X emissions to air from the combustion of natural gas in gas turbines, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a	Dry low-NO_X burners (DLN)	See description in Section 10.8	The applicability may be limited in the case of ~~very old~~ turbines where a retrofitting package is not available or when steam/water addition ~~injection~~ systems are installed

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_x emissions (3/6) – BP 1.6.3

Technique		Description	Applicability
b	Selective catalytic reduction (SCR)	See description in Section 10.8	Not applicable in the case of combustion plants operated in emergency-load mode. Not generally applicable to existing combustion plants of < 100 MW_{th}. Retrofitting existing plants may be constrained by the availability of sufficient space. There may be technical and economic restrictions for retrofitting existing plants operated in peak-load mode

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_x emissions (4/6) – BP 1.6.3

Technique		Description	Applicability
c	Water/steam addition	See description in Section 10.8. ~~This technique is used in existing gas turbines and when a DLN retrofit package is not available~~	The applicability may be limited due to water availability
d	Advanced control system	See description in Section 10.8. This technique is often used in combination with other techniques or may be used alone for plants operated in emergency-load mode	~~Generally applicable to new plants.~~ The applicability to old combustion plants may be constrained by the need to retrofit the combustion and/or control command system(s)

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_x emissions (5/6) – BP 1.6.3

Technique		Description	Applicability
e	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 in decoupled combustion stages	Applicable depending on the gas turbine design

Natural gas in gas turbines

BAT 47 in Revised Draft 1

Techniques to reduce NO_X emissions (6/6) – BP 1.6.3

Technique		Description	Applicability
f	Low-NO_X burners (LNB)	See description in Section 10.8	Generally applicable to supplementary firing for heat recovery steam generators (HRSG) in the case of combined cycle gas turbine (CCGT) combustion plants

Natural gas in engines

BAT 48 in Revised Draft 1

Techniques to reduce NO_X emissions (1/3) – BP 1.6.4

BAT 48 In order to prevent and/or reduce NO_X emissions to air from the combustion of natural gas in engines, BAT is to use one or a combination of the techniques given below.

Technique		Description	Applicability
a	Lean-burn concept	See description in Section 10.8. Generally used in combination with SCR	Only applicable to new gas-fired engines
b	Advanced lean-burn concept	See description in Section 10.8	Only applicable to new spark plug or other ignited (SG)-type engines

Natural gas in engines

BAT 48 in Revised Draft 1

Techniques to reduce NO_X emissions (2/3) – BP 1.6.4

	Technique	Description	Applicability
c	Selective catalytic reduction (SCR)	See description in Section 10.8	Retrofitting existing plants may be constrained by the availability of sufficient space. Not applicable in the case of combustion plants operated in emergency-load mode. There may be technical and economic restrictions for retrofitting existing plants operated in peak-load mode

Natural gas in engines

BAT 48 in Revised Draft 1

Techniques to reduce NO_x emissions (3/3) – BP 1.6.4

Technique		Description	Applicability
d	Advanced control system	See description in Section 10.8. This technique is often used in combination with other techniques or may be used alone for combustion plants operated in emergency-load mode	~~Generally applicable to new plants.~~ The applicability to old combustion plants may be constrained by the need to retrofit the combustion and/or control command system(s)

Natural gas

BAT 49 in Revised Draft 1

Techniques to reduce CO emissions (1/2) – BP 1.6.5

- Specify in the BREF chapter on 'Concluding remarks and recommendations for future work' that more information on the applicability of oxidation catalysts when combusting natural gas should be collected during the next BREF review.

Natural gas

BAT 49 in Revised Draft 1

Techniques to reduce CO emissions (2/2) – BP 1.6.5

BAT 49 In order 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 given below.

