----ENEMALTA DPS IPPC APPLICATION - FORM C----

APPENDIX B – Best-Available-Technology Conclusions

0466 – Enemalta DPS IPPC Application

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1. A horizontal approach to defining BAT for cooling systems

Aspect of BAT	BAT	Status at Installation
Introduction	Before summarising the BAT conclusions in this chapter, a short explanation is given on how the horizontal character of this BREF should be interpreted. In a horizontal approach it is assumed that the environmental aspects of the applied techniques and the associated reduction measures can be assessed and that generic BAT can be identified that are independent of the industrial processes in which techniques are applied. Industrial cooling systems are an integrated part of the industrial process to be cooled. The cooling systems within the scope of this document are used in many of the industrial sectors under the scope of IPPC. Consequently, the variety of applications, techniques and operational practices is enormous. Additionally, the thermodynamic character of the process leads to further variations in performance and consequently in the environmental effects. Due to this large variation, comparisons between techniques leading to general conclusions on BAT are difficult. The identification of a general preventive approach is considered to be possible, based on practical experience with reduction of emissions from cooling systems. In this preventive approach or, primary BAT-approach,	D2A is air cooled and does not operate a steam cycle. Cooling is provided via a forced draft heat exchanger making use of fans. The water utilised for cooling is retained within a closed freshwater system. D2B has a traditional seawater cooling system. D2B uses a constant speed seawater pump, rated at 8500m^3/hr max. 780m^3/hr is used to cool the generators and gas turbines auxiliary load through seawater/freshwater heat exchangers that cater for the cooling requirements of all the plant apart for the steam turbine condenser. The remaining 7720m^3/hr is consumed directly by the steam turbine condenser as a heat sink. It is to be noted that both D2A and D2B are standby plant.

Aspect of BAT	BAT	Status at Installation
	attention is firstly given to the process to be cooled. The design and the construction of the cooling system are an essential second step, in particular for new installations. Finally, changes of equipment and the way in which the cooling system should be operated will address new installations, but are particularly important in existing systems, where technological options are considerably limited and cost-intensive. Careful evaluations must be performed case by case.	
Integrated heat management **Industrial cooling = Heat management**	Cooling of industrial processes can be considered as heat management and is part of the total energy management within a plant. The amount and level of heat to be dissipated requires a certain level of cooling systems performance. This performance level will in turn affect the system configuration, design and operation and consequently the cooling systems' environmental performance (direct impact). Reversibly, the cooling performance will also affect the overall efficiency of the industrial process (indirect impact). Both impacts, direct and indirect, need to be balanced, taking into account all variables. Every change in the cooling system has to be considered against the consequences it may have for this balance. This concept can be used as a starting point to formulate the first principle of BAT for cooling systems. BAT for all installations is an integrated approach to reduce the environmental impact of industrial cooling systems maintaining the balance between both the direct and indirect impacts. In other words, the effect of an emission reduction	The sea water temperature rise for D2B is limited to $8^{o}C$. The seawater pumps capacity is rated to achieve this temperature rise in the worst operating conditions.

Aspect of BAT	BAT	Status at Installation
	has to be balanced against the potential change in the overall energy efficiency. There is currently no minimum ratio in terms of the environmental benefits and the possible loss in overall energy efficiency that can be used as a benchmark to arrive at techniques that can be considered BAT. Nevertheless, this concept can be used to compare alternatives (Chapter 3.2 and Annex II).	
Integrated heat management **Reduction of the level of heat discharge by optimization of internal/external heat reuse**	A preventive approach should start with the industrial process requiring heat dissipation and aim to reduce the need for heat discharge in the first place. In fact, discharge of heat is wasting energy and as such not BAT. Reuse of heat within the process should always be a first step in the evaluation of cooling needs. Process-integrated energy measures are outside the scope of this document, but reference is made to other BAT Reference Documents drafted in the framework of IPPC describing options for energy measures. In a greenfield situation, assessment of the required heat capacity can only be BAT if it is the outcome of maximum use of the internal and external available and applicable options for reuse of excess heat. In an existing installation, optimizing internal and external reuse and reducing the amount and level of heat to be discharged must also precede any change to the potential capacity of the applied cooling system. Increasing the efficiency of an existing cooling system by improving systems operation must be evaluated against an increase of efficiency by technological measures through retrofit or	D1 plant uses condensate pre heaters to increase steam cycle overall efficiency which in turn results in an overall higher thermal process efficiency. This in turn means an optimisation of the overall cooling requirement. D2A does not operate a steam cycle by design. D2B requires auxiliary steam to operate. This auxiliary steam can be extracted from the superheated pressure reduced to 18bar and 260 degrees, or extracted from the steam turbine. D2B does not have a reheat cycle by design. It has the ability to produce auxiliary steam by extracting steam from the steam turbine itself, thus avoiding having to avoid steam from the high pressure steam with would reduce steam turbine output. Since D2B makes use of fixed speed pumps the system is designed for worst case and the pumps operate to said case.

Aspect of BAT	BAT	Status at Installation
	technological change. In general and for large existing cooling systems, the improvement of the systems operation is considered to be more cost effective than the application of new or improved technology and can therefore be regarded as BAT.	
Integrated heat management **Cooling system and process requirements**	Once the level and amount of waste heat generated by the process is established and no further reduction of waste heat can be achieved, an initial selection of a cooling system can be made in the light of the process requirements discussed in Chapter 1. Every process has its unique combination of requirements, where the level of control of the process, process reliability and safety play an important role. This makes it almost impossible at this stage to make a first characterisation of BAT, but the following conclusions can be drawn with respect to a number of process characteristics. The application of the ambient temperature levels is based on the experiences in Europe in applying cooling systems under different climatic conditions. Generally, dry bulb temperatures do not justify cooling away low level waste, heat and water-cooling is preferred. But in areas with low average dry bulb temperatures dry air-cooling is applied to cool down to lower process temperatures (after options for reuse have been explored). Water-cooling, if sufficient water is available, can then dissipate the residual amount of waste heat. Hazardous process substances, which involve a high environmental risk to the aquatic environment in case of	A sea water based cooling system is the only feasible solution for both D1 and D2B. Alternative systems using evaporative process are not feasible due to high ambient humidity conditions. In these plants sea water is passed through condensers as part of the steam cycle, as well as through sea water/fresh water heat exchangers. For D2B it is limited to 8°C. The formation of scale deposits which can negatively effect heat transfer is avoided with the indicated sea water temperature rise. Sea water is treated to prevent the formation of organisms in the heat exchangers and condensers which would reduce the efficiency of heat exchange, and thus negatively effect the steam processes. Two stages of course filtration are in place upstream of the sea water pumps to avoid entrainment of aquatic organisms and infiltration of debris into the cooling systems. Additional filtration systems are installed upstream of the heat exchangers. D2B cooling systems uses indirect cooling by means of freshwater/seawater heat exchangers. The freshwater system can be contaminated by substances such as oils. It is to be noted that this is a secondary benefit and its primary selection was to reduce the effects of corrosion on the system. The pressure drop across the

Aspect of BAT	BAT	Status at Installation
	leakage, should be cooled by means of indirect cooling systems to prevent an uncontrollable situation. The selection of a cooling configuration should be based on a comparison between the different feasible alternatives within all requirements of the process. Process requirements are for example control of chemical reactions, reliability of process performance and maintenance of required safety levels. The aim is to minimise the indirect impact of the selected alternative. For each alternative the environmental performances can be best compared if expressed in direct and indirect use of energy (kWe) per unit of energy discharged (kWth). Another way to compare configurations is to express the change in direct energy use (kWe) of the cooling system and the change in production level of the process in tonnes, both per unit of energy discharged (kWth). A change in cooling technology to reduce the environmental impact can only be considered BAT if the efficiency of cooling is maintained at the same level or, even better, at an increased level. See Figure 1.	condensers is measured as a means of monitoring fouling. In this way optimum operations can be maintained. If necessary mechanical cleaning methods are applied to maintain optimum operational capability. Since D2A is composed of open cycle gas turbines with a limited amount of waste heat being produced, an air cooled system is. Since D2A does not make use of seawater cooling, contamination of seawater is impossible.
Integrated heat management **Cooling system and site requirements**	The site-imposed limits apply particularly to new installations, where a cooling system must still be selected. If the required heat discharge capacity is known it may influence the selection of an appropriate site. For temperature-sensitive processes it is BAT to select the site	This section does not apply to the installation since site selection requirements are to be considered for proposed sites. This is an existing installation.

Aspect of BAT	BAT	Status at Installation
	with the required availability of cooling water. For many reasons new installations are not always erected on a site that is preferred from a cooling technology point of view, whereas for both new and existing installations the site characteristics are clear once the site is known. The most important thermodynamic characteristic of a site is its annual climatic pattern described by the dry and wet bulb temperatures. Other characteristics identified are space, water availability to cool and to discharge and the surrounding sensitive areas (urban and industrial). With respect to groundwater, it can be BAT to apply a dry cooling system following the principle to minimise the use of groundwater, particularly in those areas where depletion of aquifers cannot be ruled out. In Figure 2, BAT examples are shown that have been identified for a few site characteristics.	
Application of BAT in industrial cooling systems	In Chapter 1 the outline of a preventive approach is presented showing how a step-by-step evaluation of all constraints can lead to what may be called “Best available cooling technique”. Within the framework of this approach, Chapter 1 and Chapter 3 and the associated Annexes discuss the factors and offer techniques involved in the identification of potential BAT for the major cooling configurations using water and/or air. The optimization of a cooling system to reduce its environmental impact is a complex exercise and not an exact mathematical	For existing wet cooling systems, the focus is largely on environmental measures to reduce water use and to emissions of chemicals to the surface water, BAT has not so much technological but rather an operational character. Monitoring, operation and maintenance are the key issues. Dosing is carried out with chlorine dioxide to limit marine growth which adversely effects heat transfer in the heat exchangers. Residual chlorine levels are monitored within the system to ensure optimum levels are maintained. D2B

Aspect of BAT	BAT	Status at Installation
	comparison. In other words, combining techniques selected from the BAT-tables does not lead to a BAT cooling system. The final BAT solution will be a site-specific solution. However, it is believed that, based on experience in industry, conclusions can be drawn on BAT, in quantified terms where possible. In Chapter 3 options for reducing emissions into the environment have been presented based on the information submitted by the TWG. For each environmental issue and for each relevant cooling configuration an attempt has been made to identify a general approach and arrive at BAT. Some techniques are described in more detail in the Annexes. Emphasis is clearly on the water-related problems with a focus on reduction of the application of biocides and blacklisted substances. The proposed techniques are applied techniques. They have proven to be effective, although quantification is difficult and they may create unrealistic expectations. It can be assumed that all measures proposed as BAT, and which are not entirely dependant on the local situation, can be considered for new systems. With respect to existing installations, care must be taken as the assessment is more difficult where options are limited and depend on a multitude of (process) factors. There do not seem to be many obstacles to implementation of operational measures in existing cooling systems, unless the technological design limits the number of options for modification.	heat exchangers were designed with strainers prior to the heat exchangers so the seawater is filtered prior to entrance into the heat exchangers. The steam turbine condenser of D2B has an inside pipe diameter is of 1inch which precludes the ingress fouling, hence doing away with the need for filtration.

Aspect of BAT	BAT	Status at Installation
	In Figure 3 to Figure 11, techniques are presented that are considered BAT, following on from the primary BAT-approach for: • increasing the overall energy efficiency, • reduction of use of water and of cooling water additives, • reduction of emissions to air and water, • reduction of noise, • reduction of entrainment of aquatic organisms and • reduction of biological risks. No clear BAT has been identified on the reduction of waste or techniques to handle waste avoiding environmental problems, such as contamination of soil and water, or air in the case of incineration. For each environmental issue the consequences for other media of the application of a reduction technique have been identified. Generally speaking every change made to a cooling system must be carefully balanced against the associated effects and in this sense the optimisation of industrial cooling is a cross-media issue. For some measures BAT-values have been identified. However, addressing the application of different cooling techniques in a multitude of varying process conditions does not allow for clear associated levels. In those cases a qualitative description is given. For new cooling installations it is BAT to start identifying	

Aspect of BAT	BAT	Status at Installation
	reduction measures in the design phase, applying equipment with low energy requiring requirement and by choosing the appropriate material for equipment in contact with the process substance and/or the cooling water. In this sense the following quotation is exemplary: “in practice… attention to design, layout and maintenance of the cooling water system has a relatively low priority compared to the environmental consequences of a poorly designed and/or operated cooling water system. Since little attention is paid to design factors, treatments often have to make up for bad design, and therefore need to be chosen in such a way that they minimize risks of fouling. Few changes of this attitude are to be expected as long as there is a low level of awareness of the long-term costs of operating and maintaining poorly designed CWS” [tm005, Van Donk and Jenner, 1996]. If dry air cooling systems are the preferred option, measures are primarily related to reduction of direct energy consumption and noise emissions and the optimization of size with respect to the required cooling surface. For existing installations, technological measures can be BAT under certain circumstances. Generally, a change in technology is cost-intensive where overall efficiency must be maintained. Cost evaluation should then compare investment costs of the change versus the change in operational costs and validate the reduction effect versus other environmental consequences. For example, it would need a comparison between the environmental effect of recirculating the cooling water - requiring the application of	

Aspect of BAT	BAT	Status at Installation
	biocidal water treatment - against a once-through system without biocides, but a large heat emission to the aquatic environment. In the case of pre-assembled off-the-peg cooling towers, a change in technology seems feasible both technically and economically. No comparable data have been submitted that can support this, but supplier experience is that it is relatively easy to change small size cooling towers, for example, from a closed recirculating wet to a closed recirculating hybrid or wet/dry configuration. This would not need major process modifications or construction work. For large custom-designed towers that are erected on-site, technological changes are not easy to make. A different technology generally means a completely new cooling tower. For existing wet cooling systems, where the focus is largely on environmental measures to reduce water use and to emissions of chemicals to the surface water, BAT has not so much technological but rather an operational character. Monitoring, operation and maintenance are the key issues here.	

Figure 1:

Table 4.1: Examples of process requirements and BAT

Process characteristics	Criteria	Primary BAT approach	Remark	Reference
Level of dissipated heat high (> 60ºC)	Reduce use of water and chemicals and improve overall energy efficiency	(Pre-) cooling with dry air	Energy efficiency and size of cooling system are limiting factors	Section 1.1/1.3
Level of dissipated heat medium (25-60ºC)	Improve overall energy efficiency	Not evident	Site-specific	Section 1.1/1.3
Level of dissipated heat low (<25ºC)	Improve overall energy efficiency	Water cooling	Site selection	Section 1.1/1.3
Low and medium heat level and capacity	Optimum overall energy efficiency with water saving and visible plume reduction	Wet and hybrid cooling system	Dry cooling less suitable due to required space and loss of overall energy efficiency	Section 1.4
Hazardous substances to be cooled involving high environmental risk	Reduction of risk of leakage	Indirect cooling system	Accept an increase in approach	Section 1.4 and Annex VI

Figure 2:

Table 4.2: Examples of site characteristics and BAT

Characteristics of site	Criteria	Primary BAT approach	Remarks	Reference
Climate	Required design temperature	Assess variation in wet and dry bulb T	With high dry bulb T dry air cooling generally has lower Energy efficiency	Section 1.4.3
Space	Restricted surface on-site	(Pre-assembled) Roof type constructions	Limits to size and weight of the cooling system	Section 1.4.2
Surface water availability	Restricted availability	Recirculating systems	Wet, dry or hybrid feasible	Section 2.3 and 3.3
Sensitivity of receiving water body for thermal loads	Meet capacity to accommodate thermal load	- Optimise level of heat reuse - Use recirculating systems - Site selection (new cooling system)		Section 1.1
Restricted availability of groundwater	Minimisation of groundwater use	Air cooling if no adequate alternative water source is available	Accept energy penalty	Section 3.3
Coastal area	Large capacity > 10 MW_{th}	Once-through systems	Avoid mixing of local thermal plume near intake point, e.g. by deep water extraction below mixing zone using temperature stratification	Section 1.2.1 / Section 3.2 /Annex XI.3
Specific site requirements	In case of obligation forplume reduction and reduced tower height	Apply hybrid cooling system	Accept energy penalty	Ch.2

2. Reduction of energy consumption

Aspect of BAT	BAT	Status at Installation
General	It is BAT in the design phase of a cooling system: • To reduce resistance to water and airflow • To apply high efficiency/low energy equipment • To reduce the amount of energy demanding equipment (Annex XI.8.1) • To apply optimised cooling water treatment in once-through systems and wet cooling towers to keep surfaces clean and avoid scaling, fouling and corrosion. For each individual case a combination of the above-mentioned factors should lead to the lowest attainable energy consumption to operate a cooling system. Concerning BAT a number of techniques/approaches have been identified.	Sea water pipe systems are designed so as to reduce pumping losses, thus minimising the overall pumping power required whilst maintaining plant efficiency. The seawater velocity within the pipes is limited to less than 3m/s to avoid head-loss.
Identified reduction techniques within the BAT-approach	In an integrated approach to cooling an industrial process, both the direct and indirect use of energy are taken into account. In terms of the overall energy efficiency of an installation, the use of once-through systems is BAT, in particular for processes requiring large cooling capacities (e.g. > 10 MWth). In the case of rivers and/or estuaries once-through can be acceptable if also: ▪ extension of heat plume in the surface water leaves passage for fish migration; ▪ cooling water intake is designed aiming at reduced fish entrainment;	D2B makes use of once through cooling. As discussed earlier D2A is air-cooled.

Aspect of BAT	BAT	Status at Installation
	▪ heat load does not interfere with other users of receiving surface water. For power stations, if once-through is not possible, natural draught wet cooling towers are most energy-efficient than other cooling configurations, but application can be restricted because of the visual impact of their overall height. See Figure 3.	

Figure 3:

Table 4.3: BAT for increasing overall energy efficiency

Relevance	Criterion	Primary BAT approach	Remarks	Reference
Large cooling capacity	Overall energy efficiency	Select site for once-through option	See text above table	Section 3.2
All systems	Overall energy efficiency	Apply option for variable operation	Identify required cooling range	Section 1.4
All systems	Variable operation	Modulation of air/ water flow	Avoid instability cavitation in system (corrosion and erosion)	
All wet systems	Clean circuit/ exchanger surfaces	Optimised water treatment and pipe surface treatment	Requires adequate monitoring	Section 3.4
Once-through systems	Maintain cooling efficiency	Avoid recirculation of warm water plume in rivers and minimise it in estuaries and on marine sites		Annex XII
All cooling towers	Reduce specific energy consumption	Apply pumping heads and fans with reduced energy consumption		

3. Reduction of water requirements

Aspect of BAT	BAT	Status at Installation
General	For new systems the following statements can be made: • In the light of the overall energy balance, cooling with water is most efficient; • For new installations a site should be selected for the availability of sufficient quantities of (surface) water in the case of large cooling water demand; • The cooling demand should be reduced by optimising heat reuse; • For new installations a site should be selected for the availability of an adequate receiving water, particularly in case of large cooling water discharges; • Where water availability is limited, a technology should be chosen that enables different modes of operation requiring less water for achieving the required cooling capacity at all times; • In all cases recirculating cooling is an option, but this needs careful balancing with other factors, such as the required water conditioning and a lower overall Energy efficiency.	This section does not apply as ENE plant is an existing installation.
	For existing water cooling systems, increasing heat reuse and improving operation of the system can reduce the required amount of cooling water. In the case of rivers with limited availability of surface water, a change from a once-through system to recirculating cooling systems is a technological option and may be considered BAT.	As previously stated D2A is air-cooled. D2B is a standby plant and as such cannot be relied upon for auxiliary systems such as the production of water. In view of the fact that ENE plant is standby plant and space on site is limited it is not prudent to dedicate additional space for new D2A/D2B systems.

Aspect of BAT	BAT	Status at Installation
	For power stations with large cooling capacities, this is generally considered as a cost-intensive exercise requiring a new construction. Space requirements must be taken into account.	
Identified reduction techniques within the BAT-approach	See Figure 4. Application of dry air-cooling has been suggested on a number of occasions. If the overall Energy efficiency is taken into account, dry air-cooling is less attractive than wet cooling. With this the dry technology is not disqualified. For shorter lifetime periods it was calculated that the differences in costs between dry and wet become less than for longer lifetime periods. When costs for water and water treatment are taken into account, differences also become smaller. Dry cooling can be recommended in certain circumstances and for precooling at higher temperature levels, where excessive water would be needed.	D2A being a simple-cycle unit, has a relatively low cooling load requirement making dry air cooling feasible. D2B being a combined cycle plant has a much higher cooling load requirement, therefore rendering dry air cooling systems impractical. The cooling load of D2B is approximately 10 times that of D2A due to the steam cycle process.

Figure 4:

Table 4.4: BAT for reduction of water requirements

Relevance	Criterion	Primary BAT approach	Remarks	Ref.
All wet cooling systems	Reduction of need for cooling	Optimisation of heat reuse		Ch.1
	Reduction of use of limited sources	Use of groundwater is not BAT	Site-specific in particular for existing systems	Ch.2
	Reduction of water use	Apply recirculating systems	Different demand on water conditioning	Ch.2/3.3
	Reduction of water use, where obligation for plume reduction and reduced tower height	Apply hybrid cooling system	Accept energy penalty	Ch.2.6/ 3.3.1.2
	Where water (make-up water) is not available during (part of) process period or very limited (drought-stricken areas)	Apply dry cooling	Accept energy penalty	Section 3.2 and 3.3 Annex XII.6
All recirculating wet and wet/dry cooling systems	Reduction of water use	Optimization of cycles of concentration	Increased demand on conditioning of water, such as use of softened make-up water	Section 3.2 and section XI

4. Reduction of entrainment of organisms

Aspect of BAT	BAT	Status at Installation
General	The adaptation of water intake devices to lower the entrainment of fish and other organisms is highly complex and site-specific. Changes to an existing water intake are possible but costly. From the applied or tested fish protection or repulsive technologies, no particular techniques can yet be identified as BAT. The local situation will determine which fish protection or repulsive technique will be BAT. Some general applied strategies in design and position of the intake can be considered as BAT, but these are particularly valid for new systems. On the application of sieves it should be noted that costs of disposal of the resulting organic waste collected from the sieves can be considerable.	The filtration systems used at the DPS plant is composed of multiple layers each having a finer sieve size to the previous. Floating debris is removed by bar screens. A rotating screen is used to reduce finer debris.
Identified reduction techniques within the BAT-approach	See Figure 5.	The intake to D2A and D2B is located in a pre-existing location. The EIA study assessing the impacts on marine ecology has already been carried out, together with the SVASEK study which assessed the impacts on currents within the bay on currents. It was noted that the sea-water intake aided in water circulation within the bay.