Technique		Description
a	Combustion optimisation	See description in Section 10.8
d	Oxidation catalysts	See description in Section 10.8

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (1/15) – BP 1.6.6.1.1 and 1.6.6.1.2

- Specify the emission levels that are expected for CO and change the following tables accordingly.
- The decision of not setting BAT-AELs for CO is not supported by AT, BE, DE, EEB, CAN Europe.
- The decision on the BAT-AEL for NO_X for new OCGTs is not supported by EU turbines, CAN Europe, EEB.
- The decision on the BAT-AEL for NO_X for existing CCGTs with a size of ≥ 600 MW_{th} is not supported by AT, BE, CAN Europe, EEB, EU turbines.
- The decision on the BAT-AEL for NO_X for existing CCGTs with a size of 50–600 MW_{th} is not supported by CEFIC, BE, CAN Europe, EEB, EU turbines, Eurelectric.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (2/15) – BP 1.6.6.1.1 and 1.6.6.1.2

- The decision on the BAT-AEL for NO_X for existing gas turbines for mechanical drive applications (all but emergency load mode) is not supported by BE, DE, Business Europe.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (3/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Table 10.27: BAT-associated emission levels (BAT-AELs) for NO_X and CO emissions to air from the combustion of natural gas in gas turbines

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3) (16)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)

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

(16) Footnote on load? (to be revisited)

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (4/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)

(7) These BAT-AELs do not apply in the case of existing plants operated in peak- or emergency-load mode.

(14) Optimising the functioning of an existing technique to reduce further NO_X emissions may lead to levels of CO emissions at the higher end of the indicative ~~BAT-AEL~~ range for CO.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (5/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
Open-cycle gas turbines (OCGTs)				
New OCGT	≥ 50	25–50 (13)	15–35 (13)	< 5–40 (13)

(13) 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.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (6/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	… input (MW_{th})	BAT-AELs (mg/Nm^3) ([3])		
		NO_X		CO
		Daily average …	Yearly average …	Yearly average …
Existing OCGT (excluding turbines for mechanical drive applications) – All but emergency-load mode	≥ 50	25–55 ([5])	15–50	< 5–40 ([6]) ([9])

([5]) The higher end of the range is 80 mg/Nm^3 in the case of plants which were put into operation no later than 27 November 2003 and operated in peak-load mode.

([6]) The higher end of the range is 80 mg/Nm^3 in the case of existing plants that cannot be fitted with dry techniques for NO_X reduction.

([9]) The higher end of the range is 50 mg/Nm^3 when plants operate at low load ~~(e.g. with an equivalent full load factor below 60 %)~~.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (7/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
Combined cycle gas turbines (CCGTs) (11) (15)				
(11) These BAT-AELs do not apply to turbines for mechanical drive applications or to plants operated in emergency-load mode.				
~~(15) When the boiler of a CCGT operates alone (i.e. the gas turbine does not operate), the BAT-AELs that apply are those related to boilers (see Table 10.28).~~				

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (8/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
New CCGT	≥ 50	15–40 (12)	10–30 (12)	< 5–30 (12)

(12) A correction factor may be applied to the higher end of the BAT-AEL range, corresponding to [higher end] x EE / 55 where EE is the net electrical energy efficiency of the plant determined at ISO baseload conditions.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (9/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	… input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average …	Yearly average …	Yearly average …
Existing CCGT with a net total fuel utilisation < 75 %	≥ 600	18–50	10–40	< 5–30 (9)
Existing CCGT with a net total fuel utilisation ≥ 75 %	≥ 600	18–55 (16)	10–50	< 5–30 (9)

(9) The higher end of the range is 50 mg/Nm^3 when plants operate at low load (e.g. with an equivalent full load factor below 60 %).

(16) For existing plants put into operation no later than 7 January 2014, the upper end of the BAT-AEL range is 65 mg/Nm^3.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (10/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	… input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average …	Yearly average …	Yearly average …
Existing CCGT with a net total fuel utilisation of < 75 %	50–600	35–55	10–45	< 5–30 (9)
Existing CCGT with a net total fuel utilisation of ≥ 75 %	50–600	35–55 (17)	25–50 ~~(10)~~(18)	< 5–30 (9)

(9) The higher end of the range is 50 mg/Nm^3 when plants operate at low load ~~(e.g. with an equivalent full load factor below 60 %)~~.

~~(10) Where it can be demonstrated that it is not possible to further retrofit a plant operated in peak-load mode due to techno-economic reasons, the higher end of the range is 75 mg/Nm^3.~~ (to be revisited)

(17) For existing plants put into operation no later than 7 January 2014, the upper end of the BAT-AEL range is 80 mg/Nm^3.

(18) For existing plants put into operation no later than 7 January 2014, the upper end of the BAT-AEL range is 55 mg/Nm^3.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (11/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
Open- and combined cycle gas turbines				
Existing gas turbine – Emergency-load mode ~~(2)~~	≥ 50	60–140 (2) (to be revisited)	NA	NA

(2) The lower end of the BAT-AEL range for NO_X can be achieved with dry low-NO_X burners.

NB: NA = No BAT-AEL.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (12/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
Open- and combined cycle gas turbines				
Existing gas turbine for mechanical drive applications – All but emergency-load mode	≥ 50	25–55 (19)	15–50 (20)	< 5–40 (9)

(9) The higher end of the range is 50 mg/Nm^3 when plants operate at low load ~~(e.g. with an equivalent full load factor below 60 %)~~.

(19) For existing plants put into operation no later than 7 January 2014, the upper end of the BAT-AEL range is 65 mg/Nm^3.

(20) For existing plants put into operation no later than 7 January 2014, the upper end of the BAT-AEL range is 60 mg/Nm^3.

Natural gas in gas turbines

Table 10.27 in Revised Draft 1

BAT-AELs for NO_X and CO (13/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Type of gas turbine	Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3) (3)		
		NO_X		CO
		Daily average or average over the sampling period	Yearly average (7) (14)	Yearly average (7) (14)
Open- and combined cycle gas turbines				
Existing/New dual fuel gas turbine combusting liquid fuels in emergency-load mode	≥ 50	145–250 (to be revisited)	NA	NA
NB: NA = No BAT-AEL.				

Natural gas in gas turbines

BAT 3 ter in Revised Draft 1

BAT-AELs for NO_X and CO (14/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Substance/ Parameter	Fuel/ Process	Combustion plant total rated thermal input	Standard(s) (1)	Minimum monitoring frequency	Monitoring associated with
NO_X	Natural gas-fired turbines	All sizes	Generic EN standards	Continuous (2)(4)	BAT 47
CO					BAT 49

(2) In the case of plants with a rated thermal input of < 100 MW_{th} operated in emergency-load mode, the monitoring frequency may be reduced to at least once every year. In the case of plants with a rated thermal input of < 100 MW_{th} operated in peak-load mode, the monitoring frequency may be reduced to at least once every six months. Periodic monitoring is carried out with a combustion plant load of > 70 %. (to be revisited)

Natural gas in gas turbines

BAT 3 ter in Revised Draft 1

BAT-AELs for NO_X and CO (15/15) – BP 1.6.6.1.1 and 1.6.6.1.2

Substance/ Parameter	Fuel/ Process	Combustion plant total rated thermal input	Standard(s) (1)	Minimum monitoring frequency	Monitoring associated with
NO_X	Natural gas-fired turbines	All sizes	Generic EN standards	Continuous (2)(4)	BAT 47
CO					BAT 49

(4) In the case of natural gas-fired turbines with a rated thermal input of < 100 MW_{th} operated in emergency- or peak-load modes, or in the case of existing OCGTs, PEMS may be used alternatively. (to be revisited)

Natural gas in boilers and engines

Table 10.28 in Revised Draft 1

BAT-AELs for NO_X and CO (1/5) – BP 1.6.6.2.1 and 1.6.6.2.2

- Specify the emission levels that are expected for CO and change the following tables accordingly.
- The decision of not setting BAT-AELs for CO is not supported by AT, BE, DE, EEB, CAN Europe.
- The decision on the BAT-AELs for NO_X for boilers is not supported by CAN Europe.
- The decision on the BAT-AELs for NO_X for engines is not supported by EEB, CAN Europe.