Figure 5:

Table 4.5: BAT for reduction of entrainment

Relevance	Criterion	Primary BAT approach	Remarks	Ref.
All once-through systems or cooling systems with intakes of surface water	Appropriate position and design of intake and selection of protection technique	Analysis of the biotope in surface water source	Also critical areas, such as spawning grounds, migration areas and fish nurseries	Section 3.3.3 and Annex XII.3.3
	Construction of intake channels	Optimise water velocities in intake channels to limit sedimentation; watch for seasonal occurrence of macrofouling		Section 3.3.3

5. Reduction of emissions to water

Aspect of BAT	BAT	Status at Installation
General BAT approach to reduce heat emissions	Whether heat emissions into the surface water will have an environmental impact strongly depends on the local conditions. Such site conditions have been described, but do not lead to a conclusion on BAT in general terms. Where, in practice, limits to heat discharge were applicable, the solution was to change from once-through technology to open recirculating cooling (open wet cooling tower). From the available information, and considering all possible aspects, care must be taken in concluding that this can be qualified as BAT. It would need to balance the penalty increase in overall energy efficiency of applying a wet cooling tower (Chapter 3.2) against the effect of reduced environmental impact of reduced heat discharge. In a fully integrated assessment at the level of a river catchment, this could for example include the raised overall efficiency levels of other processes using the same, but now colder, water source, which becomes available because there is no longer a large warm water discharge into it. Where the measures generally aim at reducing the ΔT of the discharged cooling water, a few conclusions on BAT can be drawn. Pre-cooling (Annex XII) has been applied for large power plants where the specific situation requires this, e.g. to avoid raised temperature of the intake water. Discharges will have to be limited with reference to the constraints of the requirements of Directive 78/659/EEC for	As a standby plant, modifications to the existing system are not feasible when considering the contribution such plant has to the environmental impacts of DPS. D2A and D2B have a water temperature limited to $8^{o}C$ above ambient water temperature at outfall. The existing temperature limits and their effects have been studied in previous IPPC applications. Fresh water used for cooling is maintained within a closed loop resulting in minimal fresh-water losses.

Aspect of BAT	BAT	Status at Installation
	fresh water sources. The criteria are summarised in BREF Table 3.6. Reference is made to a provision in Article 11 of this directive regarding derogation of the requirements in certain circumstances.	
General BAT approach to reduce chemical emissions to water	Prevention and control of chemical emissions resulting from cooling systems have received the most attention in Member States' policies and industry. Next to heat discharge they are still considered to be the most important issue in cooling. Referring to the statement that 80% of the environmental impact is decided on the design table, measures should be taken in the design phase of wet cooling system using the following order of approach: o identify process conditions (pressure, T, corrosiveness of substance), o identify chemical characteristics of cooling water source, o select the appropriate material for heat exchanger combining both process conditions and cooling water characteristics, o select the appropriate material for other parts of the cooling system, o identify operational requirements of the cooling system, o select feasible cooling water treatment (chemical composition) using less hazardous chemicals or chemicals that have lower potential for impact on	The choice of materials used in the cooling systems is appropriate for sea water use, thus minimising corrosion during the plant's operational lifetime. So as to reduce the environmental impacts chlorine dosing was replaced by chlorite and hydraulic acid which when combined produce chlorine dioxide. To avoid liberation fumes, the mixing of substances is carried out beneath the surface of the sea. Dosing is customised to seawater temperature (seasonal changes). Monitoring of residual chlorine dioxide levels to verify that they are within permissible limits.

Aspect of BAT	BAT	Status at Installation
	the environment (Section 3.4.5, Annex VI and VIII) o apply the biocide selection scheme (Chapter 3, Figure 3.2) and o optimise dosage regime by monitoring of cooling water and systems conditions. This approach intends to reduce the need for cooling water treatment in the first place. For existing systems technological changes or changes to the equipment are difficult and generally cost-intensive. Focus should be on the operation of the systems using monitoring linked to optimized dosage. A few examples of techniques with good performances have been identified. They are generally applicable for certain categories of systems, they are considered cost effective and do not need large changes to the cooling installation. After reducing the sensitivity of the cooling system to fouling and corrosion, treatment may still be needed to maintain an efficient heat exchange. Selecting cooling water additives less harmful to the aquatic environment and to applying them in the most efficient way is then the next step. With respect to the selection of chemicals, it has been concluded that a ranking of treatments and the chemicals of which they are composed is difficult if not impossible to carry out in a general way and would be unlikely to lead to BAT conclusions. Due to the large variation in conditions and treatments only a site-by-site assessment will lead to the	

Aspect of BAT	BAT	Status at Installation
	appropriate solution. Such an assessment and its constituent parts could represent an approach that can be considered BAT. This approach is offered in this BREF and consists of a tool that can assist in a first ranking of selected chemicals and of an approach to assess biocides, linking the requirements of the cooling system to requirements of the receiving aquatic ecosystem (Annex VIII). The approach aims at minimising the impact of cooling water additives and, in particular, biocides. The Biocidal Products Directive 98/8/EC (BPD) and the Water Framework Directive (WFD) form the key building blocks for this approach. It is essential to use PEC and PNEC values for the different substances, where the PEC/PNEC ratio could function as a yardstick for BAT determination. On the application of specific substances, much experience has been obtained in once-through systems with chlorine-derived components (in particular hypochlorite, chloramine) and chlorine/bromine combinations, as well as with the application of reduced concentration levels. The same applies to the use of biocides for conditioning of recirculating systems. Treatments for these systems are often multisubstances. It is clear that some components or substances can be identified as not BAT or should not be applied at all. A general approach to select the appropriate biocide will include local aspects, such as the water quality	

Aspect of BAT	BAT	Status at Installation
	objectives of the receiving surface water.	
Identified reduction techniques within the BAT-approach **Prevention by design and maintenance**	See Figure 6.	Shell and tube configuration is implemented which enables access to the tubes from both ends for cleaning purposes. This ensures optimal operation. D2B utilises corrosion resistant cupronickel tubes. Minimum filter size is 10mm to avoid clogging of the system Water velocity > 0.8m/s as per BAT
Identified reduction techniques within the BAT-approach **Control by optimised cooling water treatment**	See Figure 7.	Biocide monitoring is carried out and dosing adjusted accordingly as per BAT.

Figure 6:

Table 4.6: BAT for reduction of emissions to water by design and maintenance techniques

Relevance	Criterion	Primary BAT approach	Remarks	Reference
All wet cooling systems	Apply less corrosion-sensitive material	Analysis of corrosiveness of process substance as well as of cooling water to select the right material		Ch.3.4
	Reduction of fouling and corrosion	Design cooling system to avoid stagnant zones		Annex XI.3.3.2.1
Shell&tube heat exchanger	Design to facilitate cleaning	Cooling water flow inside tube and heavy fouling medium on tube side	Depending on design, process T and pressure	Annex III.1
Condensers of power plants	Reduce corrosion-sensitiveness	Application of Ti in condensers using seawater or brackish water		Annex XII
	Reduce corrosion-sensitiveness	Application of low corrosion alloys (Stainless Steel with high pitting index or Copper Nickel)	Change to low corrosion alloys can affect formation of pathogens	Annex XII.5.1

	Mechanical cleaning	Use of automated cleaning systems with foam balls or brushes	In addition mechanical cleaning and high water pressure may be necessary	Annex XII.5.1
Condensers and heat exchangers	Reduce deposition (fouling) in condensers	Water velocity > 1.8 m/s for new equipment and 1.5 m/s in case of tube bundle retrofit	Depending on corrosion sensitivity of material, water quality and surface treatment	Annex XII.5.1
	Reduce deposition (fouling) in heat exchangers	Water velocity > 0.8 m/s	Depending on corrosion sensitivity of material, water quality and surface treatment	Annex XII.3.2
	Avoid clogging	Use debris filters to protect the heat exchangers where clogging is a risk		Annex XII

Table 4.6 (continued): BAT for reduction of emissions to water by design and maintenance techniques

Relevance	Criterion	Primary BAT approach	Remarks	Reference
Once-through cooling system	Reduce corrosion-sensitiveness	Apply carbon steel in cooling water systems if corrosion allowance can be met	Not for brackish water	Annex IV.1
	Reduce corrosion-sensitiveness	Apply reinforced glass fibre plastics, coated reinforced concrete or coated carbon steel in case of underground conduits		Annex IV.2
	Reduce corrosion-sensitiveness	Apply Ti for tubes of shell&tube heat exchanger in highly corrosive environment orhigh quality stainless steel with similar performance	Ti not in reducing environment, optimised biofouling control may be necessary	Annex IV.2
Open wet cooling towers	Reduce fouling in salt water condition	Apply fill that is open low fouling with high load support		Annex IV.4
	Avoid hazardous substances due to anti-fouling treatment	CCA treatment of wooden parts or TBTO containing paints is not BAT		Section 3.4 Annex IV.4
Natural draught wet cooling towers	Reduce anti-fouling treatment	Apply fill under consideration of local water quality (e.g. high solid content, scale)		Annex XII.8.3

Figure 7:

Table 4.7: BAT for reduction of emissions to water by optimised cooling water treatment

Relevance	Criterion	Primary BAT approach	Remarks	Reference
All wet systems	Reduce additive application	Monitoring and control of cooling water chemistry		Section 3.4 and Annex XI.7.3
	Use of less hazardous chemicals	It is not BAT to use • chromium compounds • mercury compounds • organometallic compounds (e.g. organotin compounds) • mercaptobenzothiazole • shock treatment with biocidal substances other than chlorine, bromine, ozone and H_2O_2		Section 3.4/ Annex VI
Once-through cooling system and open wet cooling towers	Target biocide dosage	To monitor macrofouling for optimising biocide dosage		Annex XI.3.3.1.1
	Limit application of biocides	With sea water temperature below 10-12°C no use of biocides	In some areas winter treatment may be needed (harbours)	Annex V

Once-through cooling system	Reduction of FO emission	Use of variation of residence times and water velocities with an associated FO or FRO-level of 0.1 mg/l at the outlet	Not applicable for condensers	Ch.3.4 Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.2 mg/l at the outlet for continuous chlorination of sea water	Daily (24h) average value	Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.2 mg/l at the outlet for intermittent and shock chlorination of sea water	Daily (24h) average value	Annex XI.3.3.2
	Emissions of free (residual) oxidant	FO or FRO ≤ 0.5 mg/l at the outlet for intermittent and shock chlorination of sea water	Hourly average value within one day used for process control requirements	Annex XI.3.3.2
	Reduce amount of OX-forming compounds in fresh water	Continuous chlorinating in fresh water is not BAT		Ch.3.4 Annex XII

Table 4.7 continued: BAT for reduction of emissions to water by optimised cooling water treatment

Relevance	Criterion	Primary BAT approach	Remarks	Reference
Open wet cooling towers	Reduce amount of hypochlorite	Operate at $7 \leq pH \leq 9$ of the cooling water		Annex XI
	Reduce amount of biocide and reduce blowdown	Application of side-stream biofiltration is BAT		Annex XI.3.1.1
	Reduce emission of fast hydrolyzing biocides	Close blowdown temporarily after dosage		Section 3.4
	Application of ozone	Treatment levels of ≤ 0.1 mg O_3/l	Assessment of total cost against the application of other biocides	Annex XI.3.4.1

6. Reduction of emissions to air

Aspect of BAT	BAT	Status at Installation
General approach	Comparatively, air emissions from cooling towers have not been given much attention, except for the effects of plume formation. From some reported data it is concluded that levels are generally low but that these emissions should not be neglected. Lowering concentration levels in the circulating cooling water will obviously affect the potential emission of substances in the plume. Some general recommendations can be made which have a BAT-character.	No air cooling towers are operated by ENE at DPS.
Identified reduction techniques within the BAT-approach	Avoid. See Figure 8.	No air cooling towers are operated by ENE at DPS.

Figure 8:

Table 4.8: BAT for reduction of emissions to air

Relevance	Criterion	Primary BAT approach	Remarks	Reference
All wet cooling towers	Avoid plume reaching ground level	Plume emission at sufficient height and with a minimum discharge air velocity at the tower outlet		Chapter 3.5.3
	Avoid plume formation	Application of hybrid technique or other plume suppressing techniques such as reheating of air	Need local assessment (urban areas, traffic)	Chapter 3.5.3
All wet cooling towers	Use of less hazardous material	Use of asbestos, or wood preserved with CCA (or similar) or TBTO is <u>not BAT</u>		Chapter 3.8.3
	Avoid affecting indoor air quality	Design and positioning of tower outlet to avoid risk of air intake by air conditioning systems	Is expected to be less important for large natural draught CT with considerable height	Section 3.5
All wet cooling towers	Reduction of drift loss	Apply drift eliminators with a loss <0.01% of total recirculating flow	Low resistance to airflow to be maintained	Section 3.5 and XI.5.1

7. Reduction of noise emissions

Aspect of BAT	BAT	Status at Installation
General	Noise emissions have local impact. Noise emissions of cooling installations are part of the total noise emissions from the site. A number of primary and secondary measures have been identified that can be applied to reduce noise emissions where necessary. The primary measures change the sound power level of the source, where the secondary measures reduce the emitted noise level. The secondary measures in particular will lead to pressure loss, which has to be compensated by extra energy input, which reduces overall energy efficiency of the cooling system. The ultimate choice for a noise abatement technique will be an individual matter, as will the resulting associated performance level. The following measures and minimum reduction levels are considered as BAT.	From the EIA noise assessment study, noise emissions of pumps were considered to be within the acceptable level.
Identified reduction techniques within the BAT-approach	See Figure 9.	No cooling towers are operated by ENE on site.

Figure 9:

Table 4.9: BAT for the reduction of noise emissions

Cooling system	Criterion	Primary BAT approach	Associated reduction levels	Ref.
Natural draught cooling towers	Reduce noise of cascading water at air inlet	Different techniques available	≥ 5 dB(A)	Section 3.6
	Reduce noise emission around tower base	E.g application of earth barrier or noise attenuating wall	< 10 dB(A)	Section 3.6
Mechanical draught cooling towers	Reduction of fan noise	Apply low noise fan with characteristics, e.g.: - larger diameter fans; - Reduced tip speed (≤ 40 m/s)	< 5 dB(A)	Section 3.6 Section 3.6
	Optimised diffuser design	Sufficient height or installation of sound attenuators	Variable	Section 3.6
	Noise reduction	Apply attenuation measures to inlet and outlet	≥ 15 dB(A)	Section 3.6

8. Reduction of risk of leakage

Aspect of BAT	BAT	Status at Installation
General approach	To reduce the risk of leakage, attention must be paid to the design of the heat exchanger, the hazardousness of the process substances and the cooling configuration. The following general measures to reduce the occurrence of leakages can be applied: • select material for equipment of wet cooling systems according to the applied water quality; • operate the system according to its design, • if cooling water treatment is needed, select the right cooling water treatment programme, • monitor leakage in cooling water discharge in recirculating wet cooling systems by analysing the blowdown.	The cooling system is designed such that sea water is not directly cooling any potentially contaminant substance. This heavily minimises the chance of a leakage resulting in contamination at the outfall. As an example let us take the the oil cooling system: The oil is cooled by a closed loop of freshwater which loop is being cooled by seawater. The systems are design such that contaminating substances are at a lower operating pressure to the cooling water.
Identified reduction techniques within the BAT-approach	See Figure 10.	Delta T over heat exchanges is less than 50 degrees

Figure 10:

Table 4.10: BAT to reduce the risk of leakage

Relevance[1)]	Criterion	Primary BAT approach	Remarks	Reference
All heat exchangers	Avoid small cracks	ΔT over heat exchanger of ≤ 50°C	Technical solution for higher ΔT on case-by-case basis	Annex III
Shell&tube heat exchanger	Operate within design limits	Monitor process operation		Annex III.1
	Strength of tube/tube plate construction	Apply welding technology	Welding not always applicable	Annex III.3
Equipment	Reduce corrosion	T of metal on cooling water side < 60°C	Temp. affects inhibition of corrosion	Annex IV.1
	VCI score of 5-8	Direct system $P_{cooling\ water} > P_{process}$ and monitoring	Immediate measures in case of leakage	Annex VII
	VCI score of 5-8	Direct system $P_{cooling\ water} = P_{process}$ and automatic analytical monitoring	Immediate measures in case of leakage	Annex VII
	VCI score of ≥ 9	Direct system $P_{cooling\ water} > P_{process}$ and automatic analytical monitoring	Immediate measures in case of leakage	Annex VII

Once-through cooling systems	VCI score of ≥ 9	Direct system with heat exchanger of highly anticorrosive material/ automatic analytical monitoring	Automatic measures in case of leakage	Annex VII
	VCI score of ≥ 9	Change technology - indirect cooling - recirculating cooling - air cooling		Annex VII
	Cooling of dangerous substances	Always monitoring of cooling water		Annex VII
	Apply preventive maintenance	Inspection by means of eddy current	Other non-destructive inspection techniques are available	
Recirculating cooling systems	Cooling of dangerous substances	Constant monitoring of blowdown		

1) Table not applicable for condensers

9. Reduction of biological risk

Aspect of BAT	BAT	Status at Installation
General approach	To reduce the biological risk due to cooling systems operation, it is important to control temperature, maintain the system on a regular basis and avoid scale and corrosion. All measures are more or less within the good maintenance practice that would apply to a recirculating wet cooling system in general. The more critical moments are start-up periods, where systems' operation is not optimal, and standstill for repair or maintenance. For new towers consideration must be given to design and position with respect to surrounding sensitive objects, such as hospitals, schools and accommodation for elderly people.	Cooling towers are not operated by ENE within the DPS. As described above marine growth is reduced through the appropriate use of materials, controlling flow rated and temperatures together with the necessary maintenance and dosing procedures.
Identified reduction techniques within the BAT-approach	See Figure 11.	As described above marine growth is reduced through the appropriate use of materials, controlling flow rated and temperatures together with the necessary maintenance and dosing procedures.

Figure 11:

Table 4.11: BAT to reduce biological growth

Cooling system	Criterion	Primary BAT approach	Remarks	Reference
All wet recirculating cooling systems	Reduce algae formation	Reduce light energy reaching the cooling water		Section 3.7.3
	Reduce biological growth	Avoid stagnant zones (design) and apply optimized chemical treatment		
	Cleaning after outbreak	A combination of mechanical and chemical cleaning		Section 3.7.3
	Control of pathogens	Periodic monitoring of pathogens in the cooling systems		Section 3.7.3
Open wet cooling towers	Reduce risk of infection	Operators should wear nose and mouth protection (P3-mask) when entering a wet cooling tower	If spraying equipment is on or when high-pressure cleaning	Section 3.7.3

Annex I: Comparison of the processes at Facility with the BREF for Large Combustion Plants (published July 2006).

Part 1. Combustion techniques for coal and lignite

Aspect of BAT	BAT	Status at Installation
Unloading, storage and handling of fuel and additives	The BAT for preventing releases from the unloading, storage and handling of coal, and lignite, and also for additives such as lime, limestone, ammonia, etc. are summarised in Figure 1.	Section is not applicable since no coal or ignite is used in ENE operated plant
Fuel pre-treatment	For the fuel pre-treatment of coal and lignite, blending and mixing of fuel are considered to be part of BAT, in order to ensure stable combustion conditions and to thus reduce peak emissions. Switching fuel, for example from one coal to another coal with a better environmental profile, can also be regarded as BAT.	Section is not applicable since no coal or ignite is used in ENE operated plant
Combustion	For the combustion of coal and lignite, pulverised combustion (PC), fluidised bed combustion (CFBC and BFBC) as well as pressurised fluidised bed combustion (PFBC) and grate firing are all considered to be BAT for new and existing plants. Grate firing should preferably only be applied to new plants with a rated thermal input below 100 MW. For the design of new boilers or retrofit projects for existing plants, those firing systems are BAT which assure a high boiler efficiency and which include primary measures to reduce the generation of NO_X emissions, such as air and fuel staging, advanced low-NO_X burners and/or reburning,	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	etc. The use of advanced computerised control system in order to achieve a high boiler performance with increased combustion conditions that support the reduction of emissions are also considered as BAT.	
Thermal efficiency	For the reduction of greenhouse gases, in particular releases of CO_2 from coal- and lignite-fired combustion plants, the best available options from today's point of view are techniques and operational measures to increase thermal efficiency. Secondary measures of CO_2 capture and disposal, as described in Annex 10.2 of this document, are at an early stage of development. These techniques might be available in the future, but they cannot yet be considered as BAT. For power plants, energy efficiency is considered as the heat rate (fuel input energy/energy output at power plant border) and as the power plant efficiency, which is here considered as the inverse of heat rate, i.e. the percentage of energy produced/fuel input energy. The fuel energy is measured as the lower heating value. By applying ultra supercritical steam parameters to improve the efficiency, such as double reheat, and the most advanced high temperature materials, coal- and lignite-fired condensing power plants with a heat rate of 2.08 (48 %) have been built using direct water cooling. Because extremely efficient condensing power plants tend to be so expensive to build they are considered to be economically not competitive. Therefore, the heat rate and	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	the efficiency level associated with the use of BAT for new coal- or lignite-fired condensing power plants (pulverised coal or lignite combustion in DBB or WBB boilers) with direct water cooling (with a capacity of over 300 MWth) is considered to be 2.3 – 2.2 (43 – 47 %), using supercritical steam parameters. Increasing steam parameters (supercritical steam) is another means to increase efficiency when CHP is not possible. Highest efficiencies are only achieved with extremely high steam parameters used in base load plants. Peak load plants with frequent start-up cycles have to be designed with lower steam parameters resulting in lower efficiencies. CHP plants need to be one of the technically and economically most efficient means to increase the energy efficiency (fuel utilisation) of an energy supply system. Co-generation is therefore considered as the most important BAT option in order to reduce the amount of CO_2 released to the air per unit of energy generated. CHP should be a task for any new build power plant whenever economically feasible, i.e. whenever the local heat demand is high enough to warrant the construction of the more expensive co-generation plant instead of the simpler heat or electricity only plant. Because the demand of heat varies throughout the year, CHP plants needs to be very flexible concerning the ratio of produced heat to electricity and they should also possess high efficiencies for part load operation. In this context, plants containing condensing turbines with steam withdrawal are also mentioned, where efficiency of plants	

Aspect of BAT	BAT	Status at Installation
	with condensing turbines with steam withdrawal is between co-generation and condensing plants. The exergetic efficiency (see also Section 2.7.5) associated with the operation of a CHP plant under BAT conditions is considered to be 45 - 55 %, which is equal to a heat rate in the range of 1.3 - 1.1, and an energy (fuel) efficiency of 75 - 90 %, depending on the specific plant application. Comparing this to the heat rate and the efficiency of new coal- and lignite-fired electricity only condensing plants with efficiencies of 42 – 47 % and heat rates of 2.3, the fuel savings, and thus the reduced amount of CO_2 generated, become apparent. It should be kept in mind that these BAT levels are not achieved under all operating conditions. The energy efficiency is at its best at the design point of the plant. The actual energy efficiencies throughout the operational period of the plants may be lower due to changes in the load during the operation, quality of the fuel, etc. The energy efficiency also depends on the cooling system of the power plant, its geographical location (see Table 2.3), and on the energy consumption of the flue-gas cleaning system. For existing coal- and lignite-fired plants, a number of retrofit and repowering techniques can be applied to improve the thermal efficiency. The technical measures described in Section 3.2.6.1 should be taken into account as part of the BAT options to improve the efficiency of	

Aspect of BAT	BAT	Status at Installation
	existing plants. Significant results have been achieved by repowering old boilers, especially in transition phase countries. In general, the following measures need to taken into consideration to increase efficiency: ➢ combustion: minimising the heat loss due to unburned gases and elements in solid wastes and residues from combustion ➢ the highest possible pressure and temperature of medium pressure steam. Repeated superheating of the steam to increase net electric efficiency ➢ the highest possible pressure drop in the low pressure end of the steam turbine through the lowest possible temperature of the cooling water (fresh water cooling) ➢ minimising the heat loss through the flue-gas (utilisation of residual heat or district heating) ➢ minimising the heat loss through the slag ➢ minimising the heat loss through conduction and radiation with isolation ➢ minimising the internal energy consumption by taking appropriate measures, e.g. scorification of the evaporator, greater efficiency of the feed-water pump, etc. ➢ preheating the boiler feed-water with steam ➢ improving blade geometry of the turbines. The levels of the thermal efficiency associated with the	