Natural gas in boilers and engines

Table 10.28 in Revised Draft 1

BAT-AELs for NO_X and CO (2/5) – BP 1.6.6.2.1 and 1.6.6.2.2

Table 10.28: BAT-associated emission levels (BAT-AELs) for NO_X and CO emissions to air from the combustion of natural gas in boilers and engines

Type of combustion plant	BAT-AELs (mg/Nm^3)		
	NO_X		CO
	Daily average or average over the sampling period	Yearly average ~~([3])~~ ([4])	Yearly average ~~([3])~~ ([4])

([3]) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.

([4]) Optimising the functioning of an existing technique to reduce further NO_X emissions may lead to levels of CO emissions at the higher end of the range ~~BAT-AELs~~ for CO.

Natural gas in boilers and engines

Table 10.28 in Revised Draft 1

BAT-AELs for NO_X and CO (3/5) – BP 1.6.6.2.1 and 1.6.6.2.2

Type of combustion plant	BAT-AELs (mg/Nm^3)		
	NO_X		CO
	Daily average or average over the sampling period	Yearly average ~~(3)~~ (4)	Yearly average ~~(3)~~ (4)
Boilers			
New boiler	30-85	10–60	< 5–15
Existing boiler	85–110	50–100 (3)	< 5–40 (3)
(3) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.			

Natural gas in boilers and engines

Table 10.28 in Revised Draft 1

BAT-AELs for NO_X and CO (4/5) – BP 1.6.6.2.1 and 1.6.6.2.2

Type of combustion plant	BAT-AELs (mg/Nm³)		
	NO_X		CO
	Daily average or average over the sampling period	Yearly average ~~(3)~~ (4)	Yearly average ~~(3)~~ (4)
Engines (1)			
New engine	55–85	20–75	30–100
Existing engine	55–110 (2)	20–100 (3)	30–100 (3)

(1) These BAT-AELs only apply to SG- and DF-type engines. They do not apply to GD-type engines.

(2) In the case of engines operated in emergency-load mode that could not apply the lean-burn concept or use an SCR system for techno-economic reasons, the higher end of the range is 175 mg/Nm³.

(3) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.

Natural gas in boilers and engines

BAT 3 ter in Revised Draft 1

BAT-AELs for NO_X and CO (5/5) – BP 1.6.6.2.1 and 1.6.6.2.2

Substance/ Parameter	Fuel/ Process	Combustion plant total rated thermal input	Standard(s) (1)	Minimum monitoring frequency	Monitoring associated with
NO_X	Natural gas-fired boilers and engines	All sizes	Generic EN standards	Continuous (2)	BAT 48
CO					BAT 49

(2) In the case of plants with a rated thermal input of < 100 MW_{th} operated in emergency-load mode, the monitoring frequency may be reduced to at least once every year. In the case of plants with a rated thermal input of < 100 MW_{th} operated in peak-load mode, the monitoring frequency may be reduced to at least once every six months.

Natural gas in engines

BAT 50 in Revised Draft 1

Techniques/BAT-AELs for NMVOC and CH_4 (1/3) – BP 1.6.7

- The decision on the BAT-AELs for formaldehyde and methane is not supported by DK.

Natural gas in engines

BAT 50 in Revised Draft 1

Techniques/BAT-AELs for NMVOC and CH_4 (2/3) – BP 1.6.7

BAT 50 In order to reduce non-methane volatile organic compounds (NMVOC) and methane (CH_4) emissions to air from the combustion of natural gas in spark-ignited lean-burn gas (SG) engines, BAT is to ensure an optimised combustion and/or to apply oxidation catalysts.

Description

Oxidation catalysts do not work with hydrocarbons containing less than four carbon atoms.

Natural gas in engines

Table 10.29 in Revised Draft 1

Techniques/BAT-AELs for NMVOC and CH_4 (3/3) – BP 1.6.7

Table 10.29: BAT-associated emission levels (BAT-AELs) for formaldehyde and CH_4 emissions to air from the combustion of natural gas in a spark-ignited lean burn gas engine

Pollutant	Plants	BAT-AELs (mg/Nm^3)
		Average over the sampling period
Formaldehyde	All plants	5–15
CH_4	New plants	215–500 (1)
	Existing plants	215–560 (1)

(1) This BAT-AEL applies only to an SG-type engine and is expressed as C at maximum continuous rating (MCR)