Aspect of BAT	BAT	Status at Installation
	application of the BAT measures that have been considered in Chapter 4.3 to improve efficiency are summarised in Figure 2.	
Dust	For dedusting off-gases from coal- and lignite-fired new and existing combustion plants, BAT is considered to be the use of an electrostatic precipitator (ESP) or a fabric filter, where fabric filter archives normally emission levels well below 5 mg/Nm^3. Furthermore, the best levels of Hg control are generally achieved by emission control systems (e.g. FGD + particulate control device) that use fabric filters. Cyclones and mechanical collectors alone are not BAT, but they can be used as a pre-cleaning stage in the flue-gas path. The BAT conclusion for dedusting and the associated emission levels are summarised in Figure 3. The associated dust levels take into account the need to reduce fine particulates (PM10 and PM2.5) and to minimise the emission of heavy metals (particularly the emission of particulate-bound Hg), since they have the tendency to accumulate preferentially on the finer dust particulates. For combustion plants over 100 MWth, especially over 300 MWth, the dust levels are lower because the FGD techniques which are already a part of the BAT conclusion for desulphurisation also reduce particulate matter. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represents a typical load situation. For peak load, start up	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher have to be considered.	
Heavy metals	The mineral content of the fuel includes different substances depending on its origin. All solid fuels such as coal and lignite have a certain concentration of trace elements, such as heavy metals. The behaviour of heavy metals in the combustion process involves complex physico-chemical processes. Basically most of the heavy metals evaporate in the combustion process and condensate later in the process onto the surfaces of the particulate matter (i.e. fly ash). Most metals have sufficiently low vapour pressures at the operating temperatures that exist at typical air pollution control devices that condensation onto particulate matter is possible. Therefore, BAT to reduce the emissions of heavy metals from flue-gases of coal- and lignite-fired combustion plants is to use a high performance ESP (reduction rate >99.5 %) or a fabric filter (reduction rate >99.95 %). Mercury has a high vapour pressure at the typical control device operating temperatures, and its collection by particulate matter control devices is highly variable. Taking into account that spray dryer FGD scrubbers and wet lime/limestone scrubbers are regarded as BAT for the reduction of SO_2 for larger combustion plants, low Hg emission levels are achieved. For the reduction and limitation of Hg emissions, it can be stated, that coals of good quality have comparably low Hg	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	contents and that the best levels of control are generally obtained by emission control systems that use FFs and ESPs, where high efficiency ESPs show good removal of Hg (bituminous coal) at temperatures of less than 130 ºC. In addition, some combinations of flue-gas cleaning systems can remove oxidised and particle bound Hg to some extent. For FFs or ESPs operated in combination with FGD techniques, such as wet limestone scrubbers, spray dryer scrubbers or dry sorbent injection, an average removal rate of 75 % (50 % in ESP and 50 % in FGD) or 90 % in the additional presence of SCR can be obtained. The reduction rate when firing sub-bituminous coal or lignite is considerably lower and ranges from 30 – 70 %. The lower levels of Hg capture in plants firing sub-bituminous coal and lignite are attributed to the low fly ash carbon content and the higher relative amounts of gaseous Hg in the flue-gas from the combustion of these fuels. Periodic monitoring of Hg is BAT. A frequency of every year up to every third year, depending on the coal used, is recommended. Total Hg emissions need to be monitored and not only Hg present as part of the particle matter.	
SO_2 emissions	In general, for coal- and lignite-fired combustion plants desulphurisation (FGD) and the use of low sulphur fuel are considered to be BAT. However, the use of low sulphur fuel can be a supplementary technique (particularly for plants over 100 MWth), but generally is not itself sufficient to reduce SO_2 emissions. A distinction of BAT has been made according to the boiler	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	technology: large pulverised coal-and lignite-fired plants are considered separately from fluidised bed boilers, because of the different technical options for desulphurisation. Besides the use of low sulphur coal, the techniques that are considered to be BAT for pulverised coal- and lignite-fired combustion plants are: wet scrubbers, spray dry scrubbers, and for smaller applications below approximately 250 MWth also dry sorbent injection (i.e. dry FGD with an adjacent fabric filter). These techniques have a market share of more than 90 % of the flue-gas desulphurisation techniques. The corresponding rate of desulphurisation is considered for wet scrubbers between 85 and 98 %, for spray dryer scrubbers between 80 and 92 % and for dry sorbent injection between 70 and 90 %. It is, however, not necessary to run the desulphurisation plants on these levels, if the SO_2 emission achievable in this way would be far below the emission levels associated with BAT. The wet scrubber has also a high reduction rate for HF and HCl (98 – 99 %). The associated emission level for both pollutants by using a wet scrubber is 1 – 5 mg/Nm^3. FGDs equipped with rotating gas-gas heat exchangers show higher emissions. Especially for HF, the overall removal efficiency is lower than for SO_2 and HCl. Another advantage of the wet scrubber is its contribution to the reduction of dust and heavy metal (such as Hg) emissions. Existing plants that have already applied a wet FGD system can reduce the SO_2 emissions by optimising	

Aspect of BAT	BAT	Status at Installation
	the flow pattern in the absorber vessel. The wet scrubbing process is expensive for smaller plants and has therefore not been considered as BAT for plants with a capacity of less than 100 MWth. However, on the contrary to other FGD systems, wet scrubbers produce gypsum which may be a saleable product used by the cement or construction industries. The seawater scrubber has been considered to be part of the BAT conclusion because of its high reliability, and because it is a simple process which does not require slurry handling and does not generate by-products. However, local conditions such as seawater conditions, tidal flows, the marine (aquatic) environment close to the scrubber water outlet, etc. need to be carefully examined in order to avoid any negative environmental or ecological effects. Effects may arise from the reduction of the pH level in the general vicinity of the power plant as well as from the input of remaining metals (heavy metals in particular Hg) and fly ash. This is especially applicable for plants situated in an estuary. Regarding Hg, care needs to be taken that Council Directive 84/156/EEC on mercury discharges is complied with. Under that Directive and in absence of Community limit values, the Member States will fix emission standards for mercury discharges autonomously in accordance with the previous Directive 76/464/EEC. Such standards must take into account the best technical means available and must not be less stringent than the most nearly comparable limit value in	

Aspect of BAT	BAT	Status at Installation
	Annex I of Directive 84/156/EEC. Furthermore, this requires a monitoring procedure. For combustion plants less than 100 MWth, the use of low sulphur coal or sorbent injection is considered to be BAT. Other techniques for desulphurisation described in Section 3.5, such as combined techniques for the reduction of NO_X and SO_2, like the activated carbon and the $DESONO_X$ process, may qualify as BAT in cases where site-specific conditions allow these techniques to be used or justify the investment. The effect of natural desulphurisation according to the use of low quality lignites with a low sulphur and a high alkaline ash content may also achieve SO_2 removal as high as 90 %, but will lead, because of the low quality of the fuel, to high dust emissions and higher amounts of residues. The burning temperature in FBC is favourable for sulphur to react with the calcium or magnesium compounds added into the bed. The reaction products, gypsum and unreacted limestone are removed, partly from the bed together with bed ash, and partly from the electrostatic precipitator or baghouse together with the fly ash. Higher Ca/S ratios are needed in fluidised bed combustion (FBC) than in wet scrubbing or spray towers for a high reduction of sulphur. However, even with very high Ca/S ratios, FBC combustion cannot achieve such high reduction rates as from wet scrubbing.	

Aspect of BAT	BAT	Status at Installation
	Higher degrees of desulphurisation are achieved in circulating fluidised bed combustion (CFBC) boilers than in bubbling fluidised bed combustion (BFBC) boilers. For coal and lignite, removal efficiencies as high as 80 – 95 % are possible in CFBCs with moderate Ca/S ratios (i.e. between 2 – 4). When the fuel sulphur contents increase, Ca/S decreases slightly for a certain sulphur removal (e.g. 90 % removal). However, the actual mass flowrate of limestone needed increases as well as the amount of residues generated. Hence, the current trend for CFBCs firing high sulphur (4 – 6 % S) fuels is to combine: a) in situ sulphur capture by limestone in the furnace and b) cold-end sulphur capture. When all aspects are taken into consideration, sulphur capture in CFBCs with only limestone injection in the bed is considered as BAT for low or moderate sulphur (<1 – 3 % S) fuels. In BFBCs, the corresponding removal efficiency is between 55 – 65 % with a similar quality of coal or lignite and with a similar quality and consumption of limestone. Because of the low desulphurisation in BFBCs, the injection of limestone or dolomite cannot be considered as BAT. In BFBC boilers burning only coal, end-of-pipe techniques already described as BAT for pulverised coal combustion are BAT with the associated emission levels of those techniques. The BAT conclusion for desulphurisation and the associated emission levels are summarised in Figure 4. The BAT	

Aspect of BAT	BAT	Status at Installation
	associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher have to be regarded.	
NO_x emissions	In general, for coal- and lignite-fired combustion plants, the reduction of nitrogen oxides (NO_X) by using a combination of primary and/or secondary measures is considered to be BAT. The nitrogen compounds of interest are nitric oxide (NO) and nitrogen dioxide (NO_2), collectively referred to as NO_X, and nitrous oxide (N_2O). A distinction of BAT has been made according to the boiler technology, i.e. pulverised or fluidised bed combustion, and whether coal or lignite is used as a fuel. For pulverised coal combustion plants, the reduction of NO_X emissions, by the use of primary measures in combination with secondary measures such as SCR is BAT, where the separation efficiency of the SCR system ranges between 80 and 95 %. There are different processes available today for the regeneration of used catalysts, which increases the catalyst lifetime considerably and which, therefore, reduces the operating costs. The economic feasibility of applying an SCR system to an existing boiler is primarily a question of the expected remaining lifetime of the plant, which cannot necessarily be determined by the age of the plant. The use of SCR has the disadvantage of a 'slide' ammonia emission (i.e. ammonia slip). With respect	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	to the ammonia concentration when using an SCR, a level of less than 5 mg/Nm^3 is the associated BAT level. This level also avoids problems in the future utilisation of fly ash and the smell of the flue-gas in the surrounding area. Combined techniques for the reduction of NO_X and SO_2 described in Section 3.5, such as the activated carbon and the $DESONO_X$ process, are part of the BAT conclusion, but their advantages, disadvantages and applicability need to be verified on a local level. For pulverised lignite-fired combustion plants, the combination of different primary measures is considered as BAT. This means, for instance, the use of advanced low NO_X burners in combination with other primary measures such as flue-gas recirculation, staged combustion (air staging), reburning, etc. The SCR technique is regarded as part of BAT for the reduction of NO_x emissions, but on account of the relatively low NO_X emissions of lignite-fired plants compared with hard coal-fired plants, SCR has not been considered as BAT in a general sense for the combustion of lignite. For the application of advanced low NO_X burners to existing boilers, it should be noted, that in older installation, the furnaces will usually have been built as small as possible (designed for high combustion intensity). Therefore, the furnace temperature can only be reduced to a limited extent. In addition, the furnace depth can only accommodate slightly longer flames than it was originally	

Aspect of BAT	BAT	Status at Installation
	designed for. For older furnaces, the application of modern swirl burners, which have flames not much longer than those in the original burners, are regarded as BAT. The furnace height in old furnaces is usually small and may prevent the installation of overfire air (OFA) ports. Even if there is room for an OFA, the residence time of the combustion gases in the upper part of the furnace may not be long enough for complete combustion. In boilers that were built in later years when more was known about NO_X formation, the furnace would usually be larger and lower NO_X levels can thus be achieved. The best results are obtained when low NO_X combustion is integrated into the boiler design, i.e. in new installations. For small plants without high load variations and with a stable fuel quality, the SNCR technique can be seen as an additional measure to further reduce NO_X emissions. The use of primary measures, either for coal or lignite, tends to cause incomplete combustion resulting in a higher level of unburned carbon in the fly ash and some carbon monoxide emissions. With a good design and control of combustion, these negative impacts can mostly be avoided. The amount of unburned carbon-in-ash varies according to the fuel and is normally somewhat higher than without primary measures. For most of the utilisation options for the fly ash, the associated BAT level of unburned carbon-in-ash is below 5 %. Levels of unburned carbon below 5 % can normally be achieved but with some coals only at the cost of	

Aspect of BAT	BAT	Status at Installation
	somewhat higher NO_X emissions. Primary NO_X reduction measures also have an impact on the total energy efficiency of the process. If the combustion remains incomplete, the energy efficiency remains lower. A normal rise in the amount of unburned carbon due to low NO_X combustion has a negative impact of approximately 0.1 – 0.3 % on the unit efficiency. For the fluidised bed combustion (FBC) of coal and lignite, staged combustion (air-staging) is considered to be BAT. In this case, the combustion starts in under stoichiometric conditions by pyrolysis in the bubbling bed or in the bubbling bed type lower part of the circulating bed. The rest of the combustion air is added later in stages to finally achieve the over stoichiometric conditions and to complete combustion. In circulating fluidised beds, the circulating bed material ensures an even temperature distribution that typically keeps the furnace temperature below 900^{o}C, which prevents, to a large extent, the formation of thermal NO_X. On the other hand, low temperatures promote the generation of N_2O and increase the amount of unburned carbon. The fluidised bed combustion option is, therefore, a balancing act between the partially conflicting requirements of NO_X, N_2O, and SO_2 control, and the control of unburned hydrocarbons, CO, and char. In FBC boilers, N_2O emission levels of 30 – 150 mg/Nm^3 may occur depending on the fuel used (hard coal or lignite). In the bubbling bed freeboard above the bed itself, the combustion of the pyrolysis gases can produce temperatures	

Aspect of BAT	BAT	Status at Installation
	in excess of 1200°C and promoting this, the formation of thermal NO_X. As a general rule, NO_X formation in a properly designed fluidised bed can be kept below the NO_x formation achieved by low NO_X burners. The BAT conclusion for the prevention and control of NO_X emissions and the associated emission levels are summarised in Figure 5. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represent a typical load situation. For peak load, start up and shut down periods, as well as for operational problems of the flue-gas cleaning systems, short-term peak values which could be higher have to be regarded.	
Carbon monoxide (CO)	BAT for the minimisation of CO emissions is complete combustion, which goes along with good furnace design, the use of high performance monitoring and process control techniques, and maintenance of the combustion system. Because of the negative effect of NO_X reduction on CO, a well-optimised system to reduce emissions of NO_X will also keep the CO levels down to (30 – 50 mg/Nm^3 for pulverised combustion, and below 100 mg/Nm^3 in the case of FBC). For lignite-fired combustion plants where mainly primary measures are regarded as BAT for the reduction of NO emissions, the CO levels can be higher (100 – 200 mg/Nm^3).	Section is not applicable since no coal or ignite is used in ENE operated plant
Hydrogen	For combustion plants, the wet scrubber process (especially	Section is not applicable since no coal or ignite is used in

Aspect of BAT	BAT	Status at Installation
fluoride (HF) and hydrogen chloride (HCl)	for plants with a capacity of over 100 MWth) and the spray dryer have been considered as BAT for the reduction of SO_2. These techniques also give a high reduction rate for HF and HCl (98 – 99 %). By using the wet scrubber or a spray dryer, the associated emission level for HCl is 1 – 10 mg/Nm^3 and for HF 1 – 5 mg/Nm^3. If an FGD is not applied, for example if dry lime is added to an FBC boiler, the emission level of both HCl and HF can be much higher. In measuring elevated levels of HF or HCl in the stack, the problem might be related to an internal flue-gas leakage in the rotating gas-gas heat-exchanger. In this event, raw flue-gas will then go directly to the stack without reducing the SO_2, HF and HCl contents. Therefore, a modern type of gas-gas heat-exchanger has been considered as part of the BAT conclusion. However, because of operational and economic reasons, replacement only needs to be considered when the heat exchanger needs to be changed or replaced anyway. The new gas-gas heat-exchanger might be a combination of a heat extractor (multi-pipe heat extractor) and a reheater, or the use of heat pipes. The best option in this case is flue-gas discharge via the cooling tower, if possible. In this case, no flue-gas reheating is necessary and therefore no gas-gas heat-exchanger is needed. Another option is the use of a high-grade drop catcher and passing the flue-gas via an acid resistant stack pipe, where no flue-gas reheating is necessary and therefore no gas-gas heat-exchanger is needed.	ENE operated plant

Aspect of BAT	BAT	Status at Installation
	Because the injection of limestone for CFBC has been regarded as BAT for the reduction of SO_2 instead of the wet scrubber of pulverised combustion, the BAT associated level of HCl is between 15 – 30 mg/Nm^3.	
Ammonia (NH3)	The disadvantage of SNCR and SCR systems is the emission of unreacted ammonia into the air (ammonia slip). The ammonium concentration associated with the use of BAT is considered to be below 5 mg/Nm^3 to avoid problems in the utilisation of fly ash and possibly the smell of the flue-gas in surrounding areas. The ammonium slip is often the limiting factor in the utilisation of the SNCR technique. To avoid ammonia slip with the SNCR technique, a low layer of SCR catalyst can be installed in the economiser area of the boiler. As this catalyst reduces the ammonia slip, it also reduces the corresponding amount of NO_X.	Section is not applicable since no coal or ignite is used in ENE operated plant
Water pollution	Different waste water streams (see BREF Chapter 1) are generated by operating coal- and lignite-fired combustion plants. To reduce emissions to water and to avoid water contamination all measures that have been presented in Section 3.10 are considered to be BAT and summarised in the Figure 6. As mentioned in Section “Unloading, storage and handling of fuel and additives”, the storage of coal and lignite on sealed surfaces with drainage and drain collection has been considered as BAT. Any surface run-off (rainwater) of the storage areas that washes fuel particles away should be	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	collected and treated (settling out) before being discharged. The associated BAT emission level in the discharged water is considered to be less than 30 mg/l. Small amounts of oil contaminated (washing) water cannot be prevented from occurring occasionally at a power plant. Oil separation wells are, in general, sufficient to avoid any environmental damage. The BAT conclusion for the wet scrubbing desulphurisation is related to the application of a waste water treatment plant. The waste water treatment plant consists of different chemical treatments to remove heavy metals and to decrease the amount of solid matter from entering the water. The treatment plant includes an adjustment of the pH, the precipitation of heavy metals and removal of the solid matter and the precipitate from the waste water. With modern technology the following parameters are monitored (where not all of these components are required to be monitored on a continuous basis): pH, conductivity, temperature, solid content, chlorine content, heavy metal concentrations (such as As, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn,), fluorine concentration and chemical oxygen demand (COD). The waste water from a wet FGD treated by filtration and neutralisation still has a content of COD that needs further treatment. The quality of the waste water after the waste water treatment plant varies greatly depending on the fuel quality, desulphurisation process used and to the discharge of the waste water.	

Aspect of BAT	BAT	Status at Installation
	Nevertheless, emission levels associated with the use of a BAT waste water treatment plant are summarised in Figure 7. The other techniques described for waste water treatment in BREF Chapter 3 can, in general, also be considered as BAT for this sector.	
Combustion residues	As mentioned in Section 4.3.6, a lot of attention has already been paid by industry to the utilisation of combustion residues and by-products, instead of just depositing them in landfills. Utilisation and re-use is, therefore, the best available option and is a priority. A large number of different options to re-use residues and by-products from coal and lignite-fired combustion plants are presented in BREF Table 4.2. There are tens of different utilisation possibilities for different by-products. Each different utilisation option has different specific criteria for the quality of ash it needs. It is impossible to cover all of these criteria in this BAT reference document. The quality criteria are usually connected to the structural properties of the ash and the content of any harmful substances, such as the amount of unburned coal in the ash, the solubility of heavy metals, etc. The carbon rich ash can be recovered from ash streams. This produces a carbon rich ash that can be recycled to the boiler to recover the energy in the carbon and a lower carbon ash stream that is less restricted in terms of options	Section is not applicable since no coal or ignite is used in ENE operated plant

Aspect of BAT	BAT	Status at Installation
	for beneficial re-use. The end-product of the wet scrubbing technique is gypsum, which is a commercial product for the plant. It can be sold and used instead of natural gypsum. FGD sludges can be integrated in an FGD process by-product (gypsum) in the limits allowed. The sludges can be re-injected into the furnace when FGD and SCR techniques are applied. Practically most of the gypsum produced in power plants is utilised in the plasterboard industry. The purity of gypsum limits the amount of limestone that can be fed into the process. The end-product of semi-dry desulphurisation processes is used in different construction purposes instead of natural minerals, such as in road construction, for earthworks of composting and storage fields, for the filling of mine pits, and for excavation dams in watertight construction.	

Figure 1:

Material	Pollutant	BAT
Coal and lignite	Dust	∞ the use of loading and unloading equipment that minimises the height of fuel drop to the stockpile, to reduce the generation of fugitive dust ∞ in countries where freezing does not occur, using water spray systems to reduce the formation of fugitive dust from coal stockpiles ∞ according to the generation of fugitive emissions, covering stockpiles of petroleum coke ∞ grassing over long-term storage areas of coal to prevent fugitive emission of dust and fuel loss caused by oxidation in contact with the oxygen of air ∞ applying the direct transfer of lignite via belt conveyors or trains from the mine to the on-site lignite storage area ∞ placing transfer conveyors in safe, open areas aboveground so that damage from vehicles and other equipment can be prevented. ∞ using cleaning devices for conveyor belts to minimise the generation of fugitive dust ∞ using enclosed conveyors with well designed, robust extraction and filtration equipment on conveyor transfer points to prevent the emission of dust ∞ rationalising transport systems to minimise the generation and transport of dust within the site ∞ the use of good design and construction practices and adequate maintenance.

	Water contamination	∞ having storage on sealed surfaces with drainage, drain collection and water treatment for settling out ∞ collecting surface run-off (rainwater) from coal and lignite storage areas that washes fuel particles away and treating this collected stream (settling out) before discharge.
	Fire prevention	∞ surveying storage areas for coal and lignite with automatic systems, to detect fires, caused by self-ignition and to identify risk points.
Lime and limestone	Dust	∞ having enclosed conveyors, pneumatic transfer systems and silos with well designed, robust extraction and filtration equipment on delivery and conveyor transfer points to prevent the emission of dust.
Pure liquified ammonia	Health and safety risk according to ammonia	∞ for handling and storage of pure liquified ammonia: pressure reservoirs for pure liquified ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealling processes ∞ from a safety point of view, the use of an ammonia-water solution is less risky than the storage and handling of pure liquefied ammonia.

Table 4.65: BAT for the unloading, storage, and handling of coal, lignite and additives

Figure 2:

Fuel	Comb. Tech.	Unit thermal efficiency (net) (%)	
		New plants	Existing plants
Coal and lignite	Cogeneration (CHP)	75 – 90	75 – 90
Coal	PC (DBB and WBB)	43 – 47	The achievable improvement of thermal efficiency depends on the specific plant, but as an indication a level of 36[1] – 40 % or an incremental improvement of more than 3 % points can be seen as associated with the use of BAT for existing plants
	FBC	>41	
	PFBC	>42	
Lignite	PC (DBB)	42 – 45	
	FBC	>40	
	PFBC	>42	

1 Industry and one Member State claimed that for existing plants, the achieved net unit efficiencies following major upgrading projects are only in the range of 30 – 40 %. They claimed that this depends on the specific plant and the fuel characteristics as well as the climatic conditons, taking into account the efficiency drop due to the significant energy consumption of the (usually retrofitted) emissions control equipment.

Table 4.66: Levels of thermal efficiency associated with the application of the BAT measures

Figure 3:

Capacity (MW_{th})	Dust-emission level (mg/Nm^3)		BAT to reach these levels	Monitoring	Applicability	Comments
	New plants	Existing plants				
50 – 100	5 – 20(1)	5 – 30(2)	ESP or FF	Continuous	New and existing plants	∞ the reduction rate associated with the use of an ESP is considered to be 99.5 % or higher ∞ the reduction rate associated with the use of a fabric filter is considered to be 99.95 % or higher.
100 – 300	5 – 20(3)	5 – 25(4)	ESP or FF in combination FGD (wet, sd or dsi) for PC ESP or FF for CFBC	Continuous	New and existing plants	
>300	5 – 10(5) 5 – 20(5)	5 – 20(6) 5 – 20(6)	ESP or FF in combination with FGD (wet) for PC ESP or FF for CFBC	Continuous	New and existing plants	∞ the reduction rate associated with the use of an ESP is considered to be 99.5 % or higher ∞ the reduction rate associated with the use of a fabric filter is considered to be 99.95 % or higher ∞ a wet scrubber used for desulphurisation also reduces dust.

Notes: **ESP** (Electrostatic precipitator) **FF** (Fabric filter) **FGD(wet)** (Wet flue-gas desulphurisation) **FGD(sds)** (Flue-gas desulphurisation by using a spray dryer) **FGD(dsi)** (Flue-gas desulphurisation by dry sorbent injection) For very high dust concentrations in the raw gas, which might be the case when low calorific lignite is used as a fuel, the reduction rate of 99.95 % for the ESP or 99.99 % for fabric filters is considered to be the BAT associated level, rather than the dust concentration levels mentioned in this table.	
1 2 3 4 5 6	Industry and one MS proposed 10 – 50 mg/Nm^3 Industry and one MS proposed 20 – 100 mg/Nm^3 Industry and one MS proposed 10 – 30 mg/Nm^3 Industry and one MS proposed 10 – 100 mg/Nm^3 for ESP or FF, and 10 – 50 mg/Nm^3 in the case of combination with wet FGD Industry and one MS proposed for 10 – 30 mg/Nm^3 Industry and one MS proposed for 10 – 100 mg/Nm^3 for ESP or FF, and 10 – 50 mg/Nm^3 in the case of combination with wet FGD The rationale given by Industry proposing for the values given above, is that issues such as fuel characteristics, ash resistivity, the flue-gas inlet SO_2 concentration which determines the necessity for an FGD, economics, as well as high net unit efficiency requirements have not been fully taken into account. One Member State supported the Industry view and maintained that even with high efficiency ESPs, the dust emission levels achieved, when using low quality lignite with high ash resistivity and high ash content, will never reach values lower than the proposed levels for existing plants that do not need wet FGD, due to natural desulphurisation.
1, 2	One Industry representative mentioned that for coal fired plants between 50 and 100 MW, dust emissions of less than 30 mg/Nm^3 are too optimistic and gives no margin for plant deterioration in service (especially FF) or collection variability (especially ESPs). A still very stringent, but more practically attainable dust emission limit is 50 mg/Nm^3.
5,6	One Member State proposed that the BAT level should be 10 – 50 mg/Nm^3, because these levels comply with the Member States emission limits. Their abatement systems have been installed to comply with these limits. As far as new power plants are concerned, the Member State in question has a programme on coal firing plants, where a dust emission level of 20 mg/Nm^3 is foreseen.

Table 4.67: BAT for dedusting off-gases from coal- and lignite-fired combustion plants

Figure 4:

Capacity (MW_{th})	Combustion technique	SO_2 emission level associated with BAT (mg/Nm^3)		BAT options to reach these levels	Applicability	Monitoring
		New plants	Existing plants			
50 – 100	Grate-firing	200 – 400	200 – 400	Low sulphur fuel or FGD (sds)	New and existing plants	Continuous
	PC	200 – 400(1)	200 – 400(2)	Low sulphur fuel FGD (sds, dsi)	New and existing plants	Continuous
	CFBC and PFBC	150 – 400(3)	150 – 400(4)	Low sulphur fuel Limestone injection	New and existing plants	Continuous
	BFBC	150 – 400(5)	150 – 400(6)	Low sulphur fuel FGD (dsi) FGD (sds)	New and existing plants	Continuous
100 – 300	PC	100 – 200	100 – 250(7)	Low sulphur fuel FGD (wet, sds) FGD (dsi, up to about 200 MW_{th}) Seawater scrubbing Combined techniques for the reduction of NO_x and SO_2	New and existing plants	Continuous
	CFBC and PFBC	100 – 200	100 – 250(8)	Low sulphur fuel Limestone injection	New and existing plants	Continuous
	BFBC	100 – 200	100 – 250(9)	Low sulphur fuel FGD (wet, sds)	New and existing plants	Continuous
>300	PC	20 – 150(10)	20 – 200(11)	Low sulphur fuel FGD (wet) FGD (sds) Seawater scrubbing Combined techniques for the reduction of NO_x and SO_2	New and existing plants	Continuous
	CFBC and PFBC	100 – 200	100 – 200(12)	Low sulphur fuel Limestone injection	New and existing plants	Continuous
	BFBC	20 – 150	20 – 200(13)	Low sulphur fuel FGD (wet)	New and existing plants	Continuous

Notes: **PC** (Pulverised combustion) **BFBC** (Bubbling fluidised bed combustion) **CFBC** (Circulating fluidised bed combustion) **PFBC** (Pressurised fluidised bed combustion) **FGD(wet)** (Wet flue-gas desulphurisation) **FGD(sds)** (Flue-gas desulphurisation by using a spray dryer) **FGD(dsi)** (Flue-gas desulphurisation by dry sorbent injection)	
	Industry declared that the levels should be as follows:
1-6, 8-9, 12,13	upper level 300 mg/Nm³
7	upper level 600 mg/Nm³
10	upper level 200 mg/Nm³
11	upper level 400 mg/Nm³
	These levels are proposed by Industry because they claim that better takes into account the fuel characteristics, the inlet flue-gas SO_2 concentration affects the BAT achievable levels considering the agreed wet scrubber SO_2 removal efficiencies of 85 – 98 %, the high energy consumption of such a wet scrubber system in relation with the net unit efficiency requirements, and because an optimisation is necessary between emission control technique performance (low emission levels) and related energy consumption (energy penalty). One Member State claimed mainly the same upper levels of the ranges except for (2) which should be 2000 mg/Nm³ and for (7) which should be 1200 mg/Nm³. Their rationale is, that for certain existing lignite-fired power plants, burning fuel with a high sulphur content produces raw flue-gas SO_2 concentrations in the range of 15000 – 20000 mg/Nm³ (dry and 6 % O_2 conditions). Only a sophisticated and large wet FGD system with an SO_2 removal efficiency of 98 %, can reach SO_2 emission levels of 300 – 400 mg/Nm³, dry, at 6 % O_2.
	One Member State proposed that the emission levels associated to the use of BAT should be:
7, 8, 9	upper level 600 mg/Nm³
11, 12, 13	Modify the range to 200 – 400 mg/Nm³ Their rationale is because these levels comply with the Member States emission limits. As far as new power plants are concerned, the Member State in question has a programme on coal firing plants, where an emission level of 200 mg/Nm³ is foreseen.
1-6	One Industry representative mentioned that operators of small coal-fired LCPs would welcome the opportunity to meet SO_2 emission levels by consuming low sulphur coal. However, this option is not without its commercial and operational problems and, for it to even be an option at all, the SO_2 emission limit needs to be set at a minimum of 1000 mg/Nm³.

Table 4.68: BAT for the prevention and control of sulphur dioxides from coal- and lignite-fired combustion plants

Figure 5:

Capacity (MW_{th})	Combustion technique	NO_x emission level associated with BAT (mg/Nm^3)		Fuel	BAT options to reach these levels	Applicability	Monitoring
		New plants	Existing plants				
50 – 100	Grate firing	200 – 300	200 – 300[1]	Coal and lignite	Pm and or SNCR	New and existing plants	Continuous
	PC	90 – 300[2]	90 – 300[3]	Coal	Combination of Pm (such as air and fuel staging, low NO_x burner, etc.), SNCR or SCR as an additional measure	New and existing plants	Continuous
	BFBC, CFBC and PFBC	200 – 300	200 – 300	Coal and lignite	Combination of Pm (such as air and fuel-staging)	New and existing plants	Continuous
	PC	200 – 450	200 – 450[3]	Lignite	Combination of Pm (such as air and fuel-staging)	New and existing plants	Continuous
100 – 300	PC	90[4] – 200	90 – 200[5]	Coal	Combination of Pm (such as air and fuel-staging, low NO_x burner, reburning, etc), in combination with SCR or combined techniques	New and existing plants	Continuous
	PC	100 – 200	100 – 200[6]	Lignite	Combination of Pm (such as air and fuel-staging, low NO_x burner, reburning, etc.)	New and existing plants	Continuous
	BFBC, CFBC and PFBC	100 – 200	100 – 200[7]	Coal and lignite	Combination of Pm (such as air and fuel-staging), if necessary, together with SNCR	New and existing plants	Continuous
>300	PC	90 – 150	90 - 200[8]	Coal	Combination of Pm (such as air and fuel-staging, low NO_x burner, reburning, etc.), in combination with SCR or combined techniques	New and existing plants	Continuous
	PC	50 – 200[9]	50 – 200[10]	Lignite	Combination of Pm (such as air and fuel-staging, low NO_x burner, reburning, etc)	New and existing plants	Continuous
	BFBC, CFBC and PFBC	50 – 150	50 – 200[11]	Coal and lignite	Combination of Pm (such as air and fuel-staging)	New and existing plants	Continuous

Notes:
PC (Pulverised combustion) **BFBC** (Bubbling fluidised bed combustion) **CFBC** (Circulating fluidised bed combustion) **PFBC** (Pressurised fluidised bed combustion)
Pm (Primary measures to reduce NO_x) **SCR** (Selective catalytic reduction of NO_x) **SNCR** (Selective non catalytic reduction of NO_x)
The use of anthracite hard coal may lead to higher emission levels of NO_X because of the high combustion temperatures.

	Industry and one Member State proposed that the levels should be as follows:
2, 6	upper level 450 mg/Nm^3
3	upper level 500 mg/Nm^3
4	lower level 100 mg/Nm^3
5, 7	upper level 300 mg/Nm^3
9	range 100 – 200 mg/Nm^3
10	range 100 – 450 mg/Nm^3
	Industry claimed that their proposed figures better consider the issue that the application of primary measures are restricted by boiler geometry and configuration (height restrictions may not allow retrofitting of air and fuel staging). One Member State added that for existing plants burning low quality lignite, the produced NO_X emission levels are quite low, due to the combustion technique inherent primary measures for NO_X reductions (flue-gas recirculation, fuel and air staging, etc.). Further modifications for improvement of already installed primary measures are restricted by boiler geometry and configuration and are not cost effective.
	Another Member State proposed that the BAT range for existing plants should be as follows:
5-7	range to be 100 – 300 mg/Nm^3
8,10,11	lower end of the range to be 100 mg/Nm^3
	The rationale is that these levels comply with the Member State's emission limits. As far as new power plants are concerned, the Member State in question has a programme on coal firing plants, where an emission level of 150 mg/Nm^3 is foreseen.
8,10,11	Another Member State claimed that they had explored the different instruments to meet a strict target of 150 mg/Nm^3. This is possible in a cost effective way by a system of NO_x emission trading. To have maximum flexibility in the system of NO_x emission trading, the Member State explained that for the oldest combustion plants, the highest level in the range (associated with the use of BAT) should be as practicable possible, and proposed a range of 100 – 650 mg/Nm^3 for existing plants over 300 MW.
1,3	Another Industry representative proposed that an upper emission level of 400mg/Nm^3 for plants in the 50 – 100 MW range.

Table 4.69: BAT for nitrogen oxide prevention and control in coal- and lignite-fired combustion plants

Figure 6:

Technique	Main environmental benefit	Applicability	
		New plants	Existing plants
Wet FGD			
Water treatment by flocculation, sedimentation, filtration, ion-exchange and neutralisation	Removal of fluoride, heavy metals, COD and particulates	BAT	BAT
Ammonia reduction by air stripping, precipitation or biodegradation	Reduced ammonia content	BAT only if the ammonia content in waste water is high because of a SCR/SNCR used upstream of a FGD	
Closed loop operation	Reduced waste water discharge	BAT	BAT
Mixing of waste water with coal ash	An avoided waste water discharge	BAT	BAT
Slag flushing and transport			
Closed water circuit by filtration or sedimentation	Reduced waste water discharge	BAT	BAT
Regeneration of demineralisers and condensate polishers			
Neutralisation and sedimentation	Reduced waste water discharge	BAT	BAT
Elutriation			
Neutralisation		BAT only with alkaline operation	
Washing of boilers, air preheaters and precipitators			
Neutralisation and closed loop operation, or replacement by dry cleaning methods	Reduced waste water discharge	BAT	BAT
Surface run-off			
Sedimentations or chemical treatment and internal re-use	Reduced waste water discharge	BAT	BAT

Table 4.70: BAT for waste water treatment

Figure 7:

Emissions to water from a wet FGD waste water treatment plant (mg/l)	
Solids	5 – 30
COD	<150
Nitrogen compounds	<50
Sulphate	1000 – 2000
Sulphite	0.5 – 20
Sulphide	<0.2
Fluoride	1 – 30
Cd	<0.05
Cr	<0.5
Cu	<0.5
Hg	0.01 – 0.02
Ni	<0.5
Pb	<0.1
Zn	<1

Table 4.71: Emission levels associated with the use of a BAT- FGD waste water treatment plant given as a representative 24 hour composite sample

Part 2. Combustion techniques for biomass and peat

Aspect of BAT	BAT	Status at Installation
The unloading, storage and handling of biomass, peat and additives	BAT in preventing releases from the unloading, storage and handling of biomass and peat, and also for additives such as lime, limestone, ammonia, etc. are summarised in Figure 8.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Fuel pre-treatment	For the pre-treatment of biomass, in particular for wood, classification based on the size and the contamination of the wood are considered being BAT, in order to ensure stable combustion conditions, to reduce the amount of unburned fuel in the ash, and to thus reduce peak emissions. In case the wood used is contaminated, it is BAT to know the type of contamination of the wood and an analytical knowledge of the contaminants for each load that arrives to the power plant. To increase the thermal efficiency of peat-fired power plants, the drying system is considered to be BAT. To reduce the amount of water and to thus increase the thermal efficiency of peat-fired boilers, the drying of peat by an intermediate storage on the harvesting peat field is also considered to be part of BAT.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Combustion	For the combustion of biomass and peat, pulverised combustion, fluidised bed combustion, (BFBC and CFBC) as well as the spreader stoker grate-firing technique for wood and the vibrating, water-cooled grate for straw-firing are considered to be. BAT. The use of advanced computerised control system in order	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	to achieve a high boiler performance with increased combustion conditions that support the reduction of emissions are also considered as BAT. With regard to grate-firing systems for biomass, spreader-stoker travelling grates are part of the BAT conclusion, because the resulting nitrogen oxide (NO_X >200 mg/Nm^3) and carbon monoxide emissions are usually low. For straw firing using the vibrating water-cooled grates, steam temperatures have to be kept below approximately 500°C to control corrosion. Pulverised peat combustion plants have not been considered as BAT for new plants, because of their low thermal efficiency.	
Thermal efficiency	For the reduction of greenhouse gases in particular releases of CO_2 from peat-fired combustion plants, but also for the reduction of the amount of fuel (in this sense also biomass) that is required to produce one unit of thermal energy, the best available options from today's point of view are techniques and operational measures to increase the thermal efficiency. For peat- and biomass-fired power plants, energy efficiency has been considered as heat rate (fuel input energy/energy output at power plant border) and as power plant efficiency which is here the inverse of heat rate, i.e. percentage of produced energy/fuel input energy. The fuel energy is measured as the lower heating value.	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	For biomass- and peat-fired plants, co-generation of heat and power (CHP) is by far the most important technical and economical way to increase the energy (fuel) efficiency, because the electrical efficiency for a biomass- or peat-fired power plant is normally low (20 – 30 %). Co-generation in this sense is, therefore, the most important BAT measure whenever economically feasible, i.e. whenever the local heat demand is high enough to warrant the construction of the co-generation plant which is most often the case in industrial applications. The exergetic efficiency (see also Section 2.7.5) associated with the operation of the plant under BAT conditions is considered to be 40 – 42 %. The fuel efficiency of a BAT co-generation (CHP) plant is considered to be between 75 and 90 % which corresponds to a heat rate in the range of 1.3 – 1.1. It should be borne in mind that these BAT levels are not reached under all operating conditions. The energy efficiency is as its best at the design point of the plant. The actual energy efficiencies throughout the operational period of the plants may be lower due to changes in the load during the operation, quality of the fuel, etc. The energy efficiency also depends on the cooling system of the power plant, and on the energy consumption of the flue-gas cleaning system. For existing plants, a number of retrofit techniques can be applied to improve the thermal efficiency. Combustion efficiency, for instance, can be enhanced by the pre-treatment of biofuels to reduce moisture levels. A reduction in the moisture content from 60 to 40 % could increase	

Aspect of BAT	BAT	Status at Installation
	thermal efficiency by over 10 %. Co-combustion of biomass in coal fired power plants also results in a significantly higher electric efficiency. In general, the following measures also need to be taken into consideration to increase the efficiency: ➢ combustion: minimising the heat loss due to unburned gases and elements in solid wastes and residues from combustion ➢ the highest possible pressure and temperature of the working medium steam ➢ the highest possible pressure drop in the low pressure end of the steam turbine through the lowest possible temperature of the cooling water (fresh water cooling) ➢ minimising the heat loss through the flue-gas (utilisation of residual heat or district heating) ➢ minimising the heat loss through the slag ➢ minimising the heat loss through conduction and radiation with isolation ➢ minimising the internal energy consumption by taking appropriate measures, e.g. scorification of the evaporator, greater efficiency of the feed water pump, etc.) ➢ preheating the boiler feed water with steam ➢ improved blade geometry of the turbines.	

Aspect of BAT	BAT	Status at Installation
	The levels of the energy (fuel) efficiency associated with the application of the BAT measures are summarised in Figure 9.	
Dust	For dedusting off-gases from biomass- and peat-fired new and existing combustion plants, BAT is considered to be the use of bag-houses with fabric filters or an electrostatic precipitator (ESP). In this sense, it needs to be noted that when using low sulphur fuels such as biomass, the potential for reduction performance of ESPs is reduced with low flue-gas sulphur dioxide concentrations. In this context, the FF, which leads to dust emission around 5 mg/Nm^3, is the preferred technical option to reduce dust emissions. Cyclones and mechanical collectors alone are not BAT, but they can be used as a pre-cleaning stage in the flue-gas path. The BAT conclusion for dedusting and the associated emission levels are summarised in Figure 10. The associated dust levels take into account the need to reduce fine particulates (PM10 and PM2.5) and to minimise the emission of heavy metals, since they have the tendency to accumulate preferentially on the finer dust particulates. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher, have to be regarded.	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
Heavy metals	The mineral content of the fuel includes different substances depending on its origin. Biomass and peat have certain concentrations of trace elements, such as heavy metals. The behaviour of heavy metals in the combustion process involves complex process chemistry and physics. Basically most of the heavy metals evaporate in the combustion process and condense later in the process on the surfaces of the particulate matter (fly ash). Therefore, BAT to reduce the emissions of heavy metals from flue-gases of biomass- and peat-fired combustion plants is the use of a fabric filter (reduction rate > 99.95 %) or a high performance ESP (reduction rate > 99.5 %), where the fabric filter should be seen as the first choice in the hierarchy of BAT for dedusting.	Section is not applicable as ENE operated plant does not utilise biomass or peat
SO_2 emissions	The sulphur content of peat is often low, and wood biomass contains practically no sulphur. Wood-based biomass can, therefore, be combusted in FBC without desulphurisation. The SO_2 emission level depends thus only on the sulphur content in the fuel and is typically below 50 mg/Nm^3 (O_2 = 6 %). In the combustion of peat with a higher sulphur content or with the co-firing of biomass/peat with other fuels, e.g. coal, the reduction of SO_2, by primary and/or secondary measures (depending on the fuel mixture) are considered to be BAT. Today, in the new smaller LCP boilers (i.e. <100 MWth), fluidised bed combustion is usually applied. In these boilers,	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	wet desulphurisation techniques are too expensive to be considered as BAT and the dry injection processes (in situ desulphurisation by adding limestone or dolomite to the bed) can be effective enough to reach the same emission levels. Calcium hydroxide injection in the dry form before the fabric filter or ESP can also achieve a high reduction rate. In the furnace, limestone injection together with a calcium oxide activation scrubber, is also quite effective in some cases. These measures also remove other harmful emissions, such as HCl. The HC level associated with the use of BAT is considered to be less than 25 mg/Nm^3. The degree of desulphurisation in peat-fired FBC boilers is significantly lower than that in coal-fired FBC boilers. The degree of desulphurisation with moderate Ca/S ratios (i.e. 3 – 5) for both peat-fired CFBCs and BFBCs is around 30 – 40 %. The desulphurisation does not increase over about 45 % in BFBC boilers, even for very high Ca/S ratios. In CFBC, the highest achievable degree of desulphurisation was around 80 %, but that cannot be considered as BAT due to the very high use of limestone, which resulted in problems with the end-product and involved high costs. In CFBC with high desulphurisation (e.g. >80 %), BAT is a combination of sorbent injection into the furnace including the use of a secondary measure. In many FBC boilers, peat and different types of wood biomass (sawdust, wood chips, bark, etc.) are co-combusted, therefore the co-combustion of peat and biomass can also be seen as one BAT option to reduce SO_2,	

Aspect of BAT	BAT	Status at Installation
	and at the same time to also reduce CO_2 emissions from peat-fired combustion plants. It is also the case that when co-firing wood and peat, some of the sulphur in the peat reacts with the wood ash, and this acts as an additional desulphurisation agent in FBC boilers. By co-combustion of coal with biomass, the achievable SO_2 levels depend to some extent on the sulphur content of the coal and level of co-combustion. The BAT conclusion for desulphurisation and the associated emission levels for the combustion of peat are summarised in Figure 11. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher have to be regarded.	
NO_X emissions	In general, for biomass- and peat-fired combustion plants, the reduction of nitrogen oxides (NO_X) using a combination of primary and/or secondary measures (e.g. SNCR and SCR) is considered to be BAT. The nitrogen compounds of interest are nitrogen oxide (NO) and nitrogen dioxide (NO_2), collectively referred to as NO_X, and especially for FBC boilers the emission of nitrous oxide (N_2O). For the grate-firing of biomass, in particular wood-based biomass, the spreader-stoker technique (i.e. combustion on an air-cooled travelling grate stoker) has been considered as BAT in order to reduce NO_X emissions.	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	For pulverised peat-fired combustion plants, the combination of different primary measures is considered to be BAT. This means, for instance, the use of advanced low NO_X burners in combination with other primary measures such as flue-gas recirculation, staged combustion (air staging), and reburning, etc. In FBC boilers burning biomass or peat, BAT is the reduction of NO_X emissions achieved by air distribution or by flue-gas recirculation. There is a small difference in the NO_X emissions from BFBC and CFBC combustion. The lowest emission values with peat and biomass are achieved with CFBC boilers but both techniques (BFBC and CFBC) are developing towards lower emission values with no major differences currently found. The associated emission levels while using primary NO_X reduction methods in FBC for peat and biomass combustion are: for BFBC 180 – 260 mg NO_2/Nm^3 (O_2 = 6 %), and for CFBC 155 – 260 mg NO_2/Nm^3 (O_2 = 6 %). The relatively large range is mainly due to the variation in nitrogen content of the fuel (for peat between 0.7 – 2.5 %) and due to the size of the boiler. Desulphurisation by limestone injection in the boiler has been reported to increase the NO_X emission by 10 – 25 mg/Nm^3 (O_2 = 6 %). Additionally, selective non-catalytic reduction (SNCR) by feeding ammonia or urea to the furnace is part of BAT. To avoid ammonia slip with the SNCR technique, a low layer of SCR catalyst can be installed in the economiser area of the boiler. As this catalyst reduces ammonia slip, it also	

Aspect of BAT	BAT	Status at Installation
	reduces the corresponding amount of NO_X. In CFBC boilers, using SNCR + SCR combination, a NO_X emission of 50 mg/Nm^3 with an ammonia slip below 5 mg/Nm^3 is achievable. Besides the use of primary measures, SCR is regarded as one possibility for the reduction of NO_X emissions and therefore as part of BAT. For straw fired plants, the application of SCR may not be possible because of rapid catalyst poisoning because of the formation of potassium compounds. SCR was introduced in the mid 90s and now there are six biomass-fired boilers operating with SCR within the energy sector. Five of these are fluidised beds (CFBC/BFBC) for co-generation and one is a small (40 MW – mixture biomass/peat) grate for co-generation. For all FBC-boilers it has been considered favourable to apply a combination of SNCR and SCR (high-dust). The grate only has a (low-dust) SCR. Typically NO_X emissions after SCR are below 30 mg/MJ (<90 mg/m^3). The BAT conclusion for the prevention and control of NO_X emissions and the associated emission levels are summarised in Figure 12. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 6 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher, have to be regarded.	

Aspect of BAT	BAT	Status at Installation
Carbon monoxide (CO)	BAT for the minimisation of CO emissions is complete combustion, which goes along with good furnace design, the use of high performance monitoring and process control techniques and maintenance of the combustion system. Beside the combustion conditions, a well optimised system to reduce NO_X emissions will also keep the CO levels down within the order of 50 - 250 mg/Nm^3, where emissions from FBC boilers typically are in the lower part of the interval while emission from PC and grate firing are somewhat higher.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Hydrogen fluoride (HF) and hydrogen chloride (HCl)	The BAT associated emission level for biomass and peat firing is <25 mg/Nm^3. For fuels not requiring sorbent injection for SO_2 reduction, and which inherent alkali content is not sufficient to meet the BAT level, additional alkali injection is a part of BAT. In combustion plants using straw as a fuel, the variation in the HCl emissions is from 50 to 300 mg/Nm^3 (daily mean value) with a typical yearly mean value of 100 mg/Nm^3. For larger straw-fired plants, the application of a wet scrubber or a spray dry scrubber system is considered as part of BAT if higher amounts of HCl have been measured. Both wet scrubber or spray dry scrubber systems reduce HCl (with a reduction rate of about 98 %). SO_2 emissions, which can be up to 300 mg/Nm^3 in the raw gas of a straw fired plant, can also be reduced (with a reduction rate 80 – 95 %). In this case, the associated HCl emission level is between 5 and 25 mg/Nm^3.	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	Because of the generation of HCl, straw firing leads to a high risk of high temperature corrosion particularly in the superheater section of the boiler.	
Ammonia (NH_3)	One disadvantage of SNCR and SCR systems is the emission of unreacted ammonia into the air (ammonia slip). The ammonia emission concentration associated with the use of BAT is considered to be below 5 mg/Nm^3.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Dioxins and furans	In some biomass fired plants, especially wood-fired combustion plants, the emissions of dioxins and furans have been measured and an emission level of below 0.1 ng/Nm^3 is generally regarded as achievable.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Noise	Special care has to be taken when cutting straw needed for co-firing with coal in pulverised fuel boilers. BAT for cutting straw is to use hammer-mills (which have a high noise level). Special attention has also to be paid to subsequent pneumatic transport to the burner.	Section is not applicable as ENE operated plant does not utilise biomass or peat
Water pollution	Different waste water streams (see Chapter 1) are generated by operating biomass- and peat-fired combustion plants. To reduce emissions to water and to avoid water contamination, all measures that have been presented in Section 5.4.8 are considered to be BAT and summarised in the Figure 13. As previously mentioned in BREF Section 5.4.1, as BAT it has been considered that biomass and peat should be stored on sealed surfaces with drainage and drain collection, or in silos, or enclosed storage areas. The surface run-off	Section is not applicable as ENE operated plant does not utilise biomass or peat

Aspect of BAT	BAT	Status at Installation
	(rainwater) of the storage areas that washes fuel particles away should be collected and treated (settling-out) before discharge. The associated BAT emission level in the discharged water is considered to be less than 30 mg/l. Small amounts of oil contaminated (washing) water cannot be prevented from occurring occasionally at a power plant. Oil separation wells are, in general, sufficient to avoid any environmental damage. In general, the other techniques described for waste water treatment in Chapter 3 can also be considered as BAT for this sector.	
Combustion residues	Attention has been paid by industry to the utilisation of combustion residues and by-products, instead of depositing them in landfills. Utilisation and re-use is, therefore, the best available option. There are a vast number of different possibilities for the re-use of different by-products. Each different utilisation sets specific criteria for the quality of ash. It is impossible to cover all of these criteria in this BAT reference document. As a minimum it will suffice to say that the quality criteria are usually connected to the structural properties of the ash and the content of any harmful substances such as the amount of unburned fuel in the ash, the solubility of heavy metals, etc.	Section is not applicable as ENE operated plant does not utilise biomass or peat

Figure 8:

Material	Pollutants or other effects	BAT
Biomass and peat	Dust	∞ the use of loading and unloading equipment that minimises the height of the fuel drop to the stockpile, to reduce the generation of fugitive dust, especially when storing fine wood material and dry peat ∞ water spray systems to reduce the formation of fugitive dust from storage areas ∞ the moisture content of peat must be at least 40 % during transport to the plant. This eliminates fugitive dust arising from the fuel and reduces the speeding of fire, in the event of self-ignition ∞ placing transfer conveyors in safe, open areas above ground so that damage from vehicles and other equipment can be prevented ∞ using cleaning devices for conveyor belts to minimise the generation of fugitive dust ∞ for dry peat and dusty biomass, enclosing conveyors with well designed, robust extraction and filtration equipment on conveyor transfer points, to prevent dust emissions ∞ rationalising transport systems to minimise the generation and transport of dust within the site ∞ using good design and construction practices and adequate maintenance.

	Water contamination	∞ having storage on sealed surfaces with drainage and drain collection, and water treatment by settling-out ∞ collecting the surface run-off (rainwater) from biomass and peat storage areas that washes fuel particles away, and treating this collected stream (i.e. the settling-out portion) before discharge.
	Stable combustion	∞ carrying out quality checks of the delivered straw and subsequently storing the data on a central logistics computer ∞ ensuring that, in the co-firing of several types of biomass, there are two or more storage systems so that the mixture of fed fuel can be controlled according to the quality of the fuels.
	Fire prevention	∞ surveying the biomass and peat storage areas, to detect fires, caused by self-ignition, and to identify risk points.
Lime and limestone	Dust	∞ having enclosed conveyors, pneumatic transfer systems and silos with well designed, robust extraction and filtration equipment on delivery and conveyor transfer points to prevent the emission of dust.
Pure liquified ammonia	Health and safety risk according to ammonia	∞ for handling and storage of pure liquified ammonia: pressure reservoirs for pure liquified ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealling process ∞ from a safety point of view, the use of an ammonia-water solution is less risky than the storage and handling of pure liquefied ammonia.

Table 5.30: BAT for the unloading, storage and handling of coal, lignite and additives

Figure 9:

Fuel	Comb. Tech.	Unit thermal efficiency (net) (%)	
		Electric efficiency	Fuel efficiency (co-generation, CHP)
Biomass	Grate-firing	Around 20	75 – 90 Depending on the specific plant application and the heat and electricity demand. Co-generation (CHP) is the most important BAT measure to achieve a high fuel efficiency and should be considered whenever the heat demand is high enough.
	Spreader-stoker	>23	
	FBC (CFBC)	>28 – 30	
Peat	FBC (BFBC and CFBC)	>28 – 30	

Table 5.31: Thermal efficiency levels associated with the application of the BAT measures

Figure 10:

Capacity (MW_{th})	Dust-emission level (mg/Nm^3)		BAT to reach these levels	Monitoring	Applicability	Comments
	New plants	Existing plants				
50 – 100	5 – 20	5 – 30	FF/ESP	Continuous	New and existing plants	The reduction rate associated with the use of a fabric filter is considered to be 99.95 % or higher and is, therefore, considered as the first BAT choice for dedusting biomass- and peat-fired plants.
100 – 300	5 – 20	5 – 20	FF/ESP	Continuous	New and existing plants	
>300	5 – 20	5 – 20	FF/ESP	Continuous	New and existing plants	The reduction rate associated with the use of an ESP is considered to be 99.5 % or higher.

Notes:
ESP (Electrostatic precipitator) **FF** (Fabric filter))

Table 5.32: BAT for dedusting off-gases from biomass and peat fired combustion plants

Figure 11:

Capacity (MW_{th})	Combustion technique	SO_2 emission level associated with BAT (mg/Nm^3)		BAT options to reach these levels (non- exhaustive list)	Applicability	Monitoring
		New plants	Existing plants			
50 – 100	PC	200 – 300	200 – 300	Limestone injection Calcium hydroxide injection in dry form before the baghouse or ESP FGD(sds)	New and existing plants	Continuous
	FBC (BFBC and CFBC)	200 – 300	200 – 300	Co-combustion of biomass and peat, Limestone injection, Calcium hydroxide injection in dry form before the baghouse or ESP, FGD(sds)	New and existing plants	Continuous
	PC	200 – 300	200 – 300	Limestone injection Calcium hydroxide injection in dry form before the baghouse or ESP FGD(sds)	New and existing plants	Continuous

100 – 300	FBC (BFBC and CFBC)	150 – 250	150 – 300	Co-combustion of biomass and peat, Limestone injection, Calcium hydroxide injection in dry form before the baghouse or ESP, FGD(sds)	New and existing plants	Continuous
>300	PC	50 – 150	50 – 200	FGD(wet) FGD(sds) Seawater scrubbing Combined techniques for the reduction of NO_X and SO_2	New and existing plants	Continuous
	FBC (BFBC and CFBC)	50 – 200	50 – 200	Co-combustion of biomass and peat, Limestone injection, Calcium hydroxide injection in dry form before the baghouse or ESP, FGD(sds) or FGD(wet)	New and existing plants	Continuous

Notes:
PC (Pulverised combustion)
CFBC (Circulating fluidised bed combustion)
FGD(wet) (Wet flue-gas desulphurisation)
BFBC (Bubbling fluidised bed combustion)
PFBC (Pressurised fluidised bed combustion)
FGD(sds) (Flue-gas desulphurisation by using a spray dryer)

Table 5.33: BAT for the prevention and control of sulphur dioxides from peat-fired combustion plants

Figure 12:

Capacity (MW_{th})	Combustion technique	NO_X emission level associated with BAT (mg/Nm^3)		BAT options to reach these levels (not exhaustive list)	Applicability	Monitoring
		New plants	Existing plants			
50 – 100	Grate-firing	170 – 250	200 – 300	Spreader-stoker		Continuous
	PC	150 – 250	150 – 300	Combination of Pm (such as air and fuel staging, low NO_X burner, etc.) SCR	New and existing plants	Continuous
	FBC(BFBC and CFBC)	150 – 250	150 – 300	Combination of Pm (such as air distribution or by flue-gas recirculation)	New and existing plants	Continuous
100 – 300	PC	150 – 200	150 – 250	Combination of Pm (such as air and fuel staging, low NO_X burner) if necessary SNCR and/or SCR	New and existing plants	Continuous

100 – 300						
	FBC (BFBC, and CFBC)	150 – 200	150 – 250	Combination of Pm (such as air distribution or by flue-gas recirculation)	New and existing plants	Continuous
>300	PC	50 – 150	50 – 200	Combination of Pm (such as air and fuel staging, low NO_X burner), if necessary SNCR and/or SCR	New and existing plants	Continuous
	FBC (BFBC and CFBC)	50 – 150	50 – 200	Combination of Pm (such as air distribution or by flue-gas recirculation), if necessary SNCR and/or SCR	New and existing plants	Continuous

Notes:
PC (Pulverised combustion)
CFBC (Circulating fluidised bed combustion)
Pm (Primary measures)
BFBC (Bubbling fluidised bed combustion)
PFBC (Pressurised fluidised bed combustion)

Table 5.34: BAT for nitrogen oxide prevention and control in biomass- and peat-fired combustion plants

Figure 13:

Technique	Main environmental benefit	Applicability	
		New plants	Retrofitted plants
Wet FGD (only applied if necessary under the conditions of Section 5.4.8)			
Water treatment by flocculation, sedimentation, filtration, ion-exchange and neutralisation	Removal of fluoride, heavy metal, COD and particulates	BAT	BAT
Closed loop operation	Reduced waste water discharge	BAT	BAT
Mixing of waste water with ash	Avoided waste water discharge	BAT	BAT
Slag flushing and transport			
Closed water circuit by filtration or sedimentation	Reduced waste water discharge	BAT	BAT
Regeneration of demineralisers and condensate polishers			
Neutralisation and sedimentation	Reduced waste water discharge	BAT	BAT
Washing of boilers, air preheaters and precipitators			
Neutralisation and closed loop operation, or replacement by dry cleaning methods	Reduced waste water discharge	BAT	BAT
Surface run-off			
Sedimentations or chemical treatment and internal re-use	Reduced waste water discharge	BAT	BAT

Table 5.35: BAT for the reduction of waste water contamination

Part 3. Combustion techniques for liquid fuels

Aspect of BAT	BAT	Status at Installation
Unloading, storage and handling of liquid fuel and additives	BAT in preventing releases from unloading, storage and handling of liquid fuels, but also for additives such as lime, limestone, ammonia, etc. are summarised in Figure 14.	With reference to Figure 14 all BAT suggestions pertaining to 'liquid-fuel' and 'Pure liquefied ammonia' are applicable and implemented by ENE. Amoina hydroxide is stored in volumes up to 400l. At the HFO and DO unloading station the following measures are in place: 1. containment to avoid any fuel spillages from going to the sea. 2. the use of a quick release coupling on the HFO flexible hose. An exhaustive list of operation, techniques and equipment for the prevention of releases from unloading storage and handling of liquid fuels has been provided in the 'BAT emissions from storage' document.
Pre-treatment of liquid fuels used in engines and gas turbines	For diesel oil used as a fuel in gas turbines and engines, fuel pre-treatment plants, which comprise diesel oil cleaning units of the centrifuge self-cleaning type or of the electrostatic type, are considered as BAT. With heavy fuel oil (HFO) firing, the fuel treatment plant comprises heaters for heating the HFO (electrical or steam coil type); de-emulsifier dosing systems, for breaking up the oil emulsion; separators (centrifugal or electrostatic type), for removing the solid impurities; and additive dosing systems, for raising the melting point of the vanadium oxidation products. Reference is given to the measures described in Sections	DO used in both D2A and D2B is cleaned by means of centrifuges and filtration before being used. DO is treated at the 'fuel treatment plant', which comprises diesel oil cleaning units.

Aspect of BAT	BAT	Status at Installation
	6.1.2.2 and 6.1.2.3 of the BREF.	
BAT for liquid fuel-fired boilers **Thermal efficiency**	For the reduction of greenhouse gases, in particular the releases of CO_2 from liquid fuel-fired combustion plants, the best available options, from today's point of view, are techniques and operational measures to increase thermal efficiency. This goes along with the application of advanced computerised control systems for controlling the combustion conditions to maximise the emission reduction and boiler performance. Secondary measures of CO_2 capture and disposal, as described in Annex 10.2 of the BREF document, are at a very early stage of development. These techniques might be available in the future, but they cannot yet be considered as BAT. For condensing power plants, energy efficiency has been related to, and considered as, the heat rate (fuel input energy/energy output at power plant border) and as the power plant efficiency, which is to be understood here as the inverse of the heat rate, i.e. the percentage of produced energy/fuel input energy. The fuel energy is measured as the lower heating value. By applying the measures listed in Section 6.4.2 to improve the thermal efficiency, such as double reheat and the use of the most advanced high temperature materials, liquid fuel-fired condensing power plants can achieve comparable efficiencies to hard coal-fired plants. The co-generation of heat and power (CHP) is one of the technically and economically most efficient means of	This section is not applicable since D2A is an open-cycle plant, and D2B operates unfired heat-recovery boilers.

Aspect of BAT	BAT	Status at Installation
	increasing the energy efficiency of an energy supply system. Co-generation is, therefore, considered as the most important BAT option in order to reduce the amount of CO_2 released to the atmosphere per unit of energy generated. CHP should be an aim for any new build power plant whenever economically feasible, i.e. whenever the local heat demand is high enough to warrant the construction of the more expensive co-generation plant instead of the simpler heat or electricity only plant. Because the demand for heat varies throughout the year, CHP plants need to be very flexible concerning the ratio of produced heat to electricity. They should also possess high efficiencies for part load operation. The exergetic efficiency (see also Section 2.7.5) associated with the operation of a CHP plant under BAT conditions, is considered to be 45 – 55 %, which is equal to a heat rate in the range of 1.3 – 1.1 and an energy (fuel) efficiency of 75 – 90 %, depending on the plant specific application. It should be borne in mind that these BAT levels are not attainable under all operational conditions. Energy efficiency is greatest at the design point of the plant. The actual energy efficiencies throughout the operational period of the plants may be lower due to changes in the load during the operation, quality of the fuel, etc. The energy efficiency also depends on the cooling system of the power plant, its geographical location (see BREF Table 2.3), and on the energy consumption of the flue-gas cleaning system. For existing liquid fuel-fired plants, a number of retrofit and	

Aspect of BAT	BAT	Status at Installation
	repowering techniques can be applied to improve the thermal efficiency. The technical measures described in Section 2.7.9 should be taken into account as part of the BAT options to improve the efficiency of existing plants. The use of advanced computerised control systems in order to achieve a high boiler performance with increased combustion conditions that support the reduction of emissions are also considered as BAT. In general, the following measures need to be taken into consideration to increase efficiency: ➢ combustion: minimising the heat loss due to unburned gases and elements in solid wastes and residues from combustion ➢ the highest possible pressure and temperature of the working medium steam. Repeated superheating of the steam to increase net electric efficiency ➢ the highest possible pressure drop in the low pressure end of the steam turbine through the lowest possible temperature of the cooling water (fresh water cooling) ➢ minimising the heat loss through the flue-gas (utilisation of residual heat or district heating) ➢ minimising the heat loss through conduction and radiation with isolation ➢ minimising the internal energy consumption by taking appropriate measures, e.g. scorification of the evaporator, greater efficiency of the feed water pump etc.)	

Aspect of BAT	BAT	Status at Installation
	➢ preheating the boiler feed water with steam ➢ improving blade geometry of the turbines.	
BAT for liquid fuel-fired boilers **Dust and heavy metals emissions**	For dedusting off-gases from new and existing liquid fuel-fired combustion plants, BAT is considered to be the use of an electrostatic precipitator (ESP) or a fabric filter. Cyclones and mechanical collectors alone are not BAT, but they can be used as a pre-cleaning stage in the flue-gas path. Liquid fuels, especially HFO, typically contain heavy metals, in particular Vanadium and nickel. Basically, most of the heavy metals evaporate in the combustion process and condense later in the process on the surfaces of the particulate matter (e.g. fly ash). The ESP is the most used technique for dedusting flue-gases from HFO firing. The FF is also an applied technique but less important because of the elevated risk of fire, which is reduced if the FF is applied in combination with FGD. Therefore, BAT to reduce the emissions of dust and heavy metals are the use of high performance ESPs (reduction rate of >99.5 %) or, taking into account the point mentioned above, a fabric filter (reduction rate of >99.95 %). Periodic monitoring for heavy metals is BAT. A frequency of every year up to every third year, depending on the kind of liquid fuel used is recommended. Total-Hg especially needs to be monitored and not only the part bound to particles. The associated dust levels take into account the need to	Neither ESP no FF technology are used in the plants under consideration. This section does not apply.

Aspect of BAT	BAT	Status at Installation
	reduce fine particulates (PM10 and PM2.5) and to minimise the emission of heavy metals, since they have the tendency to accumulate preferentially on the finer dust particulates. For combustion plants over 300 MWth, the dust levels are lower because the wet scrubber (FGD) that is part of the BAT conclusion for desulphurisation also reduces particulate matter. The BAT conclusion for dedusting and the associated emission levels are summarised in Figure 15. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 3 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher, have to be regarded.	
BAT for liquid fuel-fired boilers **SO_2 emissions**	In general, for liquid fuel-fired combustion plants, the use of low sulphur fuel oil and/or desulphurisation are considered to be BAT. However, the use of low sulphur fuel oil for plants over 100 MWth can, in most cases, only be seen as a supplementary but generally not in itself sufficient way to reduce SO_2. In sites where natural gas is available, co-combustion of gas and oil is also part of BAT. Besides the use of low sulphur fuel oil, the techniques that are considered to be BAT are mainly the wet scrubber (reduction rate 92 - 98 %), and the spray dry scrubber desulphurisation (reduction rate 85 – 92 %), which already has a market share of more than 90 % of flue-gas	This section does not apply since ENE is to have no fuel fired boilers under its operation.

Aspect of BAT	BAT	Status at Installation
	desulphurisation techniques. Dry FGD techniques, such as dry sorbent injection, are used mainly for plants with a thermal capacity of less than 300 MWth. The wet scrubber has also the advantage of reducing emissions of HCl, HF, dust and heavy metals. Existing plants that have already applied a wet FGD system can reduce the SO_2 emissions further by optimising the flow pattern in the absorber vessel. The wet scrubbing process is an expensive option for smaller plants and has, therefore, not been considered as BAT for plants with a capacity of less than 100 MWth. The seawater scrubber has been considered to be part of the BAT conclusion because of its high reliability, and because it is a simple process which does not require slurry handling and does not generate by-products. The local conditions, such as seawater conditions, tidal flows, the marine (aquatic) environment close to the scrubber water outlet, etc. need to be carefully examined in order to avoid any negative environmental and ecological effects. Effects may arise from the reduction of the pH level in the general vicinity of the power plant as well as from the input of any remaining metals (heavy metals) and fly ash. The BAT conclusion for desulphurisation and the associated emission levels are summarised in Figure 16. The BAT associated emission levels are based on a daily average, standard conditions and an O_2 level of 3 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be	

Aspect of BAT	BAT	Status at Installation
	higher, have to be regarded.	
BAT for liquid fuel-fired boilers **NO_X emissions**	In general, for liquid fuel-fired combustion plants, the reduction of nitrogen oxides (NO_X) by using a combination of primary and/or secondary measures such as SCR is considered to be BAT. The nitrogen compounds of interest are nitric oxide (NO), nitrogen dioxide (NO_2), collectively referred to as NO_X and nitrous oxide (N_2O). For combustion plants over 50 MWth and in particular for large plants over 100 MWth for the reduction of NO_X emissions, BAT is considered to be the use of primary measures in combination with SCR or other end-of-pipe techniques. For small plants below 50 MWth, it is not generally necessary to apply SCR, but it is an applied technique that can be used. The economic feasibility of applying an SCR system to an existing boiler is primarily a question of the expected remaining lifetime of the plant, which cannot necessarily be decided solely by the age of the plant. The use of SCR has the disadvantage of a slide ammonia emission (ammonia slip). For the ammonia concentration, a level of less than 5 mg/Nm^3 is considered as BAT and is associated with the use of SCR. Combined techniques for the reduction of NO_X and SO_2 are described in BREF Section 3.5 as part of the BAT conclusion, but their advantages, disadvantages and applicability need to be verified at a local level. For combustion plants with a capacity of less than 100	This section does not apply since ENE is to have no fuel fired boilers under its operation.

Aspect of BAT	BAT	Status at Installation
	MWth, the use of a combination of different low NO_X primary measures is considered to be BAT. The furnace height in old plants is usually small and may prevent the installation of overfire air ports. Even if there is room for an OFA, then the residence time of the combustion gases in the upper part of the furnace may not be long enough for complete combustion. In boilers that were built in years in which more was known about NO_X formation, the furnace will be larger and lower NO_X levels can be achieved. The best results will be obtained when low NO_X combustion is integrated into the boiler design, i.e. in new installations. The BAT conclusion for the prevention and control of NO_X emissions and the associated emission levels are summarised in Figure 17. The BAT associated emission levels are based on a daily average, with standard conditions and an O_2 level of 3 %, and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher, have to be regarded.	
BAT for liquid fuel-fired boilers **Carbon monoxide (CO)**	BAT for the minimisation of CO emissions is complete combustion, which goes together with good furnace design, the use of high performance monitoring and process control techniques and maintenance of the combustion system. Besides the combustion conditions, a well optimised system to reduce emissions of NO_X will also keep the CO levels between 30 and 50 mg/Nm^3.	This section does not apply since ENE is to have no fuel fired boilers under its operation.

Aspect of BAT	BAT	Status at Installation
BAT for liquid fuel-fired boilers **Ammonia (NH_3)**	The disadvantage of SNCR and SCR systems is the emission of unreacted ammonia into the air (ammonia slip). The ammonium concentration in the emission associated with the use of BAT is considered to be below 5 mg/Nm^3. The ammonium slip is often the limiting factor in the utilisation of an SNCR technique. To avoid the ammonia slip with the SNCR technique. A layer of SCR catalyst may be installed in the economiser area of the boiler, if the flue-gas temperature level is adequate to. As this catalyst reduces ammonia slip, it also reduces the corresponding amount of NO_X.	This section does not apply since ENE is to have no fuel fired boilers under its operation.
BAT for liquid fuel-fired boilers **Water pollution**	Different waste water streams (see BREF Chapter 1) are generated by liquid fuel-fired combustion plants. To reduce emissions to water and to avoid water contamination, all measures that have been presented in BREF Section 6.4.6 are considered to be BAT. The danger of oil contamination is of an entirely different scale, when considering the risk of accidents in oil transportation or storage at oil-fired power plants. These problems are, however, no different from the normal risks associated with oil transport and storage in general; so there are no LCP specific issues to deal with in this respect. Small amounts of oil contaminated (washing) water cannot be prevented from occurring occasionally at a power plant. Oil separation wells are, in general, sufficient to avoid any environmental damage.	This section does not apply since ENE is to have no fuel fired boilers under its operation.

Aspect of BAT	BAT	Status at Installation
	The BAT conclusion for wet scrubbing desulphurisation is related to the application of a waste water treatment plant. The waste water treatment plant consists of different chemical treatments to remove heavy metals and to decrease the amount of solid matter from the water. The treatment plant includes the adjustment of pH, the precipitation of heavy metals and removal of the solid matter and the precipitate from the waste water. With modern technology, the following parameters are monitored: pH, conductivity, temperature, solid content, chlorine content, heavy metal concentrations (such as Cd, Hg, As, Cr, Cu, Ni, Zn, V, Pb), fluorine concentration and chemical oxygen demand (COD). The quality of the waste water after the waste water treatment plant varies a lot according to the fuel quality, desulphurisation process and to the discharge of the waste water. Nevertheless, emissions levels associated with the use of a BAT waste water treatment plant are summarised in Figure 18. The BAT measures to avoid or to reduce emissions to water are summarised in the following Figure 19. The other techniques described for waste water treatment in BREF Chapter 3 can also, in general, be considered as BAT for this sector.	
BAT for liquid fuel-fired boilers **Combustion residues**	A lot of attention has already been paid by industry to the utilisation of combustion residues and by-products instead of depositing them in landfills. Utilisation and re-use is,	This section does not apply since ENE is to have no fuel fired boilers under its operation.

Aspect of BAT	BAT	Status at Installation
	therefore, the best available option. There are many different targets of utilisation for different by-products. Each different means of utilisation sets specific criteria for the quality of ash, etc. It is impossible to cover all of these criteria in this BAT reference document, however the quality criteria are usually connected to the structural properties of the residue and related to the content and properties of any harmful substances in the residue, such as ash, solubility of heavy metals, etc. The ash resulting from fuel-oil combustion presents, in particular when HFO is fired, a high content of unburned carbon. This ash can, therefore, be incinerated (in industrial kilns) or can be re-injected into the combustion chamber of a boiler with FGD and SCR systems. The end-product of the wet scrubbing technique is gypsum, which is potentially a commercial product for the plant. It can be sold and used instead of natural gypsum. Practically most of the gypsum produced in power plants is utilised in the plasterboard industry. The purity of gypsum limits the amount of limestone that can be fed in the process. The end-product of semi-dry desulphurisation processes is used in different construction purposes instead of natural minerals, such as in road construction, for earthworks of composting and storage fields, for the filling of mine pits, and for excavation dams in watertight construction.	

Aspect of BAT	BAT	Status at Installation
BAT for liquid fuel-fired gas turbines	For gas turbines firing liquid fuel such as LFO or diesel, the injection of water or steam is considered as BAT for the reduction of NO_X emissions. Nowadays, dry low NO_X premix burners (DLN) are also available for liquid fuel-fired gas turbines. These DLN burners can even be used if liquid fuel and natural gas is fired in the same turbine. DLN burners are only BAT for new turbines were the technique is available on the market for the use in gas turbines burning liquid fuels. SCR can also be used but according to the economic feasibility the application needs to be regarded case by case. For gas turbines using only liquid fuel (for instance, in cases where gaseous fuels are temporarily not available), reference is given to Section 7.5 of BREF. In general, for liquid fuel-fired gas turbines, the use of low sulphur fuel oil is considered to be BAT for the reduction of SO_2.	On D2B a steam injection system is installed for NOx control. D2A does not implement any NOx emissions reduction measures. The Diesel used for the firing of both D2A and D2B has a maximum sulphur content of 0.1%.
BAT for liquid fuel-fired (diesel) engines	A diesel flue-gas typically contains about 13 to 15 vol-% O2 and, therefore, the emission levels associated with the use of BAT are based on an O2 level of 15 vol-%, as the reference point.[1] The characteristics of the electricity demand determine the configuration of the installation, i.e. many small engines are needed, because the capacity of the largest unit can only reach approximately 10 – 15 % of the total installed capacity. Also, the power generation equipment needs to be very flexible for quick start-ups, shut-downs and very frequent and quick load variations, low partial load and to possess black – start capability. These features are	This section does not apply since no diesel engines are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	necessary, due to the great variations in electricity demand in each season, as well as during the day, in an effort to achieve a satisfactory level of efficiency at the same time for certain units in the lot, which must operate at the optimum load. Also, the needs of the isolated grid for stability are increased, due to increased penetration of wind power generation, encouraged and promoted on the islands. All wind power variations have to be accommodated by the flexible operation of the diesel engines. In addition to the above, the restrictions in the available fuels, as well as the difficulties in fuel supply to the islands, increase fuel costs dramatically.	
BAT for liquid fuel-fired (diesel) engines **Thermal efficiency**	The emissions of carbon dioxide (the most important greenhouse gas) depend on the fuel used and on the efficiency of the prime mover. By maintaining a high efficiency of the reciprocating engine power plant, the CO emissions can be kept at a relatively low level. Engine driven power plants are fuel flexible and suitable both for decentralised heat and power production (CHP) as well as for larger base load applications. The BAT associated total efficiencies are up to 60 to 70 % in low pressure steam generation. With supplementary firing (with the oxygen content of the engine flue-gas being used as the main ‘combustion air’ in the burner) a large amount of low pressure or high pressure steam can be generated in an efficient way. In hot water production (outlet temperature	This section does not apply since no diesel engines are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	typically in range of 80 to 120ºC), a total efficiency of about 85 % in liquid fuel mode and up to 90 % in gas fuel mode, highly depends on the portion of the engine cooling water energy recovered in the application, can be seen as the BAT associated level. Hot water up to 200ºC can, of course, be produced by utilising the energy in the flue-gas and a part of the engine cooling energy. Another advantage is the high thermal efficiency (low fuel consumption, and as a consequence low specific CO_2 emission) of the engines. The BAT electrical efficiency (at the alternator terminals) ranges from about 40 to 45 % (depending on engine size) calculated based on the lower heating value of the fuel.	
BAT for liquid fuel-fired (diesel) engines **Dust and heavy metals emissions**	The emissions of particles are fuel related. Due to the different temperature and oxygen content of the diesel flue-gas, the electrical properties of the diesel particles are different compared to particles from boiler flue-gas. The ash content is the main parameter, but other parameters such as sulphur and asphaltene contents of the fuel also affect the emission of particles. By using an SCR for NO_X reduction, a very small reduction in particulate matter may also be achieved depending on the fuel type and exhaust temperature. Because secondary cleaning devices for the reduction of particulate emissions is under development at the moment, for larger diesel engines, the use of engine measures in combination with the use of a low ash and low sulphur fuel, whenever commercially available, can be considered as BAT for reducing particulate emissions.	This section does not apply since no diesel engines are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	A large capacity plant can also consist of a number of several aggregates with comparatively small capacities. In this case, each individual aggregate can be equipped with filters for particles especially soot. Dust emissions from engines of up to 1.3 MW fuel input can be reduced below emission values of 20 mg/Nm^3. The BAT conclusion for the prevention and control of particulate emissions from four stroke engines and the associated emission levels are summarised in Figure 20. The emission levels of dust from two stroke engines can be higher.	
BAT for liquid fuel-fired (diesel) engines **SO_2 emissions**	At the moment, only a few diesel power stations exist equipped with FGD systems, and even then only for a limited number of operating hours. The investment cost for a FGD plant greatly varies according to the chosen operational method. The operating cost mainly depends on the amount and type of reagent, water, electricity consumptions, maintenance and any end-product disposal costs. Therefore, the use of low sulphur fuel oil or natural gas, whenever commercially available, is regarded as the first choice of BAT. Secondly, if low sulphur fuel oil or natural gas is not available, the use of a secondary FGD system is considered as BAT for reducing emissions of SO_2.	This section does not apply since no diesel engines are to be operated by ENE.
BAT for liquid fuel-fired (diesel) engines	The application of primary methods and secondary measures, in particular the application of an SCR system is regarded as BAT to reduce NO_X emissions from liquid-fuel-	This section does not apply since no diesel engines are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
NO_x emissions	fired engine plants. Primary methods for liquid-fuel-fired diesel engines are: ➢ the 'Miller concept' ➢ injection retard ➢ direct water injection (DWI) ➢ humid air injection HAM. During the last decade the NO_X emissions from liquid fuel-fired big diesel- and heavy fuel oil fired engines has been reduced considerably by primary measures on the engine in combination with SCR, compared to the previous values, whilst maintaining the high efficiency of the engine. A limitation for the applicability of SCR is given for small diesel and two stroke engines which needs to be operated with often varying loads. These units are operated frequently on isolated systems to be operated for a reduced number of hours only. According to the electricity demand, these engines need to be started up and shut down several times a day. SCR is an applied technique for diesel engines, but can not be seen as BAT for engines with frequent load variation, including frequent start up and shut down periods due to technical constraints. A SCR unit would not function effectively when the operating conditions and the consequent catalyst temperature are fluctuating frequently outside the necessary effective temperature window. As a result, SCR is part of BAT, but no specific emission levels	

Aspect of BAT	BAT	Status at Installation
	are associated with BAT in a general sense. The BAT conclusion for the prevention and control of NO_X emissions are summarised in Figure 21.	
BAT for liquid fuel-fired (diesel) engines **CO and hydrocarbon emissions**	For the minimisation of air emissions, good maintenance of the engine is regarded as BAT. A diesel engine has low CO and hydrocarbon (HC) emissions. CO emissions are often in opposite to NO_X emissions. CO can be reduced by primary measures aiming at complete combustion. Secondary measures such as oxidation catalysts for CO reduction can also be regarded as BAT. Oxidation catalysts are not recommended in context with liquid fuels containing sulphur. For engines, CO catalysts are available on the market and are regarded as part of the BAT conclusion. The first combined CO/NMHC catalysts have been installed in some spark-ignited engine plants and running experience is currently being gathered.	This section does not apply since no diesel engines are to be operated by ENE.
BAT for liquid fuel-fired (diesel) engines **Water pollution**	The engine plant needs only small amounts of water and can thus be operated in locations with restricted water supplies, especially if radiator cooling is applied. Together with the reduced water requirement, is the lower generation of waste water discharge, and thus consequently less thermal pollution to the surrounding watercourse.	This section does not apply since no diesel engines are to be operated by ENE.

[1] A split view from one Member State appeared about the inclusion of 'diesel engine' in this document, because diesel engines are used for power generation, only on the islands which are not interconnected to the mainland grid. Such installations which exceed 50 MWth in aggregated installed capacity are used due to the diesel engines special technical characteristics, which match the peculiarities of the electricity demands of these isolated islands. The installations operate at their full capacity only for a short period of time each year, namely the touristic season (for approximately two months). For the rest of the year, the installations operate at a small part of their capacity (approximately 1/4).

Figure 14:

Material	Pollutant	BAT (not exhaustive list)
Liquid fuel	Water contamination	∞ the use of liquid fuel storage systems that are contained in impervious bunds that have a capacity capable of containing 50 - 75 % of the maximum capacity of all tanks or at least the maximum volume of the biggest tank. Storage areas should be designed so that leaks from the upper portions of tanks and from delivery systems are intercepted and contained in the bund. Tank contents should be displayed and associated alarms used. The use of planned deliveries and automatic control systems can be applied to prevent the overfilling of storage tanks ∞ pipelines placed in safe, open areas aboveground so that leaks can be detected quickly and damage from vehicles and other equipment can be prevented. If buried pipelines are used their course can be documented and marked and safe excavation systems adopted. For underground pipes, double walled type pipes with automatic control of the spacing and special construction of piping (steel pipes, welded connections and no valves in underground section etc.) are BAT ∞ surface run-off (rainwater) that might be contaminated by any spillage of fuel from the storage and handling should be collected and treated before discharge.
Lime and Limestone		∞ enclosed conveyors, pneumatic transfer systems and silos with well designed, robust extraction and filtration equipment on delivery and conveyor transfer points to prevent the emission of dust.
Pure liquified ammonia	Health and safety risk according to ammonia	∞ for handling and storage of pure liquified ammonia: pressure reservoirs for pure liquified ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealling process ∞ from a safety point of view, the use of an ammonia water solution is less risky than the storage and handling of pure liquefied ammonia.

Table 6.41: BAT for the unloading, storage and handling of liquid fuel and additives

Figure 15:

Capacity (MW_{th})	Dust emission level (mg/Nm^3)		BAT to reach these levels	Monitoring	Applicability
	New plants	Existing plants			
50 – 100	5 – 20[(1)]	5 – 30[(2)]	ESP/FF	Continuous [(1,2)]	New and existing plants
100 – 300	5 – 20[(3)]	5 – 25[(4)]	ESP/FF/in combination FGD (wet) (depending on the specific plant size)	Continuous	New and existing plants
>300	5 – 10[(5)]	5 – 20[(6)]	ESP/FF/in combination with FGD (wet)	Continuous	New and existing plants

Notes:
ESP (Electrostatic precipitator) **FF** (Fabric filter) **FGD(wet)** (Wet flue-gas desulphurisation)

	Industry and one Member State declared that emission levels have to be presented for cases where dust emissions are controlled by ESPs only without the application of a wet FGD. The following levels were proposed:
1, 2	10 – 50 mg/Nm^3 for ESP, monitoring periodically
3, 5	upper level 30 mg/Nm^3 for ESP
4, 6	upper level 50 mg/Nm^3 for ESP
1 – 6	50 – 100 mg/Nm^3 for burners with steam atomisation or use of additives regardless of the existing power plant's capacity.
3 – 6	Industry claimed an upper level of 15 mg/Nm^3 for ESP or FF in combination with a wet FGD
4, 6	One Member State proposed that the BAT range for existing plants with a capacity over 100 MW_{th} should be 10 – 50 mg/Nm^3, because these levels comply with the Member States emission limits.
2	One Industry representative mentioned that dust emissions of around 50 mg/Nm^3 are achieved. To reduce this to 30 mg/Nm^3 by fitting fabric filters or ESPs to achieve a corresponding reduction of around 20 tonnes of dust per year cannot represent BAT.

Table 6.42: BAT for dedusting off-gases from liquid fuel fired combustion plants

Figure 16:

Capacity (MW_{th})	SO_2 emission level associated with BAT (mg/Nm^3)		BAT options to reach these levels	Applicability	Monitoring
	New plants	Existing plants			
50 – 100	100 – 350(1)	100 – 350(2)	Low sulphur fuel oil co-combustion of gas and oil FGD (dsi) or FGD (sds)	New and existing plants	Continuous
100 – 300	100 – 200(3)	100 – 250(4)	Low sulphur fuel oil co-combustion of gas and oil and FGD (dsi) or FGD (sds) or FGD (wet) (depending on the plant size) Seawater scrubbing Combined techniques for the reduction of NO_x and SO_2	New and existing plants	Continuous
>300	50 – 150(5)	50 – 200(6)	Low sulphur fuel oil co-combustion of gas and oil and FGD (wet) FGD (sds) Seawater scrubbing Combined techniques for the reduction of NO_x and SO_2	New and existing plants	Continuous

Notes: **FGD(w et)** (Wet flue-gas desulphurisation) **FGD(sds)** (Flue-gas desulphurisation by using a spray drier) **FGD(dsi)** (Flue-gas desulphurisation by dry sorbent injection)	
	The following levels were proposed by Industry and the one Member State:
1,2	range to be 200 – 850 mg/Nm^3
3, 4, 6	upper level 400 mg/Nm^3
5	upper level 200 mg/Nm^3
2, 4, 6	Industry declared no BAT level should be given if low sulphur fuel is used. Their rationale is that for oil-fired LCPs, the SO_2 emission levels by using low sulphur fuel in combination with FGD are designed to optimise environmental benefit with the high cost of fuel and the FGD. The high net unit efficiency requirement has to be optimised among the cost of the fuel, the emission control technique performance (low emission levels) and the related energy consumption (energy penalty). The Member State argued that heavy fuel oil burners operate with a very high cost fuel. The SO_2 reduction techniques and the associated emission levels have to be reasonable, in order to ensure the economic viability of the plants, with very careful assessment of the environmental benefit against all the costs and the cross-media effects involved. It is very important for existing plants to allow the use of low sulphur fuel only in order to avoid any drop in net unit efficiency.
6	One Member State proposed that the BAT range for exisiting plants over 300 MW should be 200 – 400 mg/Nm^3, because these levels comply with the Member States emission limits.

Table 6.43: BAT for the prevention and control of sulphur dioxide from liquid fuel-fired combustion plants

Figure 17:

	NO_x emission level associated with BAT (mg/Nm^3)		BAT options to achieve these levels	Applicability	Monitoring
	new plants	Existing plants			
50 - 100	150 – 300[(1)]	150 – 450	Combination of Pm (such as air and fuel staging, low-NO_x burner, etc. For LFO firing NO_X <300 mg/Nm^3 For HFO firing with max 0,2 % N in fuel oil NO_X <360 mg/Nm^3 fFr HFO firing with max 0,3 % N in fuel oil NO_X <450 mg/Nm^3 SCR SNCR in case of HFO firing	New and existing plants	Continuous [(6)]
100 - 300	50 – 150[(2)]	50 – 200[(3)]	Combination of Pm (such as air and fuel staging, low-NO_x burner, reburning, etc) in combination with SNCR, SCR or combined techniques	New and existing plants	Continuous
>300	50 – 100[(4)]	50 – 150[(5)]	Combination of Pm (such as air and fuel staging, low-NO_x burner, reburning, etc) in combination with SCR or Combined techniques	New and existing plants	Continuous
	Industry and one Member State proposed the following levels				
1, 5	upper level 400 mg/Nm^3				
2, 4	upper level 200 mg/Nm^3				
3	upper level 450 mg/Nm^3				
6	Industry claimed that they wanted to change 'continuous' by 'periodical' monitoring The rationale given for existing plants is that the new values proposed allow power plants to use heavy fuel oil with high N content with NO_x abatement primary measures only				
5	One Member State proposed that the BAT range for existing plants over 300 MW should be 100 – 400 mg/Nm^3, because these levels comply with the Member States emission limits				
1	A TWG member proposed to reduce the lower end of the range to 100 mg/Nm^3, because this reflected the performance of SCRs				

Table 6.44: BAT for nitrogen oxide prevention and control in liquid fuel-fired combustion plants

Figure 18:

Emission to water from Wet FGD waste water treatment plant (mg/l)	
COD	<150
F	1 – 30
Nitrogen compounds	<50
Solids	5 – 30
Sulphate	1000 – 2000
Sulphide	<0.2
Sulphite	0.5 – 20
Cd	<0.05
Cr	<0.5
Cu	<0.5
Hg	0.01 – 0.02
Ni	<0.5
Pb	<0.1
Zn	<1

Table 6.45: Emissions levels associated with the use of a BAT – FGD waste water treatment plant given as a representative 24 hour composite sample

Figure 19:

Technique	Main environmental benefit	Applicability	
		New plants	Retrofitted plants
For plants with wet FGD			
Water treatment by flocculation, sedimentation, filtration, ion-exchange and neutralisation	Removal of fluoride, heavy metals, COD and particulates	BAT	BAT
Ammonia reduction by air stripping, precipitation or biodegradation	Reduced ammonia content	BAT only if ammonia content in waste water is high because of SCR/SNCR used upstream FGD	
Closed loop operation	Reduced waste water discharge	BAT	BAT
Regeneration of demineralisers and condensate polishers			
Neutralisation and sedimentation	Reduced waste water discharge	BAT	BAT
Elutriation			
Neutralisation		BAT only in the case of alkaline operation	
Washing of boilers, air preheaters and precipitators			
Neutralisation and closed loop operation, or replacement by dry cleaning methods	Reduced waste water discharge	BAT	BAT
Surface run-off			
Sedimentations or chemical treatment and internal re-use	Reduced waste water discharge	BAT	BAT

Table 6.46: BAT for waste water treatment

Figure 20:

Engine type	Dust-emission level (mg/Nm^3)	Monitoring	Comments
Diesel engine	<30 LFO/diesel <50$^{(1)}$ HFO	Discontinuous once every 6 month	Steady state 85 to 100 % load of the engine. O_2-reference point at 15 vol-%, Nm^3 at 273 K and 101.3 kPa.
A dual fuel engine in back-up fuel mode (diesel oil max. 0.02 wt-% ash)	<30 LFO/diesel <50$^{(1)}$ HFO	Discontinuous once every 6 month	Particle filter systems are under development for engines over 5 MWth
1	One Member State claimed that dust emission levels from diesel engines burning heavy fuel oil should be increased to 100 mg/Nm^3 at 15 % O_2, because for diesel engines (4-stroke or 2-stroke) this higher value better reflects the dust emissions for HFO and consider the influence of other fuel parameters better apart from the ash content, such as sulphur and asphaltenes content.		

Table 6.47: BAT for dedusting off-gases from four stroke engine plants by primary engine measures

Figure 21:

Engine type	BAT	Applicability	Monitoring	Comments
Diesel oil-fired engine plant	Miller-type engine, injection retard, water injection SCR	SCR can be applied to new and existing plants	Continuous	O_2 reference point at 15 vol-%, Nm^3 at 273 K and 101.3 kPa
A dual fuel engine in back-up mode	Miller-type engine, injection retard, water injection SCR	SCR can be applied also to dual fuel engines for the gas fuel mode and the back-up mode	-	O_2 reference point at 15 vol-%, Nm^3 at 273 K and 101.3 kPa
Light fuel-fired engine plant	Miller-type engine, injection retard, water injection SCR	SCR can be applied to new and existing plants	Continuous	O_2 reference point at 15 vol-%, Nm^3 at 273 K and 101.3 kPa
Heavy fuel oil-fired engine plant	Miller-type engine, injection retard, water injection SCR	SCR can be applied to new and existing plants	Continuous	O_2 reference point at 15 vol-%, Nm^3 at 273 K and 101.3 kPa

Table 6.48: BAT associated NO_X levels for liquid fuel-fired engine plants with SCR as BAT

Part 4. Combustion techniques for gaseous fuels

Aspect of BAT	BAT	Status at Installation
Supply and handling of gaseous fuels and additives	BAT in preventing releases related to the supply and handling of gaseous fuels, but also for storage and handling of additives such as ammonia etc. are summarised in Figure 22.	This section does not apply since no gas-fired combustion plants are to be operated by ENE.
Thermal efficiency of gas-fired combustion plants	To reduce greenhouse gases, in particular releases of CO_2 from gas-fired combustion plants such as gas turbines, gas engines and gas-fired boilers, the best available options from today's point of view are techniques and operational measures to increase the thermal efficiency of the plant. Secondary measures, i.e. CO_2 capture and disposal as described in Annex 10.2 of BREF, are at a very early stage of development. These emerging techniques might be available in the future, but they cannot yet be considered as BAT. The energy efficiency has been considered as heat rate (fuel input energy/energy output at power plant border) and as power plant efficiency, which here is the inverse of heat rate, i.e. the percentage of produced energy/fuel input energy. The fuel energy is measured as the lower heating value. For gas-fired combustion plants, the application of gas turbine combined cycles and the co-generation of heat and power (CHP) are technically the most efficient means of	This section does not apply since no gas-fired combustion plants are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	increasing the energy efficiency (fuel utilisation) of an energy supply system. A combined cycle operation and co-generation of heat and power is, therefore, to be considered as the first BAT option, i.e. whenever the local heat demand is great enough to warrant the construction of such a system. The use of an advanced computerised control system in order to achieve a high boiler performance with increased combustion conditions that support the reduction of emissions are also considered as BAT. Improvement of the efficiency can also be obtained by preheating the natural gas, before its supply to the combustion chambers or burners. The heat can be obtained from low temperature sources, such as the exhaust gases from cooling from other regenerative processes. Gas engine driven power plants are suited for both decentralised heat and power production (CHP) as well as for bigger base load applications. The BAT associated total efficiencies are up to 60 – 70 % in low pressure steam generation. With supplementary firing (i.e. when the oxygen content of the engine flue-gas acts as the main 'combustion air' in the burner) a large amount of low pressure or high pressure steam can be generated in an efficient way, In hot water production (with outlet temperatures typically in range of 80 – 120ºC), a total efficiency (fuel utilisation) of up to 90 % in gas fuel mode can be seen as BAT, although highly depending on the portion of the engine cooling water energy recovered in the application. Hot water of up to 200ºC can, of course, be produced by utilising the energy in	

Aspect of BAT	BAT	Status at Installation
	the flue-gas and part of the engine cooling energy. Another advantage is the high thermal efficiency (i.e. low fuel consumption, and consequently low specific CO_2 emissions) of the engines. The BAT electrical efficiency (at alternator terminals) ranges from about 40 to 45 % (depending on the engine size) and is calculated on the lower heating value of the fuel. For existing plants, a number of retrofit and repowering techniques can be applied to improve the thermal efficiency. The technical measures described in BREF Section 2.7.8 should be taken into account as part of BAT options to improve the efficiency of existing plants. By applying the techniques and the measures listed in BREF Section 7.4.2, to improve the thermal efficiency such as double reheat, and using the most advanced high temperature materials for gas turbines and boilers, energy efficiencies associated with the use of BAT can be achieved as summarised in Figure 23. In addition, the following measures also needs to be taken into consideration to increase the efficiency: ➢ combustion: minimising the heat loss due to unburned gases ➢ the highest possible pressure and temperature of the working medium gas or steam ➢ the highest possible pressure drop in the low pressure end of the steam turbine through the lowest possible temperature of the cooling water (fresh water cooling) for boilers and CCGT plants	

Aspect of BAT	BAT	Status at Installation
	➢ minimising the heat loss through the flue-gas (utilisation of residual heat or district heating) ➢ minimising the heat loss through conduction and radiation with isolation ➢ minimising the internal energy consumption by taking appropriate measures, e.g. scorification of the evaporator, greater efficiency of the feed water pump, etc.) ➢ preheating the fuel gas and or the boiler feed water with steam ➢ improved blade geometry of the turbines.[2] It should be borne in mind that these BAT levels are not achievable in all operation conditions. The energy efficiency is at its best at the design point of the plant. The actual energy efficiencies throughout the operational period of the plants may also be lower due to changes, for instance changes in the load during the operation, quality of the fuel, etc. The energy efficiency also depends on the cooling system of the power plant, and on the energy consumption of the flue-gas cleaning system. It should also be recognised that high efficiency gas turbine systems may generate problems such as vibration and higher short term NO_X emissions.	
Dust and SO_2 emissions from gas fired combustion plants	For gas-fired combustion plants using natural gas as a fuel, emissions of dust and SO_2 are very low. The emission levels of dust by using natural gas as a fuel are normally well below 5 mg/Nm^3 and SO_2 emissions are well below 10 mg/Nm^3 (15 % O_2), without any additional technical	This section does not apply since no gas-fired combustion plants are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	measures being applied. If other industrial gases are used as a fuel such as refinery gas or blast furnace gas, pre treatment gas cleaning measures (such as fabric filters) needs to be applied and considered as BAT, in order to reduce the dust content and the amount of SO_2 in the flue-gas, which may otherwise damage the gas turbines or engines. As mentioned in the Refinery BREF, BAT is to limit the H_2S content of the refinery gas to 20 – 150 mg/Nm^3 leading to an emission of 5 – 20 mg of SO2/Nm^3. Such gas does not create particulate emissions. In the case of natural gas refineries, also refer to the Mineral Oil and Gas Refinery BREF.	
NO_X and CO emissions from gas-fired combustion plants	In general, for gas turbines, gas engines and gas fired boilers, reduction of nitrogen oxides (NO_X) is considered to be BAT. The nitrogen compounds of interest are nitric oxide (NO) and nitrogen dioxide (NO_2), collectively referred to as NO_X. For new gas turbines, dry low NO_X premix burners (DLN) are BAT. Most existing gas turbines can be converted to the dry low NO_X premix burner (DLN) technique, but sometimes the use of water and steam injection can be a better solution. This needs to be decided case by case. Several gas turbine and gas engines operating in Europe, Japan and the US have also applied SCR to reduce the emissions of NO_X. Beside the dry low NO_X premix burner technique (DLN) and the injection of water and steam, SCR is also considered to be part of the BAT conclusion.	This section does not apply since no gas-fired combustion plants are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	For new gas turbines, the DLN burners can be seen as the standard technique so that the application of an additional SCR system is, in general, not necessary. For further reduction of NO_X, SCR can be considered where local air quality standards request a further reduction of NO_X emissions compared to the levels given in Figure 24 (e.g. operation in densely populated urban areas). In Figure 24 emergency machinery has not be taken into account. For existing gas turbines, water and steam injection or conversion to the DLN technique is BAT. Gas turbines of unchanged combustion design, but with higher inlet temperatures, have higher efficiencies and higher NO_X values. In this context, it should be noted that with a higher efficiency the specific NO_X emission per kWh are still lower. SCR retrofitting is technically feasible, but not economical for existing CCGT plants if the required space in the HRSG was not foreseen in the project and is therefore not available.[3] For gas-fired stationary engine plants, the lean-burn approach is BAT analogous to the dry low NO_X technique used in gas turbines. This is an inbuilt method and no extra reagents or water need to be supplied to the site for NO_X reduction. Because gas engines are sometimes equipped with an SCR, these techniques can also be considered as part of BAT. To reduce the CO emissions, the application of oxidation catalysts is BAT with the associated emission	

Aspect of BAT	BAT	Status at Installation
	levels for natural gas firing mentioned in Figure 25. In the case of buring other gasous fuels such as biogas or landfill gases, the CO emission can be higher due to the specific fuel used. The NMVOC emissions from spark ignited lean burn gas (SG) engines and dual fuel (DF) engines in gas mode depend on the composition of natural gas. NMVOC secondary emission reduction techniques might, in some cases, be needed and an oxidation catalyst for simultaneous CO and NMVOC reduction can be applied. CO values kept below 100 mg/Nm^3 (15 % O_2) and formaldehyde values below 23 mg/Nm^3 (15 % O_2) are considered as BAT for a gas-fired engine equipped with an oxidation catalyst. BAT for the minimisation of CO emissions is complete combustion, which goes along with good furnace design, the use of high performance monitoring and process control techniques and maintenance of the combustion system. Besides the combustion conditions, a well optimised system to reduce emissions of NO_X will also keep the CO levels below 100 mg/Nm^3. In addition, the application of an oxidation catalyst for CO can be seen as BAT when it is operated in densely populated urban areas. The BAT conclusion for the prevention and control of NO_X and CO emissions and the associated emission levels are summarised in Figure 24 and Figure 25. Flue-gases from gas turbines and gas engines typically contain about 11 – 16	

Aspect of BAT	BAT	Status at Installation
	vol-% O_2 and, therefore, the emission levels associated with the use of BAT for turbines and engines have been based on an O_2 level of 15 vol-%, and standard conditions as the reference point. For gas-fired boilers, 3 vol-% O_2 is usually used as a reference level. The BAT associated emission levels are based on daily average, standard conditions and represents a typical load situation. For peak load, start up and shut down periods as well as for operational problems of the flue-gas cleaning systems, short-term peak values, which could be higher have to be regarded. For refinery gas refer to Mineral Oil and Gas Refinery BREF. In the case of Natural gas refineries, also refer to the Mineral Oil and Gas Refinery BREF.	
Water pollution	Different waste water streams (see BREF Chapter 1) are generated by gas-fired combustion plants. To reduce emissions to water and to avoid water contamination, all measures that have been presented in BREF Section 7.4.4 are considered to be BAT. Small amounts of oil contaminated (washing) water cannot be prevented from occurring occasionally at a power plant. Oil separation wells are, in general, sufficient to avoid any environmental damage. The other techniques described for waste water treatment in BREF Chapter 3 can, in general, also be considered as BAT for this sector.	This section does not apply since no gas-fired combustion plants are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
Combustion residues	A lot of attention has already been paid by industry to the utilisation of combustion residues and by-products instead of depositing them in landfills. Utilisation and re-use is, therefore, the best available option.	
BAT for combustion installations operated on offshore platforms	The conclusions on BAT for the offshore sector have taken into account that combustion installations operated offshore are used in a more complex and potentially hazardous environment than in onshore power stations. In addition, space and weight are at a premium, leading to a much higher equipment density than is common in onshore applications. In addition, any undue complexity is generally avoided offshore, because of weight, space, safety and operability factors. Therefore, techniques such as water and steam injection, which require a high quality water treatment plant or SCR with additional storage of ammonia, have not been considered as BAT for offshore applications to reduce NO_X emissions. In general, for new gas turbines operated on offshore platforms, the reduction of nitrogen oxides (NO_X) by using primary measures such as dry low NO_X premix burners (DLN) is considered to be BAT as far as this technique is available. The associated emission level of NO_X by using the dry low NO_X premix burners (DLN) for gas turbines is less than 50 mg/Nm^3. As the flame stability needs to be maintained over the full range of operating conditions, it may not be practical to maintain staged combustion at low rates, such as at start-up and part load operation. The formation of NO_X is not reduced during such periods	This section does not apply since no combustion installations on offshore platforms are to be operated by ENE.

Aspect of BAT	BAT	Status at Installation
	and hence the occurrence and duration of these periods should be minimised. Retrofitting of existing offshore gas turbines is much more expensive compared to land-based turbines due to the modification work costs. Retrofitting the DLN technology in existing offshore gas turbines is limited due to higher costs and a restriction of space within the turbine package for new fuel manifolds or combustion chambers. For aeroderivative turbines often used offshore, retrofitting to DLN is generally much more complex than for industrial turbines. The whole combustion section has to be replaced, and due to the larger outer diameter of the DLN combustion section, the gas turbine centreline is shifted. The applicability of retrofitting the DLN technology will, therefore, differ from platform to platform due to the type of turbine, the complexity, the age, etc. The BAT level for existing installations has to be determined on a case by case basis. To reduce the environmental impact of offshore gas turbines, the following measures are part of the BAT conclusion: ➢ for new installations, selecting turbines which can achieve both a high thermal efficiency and a low emissions spectrum ➢ using dual fuel turbines only where operationally necessary ➢ minimising ‘spinning reserve’ ➢ providing a fuel gas supply from a point in the	

Aspect of BAT	BAT	Status at Installation
	topside oil and gas process which offers a minimum range of fuel gas combustion parameters, e.g. calorific value, etc. ➢ providing a fuel gas supply from a point in the topside oil and gas process which offers minimum concentrations of sulphurous compounds – to minimise SO2 formation ➢ operating multiple generator or compressor sets at load points which minimise pollution ➢ optimising the maintenance and refurbishment programmes ➢ optimise and maintain inlet and exhaust systems in a way that keeps the pressure losses as low as possible ➢ optimise the process in order to minimise the mechanical power requirements and pollution ➢ utilisation of gas turbine exhaust heat for platform heating purposes. Modern ‘diesel’ engines are available with high pressure fuel injection controlled by electronics. Additionally, optimised combustion chambers and portings have been developed. This technology can result in increased fuel economy, reduced NO_X and other gaseous emissions and reduced smoke, particularly during acceleration and start-up. Where available, it represents the BAT for minimising emissions such as SO_2 and NO_X. To reduce the environmental impact of offshore engines, the following measures are part of the BAT conclusion:	

Aspect of BAT	BAT	Status at Installation
	o for new engines, selecting diesels which achieve both high thermal efficiency and a low emissions spectrum o where process gas is used as fuel, providing a supply from a point in the topside process which will offer minimum emissions of, e.g. SO_2. For liquid distillate fuels, preference should be given to low sulphur types o for larger diesels, considering gas fuelling with a ‘ torch oil’ ignition charge o optimising injection timing o operating multiple generator or compressor sets at load points which minimise pollution o optimising maintenance and refurbishment programmes. Low NO_X burners are available for many gas fired heaters, boilers and furnaces. This represents BAT for minimising NO_X, although the effect and trade off with fuel consumption must be evaluated. Other measures to increase the energy efficiency of offshore installations and thus to reduce the emissions per unit of energy used, such as the application of CHP plants, are part of the BAT conclusion. Techniques that assist the optimised use of equipment such as those based on operational monitoring approaches are BAT. In this case, the gas turbine is ‘baselined’, and predictive software is used to calculate the emissions. This software may also be used to indicate to the offshore operation personnel the optimum	

Aspect of BAT	BAT	Status at Installation
	operating point(s) for single or multiple turbine installations. Such systems do not remove the need for emission compliance checks, but may assist personnel to operate the overall combustion system more efficiently. Other techniques, like PEMS (parametric emission monitoring system) are BAT for both new and existing combustion installations operating offshore. The system offers cost effective solutions for emission monitoring and calculating the emissions. In addition it can also be used to optimise the combustion processes and maintenance schedule of gas turbines. Power integration of multiple fields is BAT and, where applicable, needs to be decided on a platform by platform and field by field basis.	

[2] There was a split view from industry about the efficiency measures applied to CCGT plants, because the proposed measures will only have a marginal improvement of the total combined cycle efficiency. It should be noted that improvements of the gas turbine efficiency may result in a decrease of efficiency of the steam cycle. Therefore, the improvement of efficiency of the total cycle will be less than the improvement of the efficiency of the gas turbine only. Based on the above given rationale, industry is of the opinion that the proposed measures shall not be incorporated in the final draft of the BREF LCP.

[3] A split view was declared by industry saying that in the case of combined cycles, the HRSG has to be modified, which means dismantled and retrofitted to enable the incorporation of an SCR.
This will increase the already high investments of SCR. Furthermore, the operation and maintenance costs of an SCR are relatively high, therefore, SCR is not cost effective for existing combined cycles. Industry also declared that, in the case of simple cycle gas turbines, SCR is not cost effective, because

a) the gases have to be cooled down. This requires an additional cooler to reduce the gas temperature to a level to enable the SCR to operate. This cooler will increase the already high investments and operational costs, and

b) simple cycle gas turbines in Europe are peak load plants, which run in emergency cases only. The high investment, operation and maintenance costs make the implementation of an SCR in a gas turbine economically unviable.

Figure 22:

Material	Environmental effect	BAT
Natural gas	Fugitive emissions	∞ using fuel gas leak detection systems and alarms.
	Efficient use of natural resources	∞ using expansion turbines to recover the energy content of the pressurised fuel gases ∞ preheating the fuel gas by using waste heat from the boiler or gas turbine
Pure liquified ammonia (if used)	Health and safety risk according to ammonia	∞ for handling and storage of pure liquified ammonia, pressure reservoirs for pure liquified ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealling process ∞ from a safety point of view, the use of an ammonia-water solution is less risky than the storage and handling of pure liquefied ammonia.

Table 7.34: BAT for the supply and handling of gaseous fuels

Figure 23:

Plant type	Electrical efficiency (%)		Fuel utilisation (%)	Remarks
	New plants	Existing plants	New and existing plants	
Gas turbine				
Gas turbine	36 – 40	32 – 35	-	
Gas engine				
Gas engine	38 – 45		-	
Gas engine with HRSG in CHP mode	>38	>35	75 – 85	The wide range of energy efficiency in CHP plants is very much dependent upon the specific situation and the local demand of electricity and heat
Gas–fired boiler				
Gas–fired boiler	40 – 42	38 – 40		
CCGT				
Combined cycle with or without supplementary firing (HRSG) for electricity generation only	54 – 58	50 – 54	-	
Combined cycle without supplementary firing (HRSG) in CHP mode	<38	<35	75 – 85	The wide range of the electrical and energy efficiency of CHP plants very much depends on the specific local demand for electricity and heat. By operating the CCGT in the CHP mode, the energy efficiency includes the amount of the electrical efficiency and should always be seen together to achieve the best overall exergetic efficiency.
Combined cycle with supplementary firing in CHP mode	<40	<35	75 – 85	

Table 7.35: Efficiency of gas-fired combustion plants associated to the use of BAT (based on ISO conditions)

Figure 24:

Plant type	Emission level associated with BAT (mg/Nm^3)		O_2 level (%)	BAT options to reach these levels	Monitoring
	NO_x	CO			
Gas–fired boilers					
New gas–fired boilers	50 – 100[1]	30 – 100	3	Low-NO_x burners or SCR or SNCR	Continuous
Existing gas–fired boiler	50 – 100[2]	30 – 100	3	Low-NO_x burners or SCR or SNCR	Continuous
CCGT					
New CCGT without supplementary firing (HRSG)	20 – 50	5 – 100	15	Dry low-NO_x premix burners or SCR	Continuous
Existing CCGT without supplementary firing (HRSG)	20 – 90[3]	5 – 100[5]	15	Dry low-NO_x premix burners or water and steam injection or SCR if the required space has already been forseen in the HRSG	Continuous
New CCGT with supplementary firing	20 - 50	30 – 100	Plant spec.	Dry low-NO_x premix burners and low-NO_x burners for the boiler part or SCR or SNCR	Continuous
Existing CCGT with supplementary firing	20 – 90[4]	30 – 100 [5	Plant spec.	Dry low-NO_x premix burners or water and steam injection and low-NO_x burners for the boiler part or SCR if the required space has already been foreseen in the HRSG or SNCR	Continuous

	Industry claimed that the ranges need to be changed to:
1,2	upper end to 120 mg/Nm^3
3	80 – 120 mg/Nm^3 because gas fired boilers depend on the firing temperature, the type of burners, the size of the boiler, the heating surfaces, the air temperature and the load factor of the power plant. In case the boiler is equipped with flue-gas recycling it is possible to decrease the NO_x emission to a level of 100 mg/Nm^3. However, retrofitting an existing boiler with flue-gas recycling will require high (not cost effective) investment costs.
2	One Member State proposed that for existing gas fired boilers, which have been converted recently from heavy fuel oil to burn natural gas, after full modification with primary measures to reduce NO_X (flue-gas recirculation, fuel and air staging), the BAT achievable emission levels should be modified to 10 – 150 mg/Nm^3.
4	Industry mentioned that due to the large wall burners which are used for supplementary firing of the HRSG the NO_x emission of the gas turbine may increase in 10 – 20 mg/Nm^3. This increase is caused by local high temperatures of these duct burners. Therefore, the level associated with BAT in the case of supplementary firing should be 80 – 140 mg/Nm^3.
3,4	One Member State claimed that the upper BAT levels for CCGT plants >50 MW cannot be over 80 mg/Nm^3 and for plants over 200 MW the upper BAT level should be below 35 mg/Nm^3 because these levels have already been fixed as ELVs in the Member State in question.
5	One Member State claimed that the upper levels of CO for CCGT plants >50 MW cannot be over 35 mg/Nm^3 because this level has already been fixed as ELV in the Member State in question.

Table 7.37: BAT for the reduction of NO_X and CO emissions from some gas-fired combustion plants

Figure 25:

Plant type	Emission level associated with BAT (mg/Nm^3)		O_2 level (%)	BAT options to reach these levels	Monitoring
	NO_x	CO			
Gas turbines					
New gas turbines	20 - 50	5 – 100	15	Dry low-NO_x premix burners (standard equipment for new gas turbines) or SCR	Continuous
DLN for existing gas turbines	20 - 75	5 - 100	15	Dry low-NO_x premix burners as retrofitting packages if available	Continuous
Existing gas turbines	50 – 90(1)	30 - 100	15	Water and steam injection or SCR	Continuous
Gas engines					
New gas engines	20 – 75(2)	30 – 100(3)	15	Lean burn concept low-NO_x tuned and oxidation catalyst for CO or SCR and oxidation catalyst for CO	Continuous (4)
New gas engine with HRSG in CHP mode	20 – 75(2)	30 – 100(3)	15	Lean burn concept low-NO_x tuned and oxidation catalyst for CO or SCR and oxidation catalyst for CO	Continuous (4)
Existing gas engines	20 – 100 (2)	30 – 100(3)	15	Low-NO_x tuned	Continuous (4)

1	Industry and one Member State claimed that the amount of water or steam that can be injected in an existing gas turbine is limited. Injection high amounts of water or steam may lead to damage of gas turbine components. Therefore, they claimed that the range needs to be substituted by 80 – 120 mg/Nm^3.
2	Industry claimed that these ranges are not according the BAT approach. The reason given was that the range given as BAT is the same as the one given by the American LAER approach (lowest achievable emission rate). Industry proposed an environmental quality driven approach taking the surrounding (urban/other areas) into account. That means that small plants situated in rural areas shall have leaner BAT levels than large plants in city areas. Industry claimed that levels of 190 mg/Nm^3 (15 % O_2) in gas mode represented the overall emission optimum considering the lowest possible fuel consumption and unburned gaseous emission of CO, VOC etc. for spark-ignited (SG) and dual fuel engines (DF) in gas mode.
3	Industry mentioned that due to technical reasons (fuel composition impact), CO should be at a level of 110 – 380 mg/Nm^3 (15 % O_2) in order to represent BAT.
 2 3	Another Industry representative claimed that the ranges should be changed to: 90 – 190 mg/Nm^3 100 mg/Nm^3 because the emission levels associated with BAT for gas engines are only applicable for burning natural gas and not for renewable gases like landfill gas, biogas or purification gas. Moreover, they claimed that such levels would create disadvantages for competitiveness in the market for such gases.
4	One Industry representative proposed charging to discontinuous monitoring because continuous engine emission monitoring is not common practice for stationary internal combustion engines.

Table 7.36: BAT for the reduction of NO_X and CO emissions from some gas-fired combustion plants

Part 5. Co-combustion of waste and recovered fuel

Aspect of BAT	BAT	Status at Installation
Acceptance and pre-acceptance criterias	BAT is to have complete pre-acceptance and acceptance criteria defined according to the BAT defined in the Waste Treatment BREF.	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.
Storage and handling of secondary fuel	For the storage, unloading and handling of secondary fuel the measures and techniques presented as BAT in the fuel specific chapters and in BREF Section 8.4.1 are all considered to be BAT for the use of co-combustion to reduce fugitive emission of dust and odorous substances. In addition, the use of suction equipment and subsequent cleaning devices for closed facilities storing sewage sludge (including the possibility of leading the polluted suction air directly to the combustion chamber or burner, where it might be used as combustion air) has been considered as BAT due to the reduced risk of explosion. Concerning health and safety, the described measures to protect the workers need to be taken into account (reference is made to national health and safety regulations). Apart from this, the BAT conclusion laid down in the BREF on the storage of bulk and dangerous substances and the waste treatment BREF also needs to be taken into account during the storage and handling of secondary fuel.	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.
Pre-treatment of secondary fuel	For the pre-treatment of secondary fuel, all the measures and techniques presented as BAT in the fuel specific chapters are generally considered to be BAT in order to ensure stable combustion conditions and to separate contaminants from the waste, in order that these waste	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.

Aspect of BAT	BAT	Status at Installation
	materials can be used as secondary fuel. In addition, some pre-treatment measures listed in BREF Chapter 8.4.2 can be considered as BAT. However, it also needs to be noted, that the detailed information on BAT for pre-treatment techniques of waste, including secondary fuel, will be described in the dedicated waste treatment and incineration BREFs.	
Introduction of secondary fuel into the combustion process	For feeding secondary fuel into the combustion chamber (boiler), the measures and techniques presented in BREF Section 8.4.3 are all considered to be BAT in order to ensure stable combustion conditions. However, the choice of the specific technique needs to be decided on a case-by-case basis according to the secondary fuel used. The spraying of liquid secondary fuel over the coal yard has not been considered as BAT because of the potential risk of water and groundwater contamination and due to the possibility of odorous emissions. Beside this, the spraying of liquid secondary fuel may increase the risk of self-ignition of the coal yard.	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.
Air emissions	The BAT conclusion in this section is based on the concept that co-combustion of secondary fuel in large combustion plants should, according to the current EU legislation, not cause higher emissions of polluting substances in that part of the exhaust gas volume resulting from such co-combustion found in the incineration plants (see WI BREF). At this point, it is necessary to mention that plants co-combusting waste have to meet the requirements of the dedicated Waste Incineration Directive (EU Directive	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.

Aspect of BAT	BAT	Status at Installation
	2000/76/EC). Large combustion plants, designed and operated according to BAT as defined in this BREF document operate effective techniques and measures for the removal of dust (including partly heavy metals), SO_2, NO_X, HCl and HF. In general, these techniques can be seen as sufficient and can, therefore, also be considered as BAT for the co-combustion of secondary fuel. The basis for this is the BAT conclusions and, in particular, the emission levels associated with the use of BAT as defined in the fuel specific chapters. Higher input of these pollutants into the firing system can be balanced within certain limits by adaptation of the flue-gas cleaning system and will normally not lead to higher emissions. Input of chlorinated compounds is also limited by the power plant operator to prevent high temperature corrosion. The rationale as to which wastes can be used for co-combustion is based on the specifications of the conventional fuel normally burned in the specific plant and its associated measured emission levels. If the range of impurities of the waste, in particular the content of heavy metals, lies within the same range as that from the normally used conventional fuel, the fuel specific BAT applies also for the co-combustion of this secondary fuel. The first BAT choice in this respect is also the careful selection of the type and mass flow of the secondary fuel, together with limiting the percentage of the secondary fuel that can be co-combusted. The following measures should be taken into	

Aspect of BAT	BAT	Status at Installation
	account in this sense: ➢ screening secondary fuel according to acceptance criteria for critical parameters (see BAT for acceptance and pre-acceptance criterias). These are heating value, water content, ash content, chlorine and fluorine content, sulphur content, nitrogen content, PCB, metals (volatile (Hg, Tl, Pb, Co and Se) and non-volatile (e.g. V, Cu, Cd, Cr, Ni)) and phosphorus and alkaline content (when use animal by-products) ➢ limiting the co-combustion rate of most polluted secondary fuel ➢ pretreating the SF ➢ avoiding Hg entering as an elevated component of the secondary fuel ➢ using gasification of the secondary fuel and cleaning of the produced gas when there are large quantities of secondary fuel with high concentrations of heavy metals (especially Hg) to be used in the LCP ➢ avoiding the introduction of chlorine compounds into the secondary fuel. However, according to the waste used the co-combustion of secondary fuel can, as already explained, lead to increased emissions of heavy metals, in particular mercury, as well as to the emission of VOCs, halides and sometimes dioxins. In this case the adaptation of flue-gas cleaning systems and the additional injection of activated carbon with an associated reduction rate of 70 - 85 % are regarded as BAT.	

Aspect of BAT	BAT	Status at Installation
	The co-combustion of secondary fuel typically leads to a loss of thermal efficiency. In this context, it should be taken into account that the main purpose of the power plant is the generation of energy rather than the thermal treatment of waste. A lost of thermal efficiency is only justified if it is balanced with less emissions of pollutants.	
Water pollution	For the co-combustion of secondary fuel the measures and techniques presented as BAT in the fuel specific chapters and in BREF Section 8.4.5 are all considered to be BAT in order to avoid an additional contamination of water and groundwater sources by the co-combustion of secondary fuel. In this respect, the proper storage and handling of secondary fuel as described earlier will help to achieve this aim. 'Good housekeeping' will prevent substances being spilled and transferred to drains. Because secondary fuel may contain higher levels of heavy metals and other substances, such as halides etc., BAT is to treat this waste water before it is discharged. The process has been described in BREF Section 3.10. With good monitoring and constant optimisation of the process conditions, possibly also with the additional use of organic sulphide, higher inputs of heavy metals can be precipitated and filtrated in the waste water treatment facility to such a level that effluent concentrations do not increase significantly. The quantity of the effluent will not change with co-combustion.	This section does not apply since no co-combustion of waste and recovered fuel is to be carried out by ENE.
Combustion	In the co-combustion of secondary fuel the measures and	This section does not apply since no co-combustion of

Aspect of BAT	BAT	Status at Installation
residues and by-products	techniques presented as BAT in the BREF fuel specific chapters and in Section 8.4.6 also are all considered to be BAT for the co-combustion of secondary fuel. The main BAT issue is maintaining the quality of gypsum, ashes and slag and other residues and by-products at the same level as those occurring without the co-combustion of secondary fuel for the purpose of recycling. If co-combustion leads to significant (extra) disposal volumes of by-products or residues or extra contamination by metals (e.g. Cr, Pb, Cd) or dioxins, additional measures need to be taken to avoid this. One additional measure to consider is to restrict co-combustion to waste fractions with pollutant concentrations similar to primary fuels (e.g. heavy metals, Cl etc.).	waste and recovered fuel is to be carried out by ENE.

Annex I: Comparison of the processes at the Installation with the BREF for Emissions from storage (published July 2006).

Part 1: Storage of liquids and liquefied gases

1.1 Tanks

All tanks have an impervious layer of bitumen beneath which there is mixture of sand and gravel. It also provides homogeneous support.

Aspect of BAT	BAT	Status at Installation
General principles to prevent and reduce emissions **Tank design**	BAT for a proper design is to take into account at least the following: • the physico-chemical properties of the substance being stored • how the storage is operated, what level of instrumentation is needed, how many operators are required, and what their workload will be • how the operators are informed of deviations from normal process conditions (alarms) • how the storage is protected against deviations from normal process conditions (safety instructions, interlock systems, pressure relief devices, leak detection and containment, etc.) • what equipment has to be installed, largely taking account of past experiences of the product (construction materials, valve quality, etc.) • which maintenance and inspection plan needs to be implemented and how to ease the maintenance and	Tanks and associated pipe work are designed and installed according to established standards. As per COMAH site requirements both local and remote level indications are in place on HFO and DO tanks High level alarms are install on all tanks. Local indicators consist of local level gauge indicators on each tank. Pressure transmitters are used for remote level detection. Drippings to check fuel level within tanks are also carried out once daily. Currently HFO “Tank 2” is being overhauled. It is planned that tank 1 will be overhauled following completion of tank2. Maintenance is carried out on the basis of requirement following inspection based on non destructive testing. So as to assess the condition of the tanks for maintenance purposes, ultrasonic testing of shell thickness on fuel tanks

Aspect of BAT	BAT	Status at Installation
	inspection work (access, layout, etc.) • how to deal with emergency situations (distances to other tanks, facilities and to the boundary, fire protection, access for emergency services such as the fire brigade, etc.). See Annex 8.19 for a typical checklist.	is carried out and as per As per IPPC Permit requirements and reported as part of the AER. The installation is supervised by two trained operators on a 24x7 basis. These operators are responsible of inspections. Being a high priority area, any identified maintenance requirements is attended to on an immediate basis. VOC adsorption filtering systems are installed on the HFO tanks. DO tanks do not require VOC filtering systems since fuel is at ambient conditions. The HFO and DO storage facilities are contained within appropriate bunded areas in accordance with good construction recommendations and industry practices. For fire fighting purposes HFO tanks are fitted with a water cooling rings coupled with top pouring foam system. For fire fighting purposes DO tanks are fitted with water cooling rings coupled with semi-sub-surface foam system. Emergency situation have been planned for in the internal Emergency response plan as per SEVESO requirements.
General principles to prevent and reduce emissions	BAT is to apply a tool to determine proactive maintenance plans and to develop risk-based inspection plans such as the risk and reliability based maintenance approach; see Section 4.1.2.2.1.	As per BAT, ENE has moved away from scheduled maintenance approach for fuel storage tanks. Maintenance is carried out on an inspection and requirement basis.

Aspect of BAT	BAT	Status at Installation
Inspection and maintenance	Inspection work can be divided into routine inspections, in-service external inspections and out-of-service internal inspections and are described in detail in Section 4.1.2.2.2.	The following type of inspections carried out: • Routine maintenance • In-service inspections • Out-of service internal inspections Routine maintenance inspections are carried out by two dedicated and trained operators on a 24x7 basis. Being a high priority area, any identified maintenance requirements is attended to on an immediate basis. So as to assess the condition of the tanks for maintenance purposes, ultrasonic testing of shell thickness on fuel tanks is carried out and as per As per IPPC Permit requirements and reported as part of the AER.
General principles to prevent and reduce emissions **Location and lay-out**	For building new tanks it is important to select the location and the layout with care, e.g. water protection areas and water catchment areas should be avoided whenever possible. See Section 4.1.2.3. BAT is to locate a tank operating at, or close to, atmospheric pressure aboveground. However, for storing flammable liquids on a site with restricted space, underground tanks can also be considered. For liquefied gases, underground, mounded storage or spheres can be considered, depending on the storage volume.	Not applicable since new tanks are not to be constructed by ENE.
General principles to	BAT is to apply either a tank colour with a reflectivity of thermal or light radiation of at least 70 %, or a solar shield	All fuel storage tanks are painted in a light colour to enhance reflectivity. As per table 4.2 of BREF, reflectivity

Aspect of BAT	BAT	Status at Installation
prevent and reduce emissions **Tank colour**	on aboveground tanks which contain volatile substances, see Section 4.1.3.6 and 4.1.3.7 respectively.	heat radiant total reflectance is estimated at 70%. No horizontal tanks are implemented therefore no solar shields have been implemented.
General principles to prevent and reduce emissions **Emissions minimization principle in tank storage**	BAT is to abate emissions from tank storage, transfer and handling that have a significant negative environmental effect, as described in Section 4.1.3.1. This is applicable to large storage facilities allowing a certain time frame for implementation.	VOC adsorption filtering systems have been installed on the HFO storage tanks. The implemented system makes use of wet-scrubbing technology. As described above, no emission to air abatement measures are installed DO tanks. With regards to abatement to Soil and water, tanks are bunded. Any spillages are contained within the bunds and passed through oil interceptors. Similarly rainwater and fire fighting water will be retained in the bunds and passed through an oil interceptor.
General principles to prevent and reduce emissions **Monitoring of VOC**	On sites where significant VOC emissions are to be expected, BAT includes calculating the VOC emissions regularly. The calculation model may occasionally need to be validated by applying a measurement method. See Section 4.1.2.2.3. [1]	Emissions are periodically measured during worst case situation (fuel loading) by an independent third party periodically. Currently the external monitor is CADA. The VOC system on the tanks is new, so not much has been done. They are not calculated
General principles to prevent and reduce emissions **Dedicating systems**	BAT is to apply dedicated systems; see Section 4.1.4.4. Dedicated systems are generally not applicable on sites where tanks are used for short to medium-term storage of different products.	As per BAT both the HFO and DO tanks are dedicated system is one which stores only 1 type of fuel.

Aspect of BAT	BAT	Status at Installation
Tank specific considerations **Open top tanks**	Open top tanks are used for the storage of, e.g. manure slurry in agricultural premises and water and other non-flammable or non-volatile liquids in industrial facilities, see Section 3.1.1. If emissions to air occur, BAT is to cover the tank by applying: • a floating cover, see Section 4.1.3.2 • a flexible or tent cover, see Section 4.1.3.3, or • a rigid cover, see Section 4.1.3.4. Additionally, with an open top tank covered with a flexible, tent or a rigid cover, a vapour treatment installation can be applied to achieve an additional emission reduction, see Section 4.1.3.15. The type of cover and the necessity for applying the vapour treatment system depend on the substances stored and must be decided on a case-by-case basis. To prevent deposition that would call for an additional cleaning step, BAT is to mix the stored substance (e.g. slurry), see Section 4.1.5.1.	Section does not apply as there are no open top tanks installed.
Tank specific considerations **External floating roof tank**	External floating roof tanks are used for the storage of, e.g. crude oil; see Section 3.1.2. The BAT associated emission reduction level for a large tank is at least 97 % (compared to a fixed roof tank without measures), which can be achieved when over at least 95 % of the circumference the gap between the roof and the wall	Section does not apply as there are no external floating roof-tanks installed.

Aspect of BAT	BAT	Status at Installation
	is less than 3.2 mm and the seals are liquid mounted, mechanical shoe seals. By installing liquid mounted primary seals and rim mounted secondary seals, a reduction in air emissions of up to 99.5 % (compared to a fixed roof tank without measures) can be achieved. However, the choice of seal is related to reliability, e.g. shoe seals are preferred for longevity and, therefore, for high turnovers. See Section 4.1.3.9. BAT is to apply direct contact floating roofs (double-deck), however, existing non-contact floating roofs (pontoon) are also BAT. See Section 3.1.2. Additional measures to reduce emissions are (see Section 4.1.3.9.2): • applying a float in the slotted guide pole • applying a sleeve over the slotted guide pole, and/or • applying 'socks' over the roof legs. A dome can be BAT for adverse weather conditions, such as high winds, rain or snowfall. See Section 4.1.3.5. For liquids containing a high level of particles (e.g. crude oil), BAT is to mix the stored substance to prevent deposition that would call for an additional cleaning step, see Section 4.1.5.1.	
Tank specific considerations **Fixed roof tanks**	Fixed roof tanks are used for the storage of flammable and other liquids, such as oil products and chemicals with all levels of toxicity, see Section 3.1.3.	HFO and DO stored fall under class (T). Vapour treatment in the form of wet-scrubbing technology is implemented in the HFO tanks. No emission to air,

Aspect of BAT	BAT	Status at Installation
	For the storage of volatile substances which are toxic (T), very toxic (T+), or carcinogenic, mutagenic and reproductive toxic (CMR) categories 1 and 2 in a fixed roof tank, BAT is to apply a vapour treatment installation. [2] For other substances, BAT is to apply a vapour treatment installation, or to install an internal floating roof (see Sections 4.1.3.15 and 4.1.3.10 respectively). Direct contact floating roofs and non-contact floating roofs are BAT. In the Netherlands, the condition for when to apply these BAT is when the substance has a vapour pressure (at 20 ºC) of 1 kPa and the tank has a volume of $\geq 50\ m^3$. In Germany, the condition for when to apply these BAT is when the substance has a vapour pressure (at 20 ºC) of 1.3 kPa and the tank has a volume of $\geq 300\ m^3$. For tanks $< 50\ m^3$, BAT is to apply a pressure relief valve set at the highest possible value consistent with the tank design criteria. The selection of the vapour treatment technology is based on criteria such as cost, toxicity of the product, abatement efficiency, quantities of rest-emissions and possibilities for product or energy recovery, and has to be decided case-by-case. The BAT associated emission reduction is at least 98 % (compared to a fixed roof tank without measures). See Section 4.1.3.15. The achievable emission reduction for a large tank using an internal floating roof is at least 97 % (compared to a fixed	abatement measures are required for DO tanks. All tanks fitted with a pressure relief valve. The valve set at the highest possible safe value to reduce releases. HFO tanks: • Open vents are connected to the VOC system. • HFO tank are to be fitted with Pressure / Vacuum Relief Valves. • Fitted with Gauging and sample hatches. • Access hatches for removal of material included. • Drains are installed - The drain allows the removal of water that may accumulate at the base of the tank. • Mixers are not installed. • Heating system is installed making use of steam as per BAT. • Level control and overfill protection is in place. • SOP – Procedure of filling fuel tanks from fuel oil tanker in place. • SOP DPS33 – Fuel transfer from tanker/barge to tank farm. DO tanks: • Open vents are installed. • DO tanks do not require Pressure / Vacuum Relief Valves. • Fitted with Gauging and sample hatches. • Access hatches for removal of material included.

Aspect of BAT	BAT	Status at Installation
	roof tank without measures), which can be achieved when over at least 95 % of the circumference of the gap between the roof and wall is less than 3.2 mm and the seals are liquid mounted, mechanical shoe seals. By applying liquid mounted primary seals and rim mounted secondary seals, even higher emission reductions can be achieved. However, the smaller the tank and the smaller the number of turnovers the less effective the floating roof is, see Annex 8.22 and Annex 8.23 respectively. Also the case studies in Annex 8.13 show that achievable emission reductions depend on several issues such as the substance that is actually stored, meteorological circumstances, number of turnovers and diameter of the tank. The calculations show that with an internal floating roof an emission reduction in the range 62.9 – 97.6 % can be achieved (compared to a fixed roof tank without measures); where 62.9 % refers to a tank of 100 m^3 equipped with only primary seals and 97.6 % refers to a tank of 10263 m^3 equipped with primary and secondary seals. For liquids containing a high level of particles (e.g. crude oil) BAT is to mix the stored substance to prevent deposition that would call for an additional cleaning step, see Section 4.1.5.1.	• Drains installed - The drain allows the removal of water that may accumulate at the base of the tank. • Mixers are not installed. • Heating system is not necessary • Level control and overfill protection is in place • SOP – Procedure of filling fuel tanks from fuel oil tanker in place. • SOP DPS33 – Fuel transfer from tanker/barge to tank farm.
Tank specific considerations **Atmospheric**	Atmospheric horizontal tanks are used for the storage of flammable and other liquids, such as oil products and chemicals in all levels of flammability and toxicity, see	This section does not apply as there are no ENE operated horizontal tanks installed.

Aspect of BAT	BAT	Status at Installation
horizontal tanks	Section 3.1.4. Horizontal tanks are different to vertical tanks, e.g. since they can inherently operate under higher pressures. For the storage of volatile substances which are toxic (T), very toxic (T+), or CMR categories 1 and 2 in an atmospheric horizontal tank, BAT is to apply a vapour treatment installation. [3] For other substances, BAT is to do all, or a combination, of the following techniques, depending on the substances stored: • apply pressure vacuum relief valves; see Section 4.1.3.11 • up rate to 56 mbar; see Section 4.1.3.11 • apply vapour balancing; see Section 4.1.3.13 • apply a vapour holding tank, see Section 4.1.3.14, or • apply vapour treatment; see Section 4.1.3.15. The selection of the vapour treatment technology has to be decided on a case-by-case basis.	
Tank specific considerations **Pressurised storage**	Pressurised storage is used for storing all categories of liquefied gases, from non-flammable up to flammable and highly toxic. The only significant emissions to air from normal operation are from draining. BAT for draining depends on the tank type, but may be the application of a closed drain system connected to a vapour treatment installation, see Section 4.1.4.	Section does not apply as there are no ENE operated pressurised storage tanks installed.

Aspect of BAT	BAT	Status at Installation
	The selection of the vapour treatment technology has to be decided on a case-by-case basis.	
Tank specific considerations **Lifter roof tanks**	For emissions to air, BAT is to (see Sections 3.1.9 and 4.1.3.14): • apply a flexible diaphragm tank equipped with pressure/vacuum relief valves, or • apply a lifter roof tank equipped with pressure/vacuum relief valves and connected to a vapour treatment installation. The selection of the vapour treatment technology has to be decided on a case-by-case basis.	Section does not apply as there are no ENE operated lifter storage tanks installed.
Tank specific considerations **Refrigerated tanks**	There are no significant emissions from normal operation, see Section 3.1.10.	Section does not apply as there are no ENE operated refrigerated storage tanks installed.
Tank specific considerations **Underground and mounded tanks**	Underground and mounded tanks are used especially for flammable products, see Sections 3.1.11 and 3.1.8 respectively. For the storage of volatile substances which are toxic (T), very toxic (T+), or CMR categories 1 and 2 in an underground or mounded tank, BAT is to apply a vapour treatment installation.[4] For other substances, BAT is to do all, or a combination, of the following techniques, depending on the substances stored: • apply pressure vacuum relief valves; see Section 4.1.3.11 • apply vapour balancing; see Section 4.1.3.13	Section does not apply as there are no ENE operated underground storage tanks installed.

Aspect of BAT	BAT	Status at Installation
	• apply a vapour holding tank, see Section 4.1.3.14, or • apply vapour treatment; see Section 4.1.3.15. The selection of the vapour treatment technology has to be decided on a case-by-case basis.	
Preventing incidents and (major) accidents **Safety and risk management**	The Seveso II Directive (Council Directive 96/82/EC of 9 December 1996 on the control of major accident hazards involving dangerous substances) requires companies to take all measures necessary to prevent and limit the consequences of major accidents. They must, in any case, have a major accident prevention policy (MAPP) and a safety management system to implement the MAPP. Companies holding large quantities of dangerous substances, the so-called upper tiered establishments, must also draw up a safety report and an on-site emergency plan and maintain an up-to-date list of substances. However, plants that do not fall under the scope of the Seveso II Directive can also cause emissions from incidents and accidents. Applying a similar, maybe less detailed, safety management system is the first step in preventing and limiting these. BAT in preventing incidents and accidents is to apply a safety management system as described in Section 4.1.6.1.	ENE compiles a safety report and has an on-site emergency plan and a major accident prevention policy in line with the Seveso II Directive (Council Directive 96/82/EC of 9 December 1996 on the control of major accident hazards involving dangerous substances). It also is in the process of establishing a safety management system. As per BAT requirements the safety management system includes: • a statement of tasks and responsibilities • an assessment of the risks of major accidents • a statement of procedures and work instructions • plans for responding to emergencies • the monitoring of the safety management system • the periodical evaluation of the policy adopted.
Preventing incidents and (major) accidents **Operational**	BAT is to implement and follow adequate organisational measures and to enable training and instruction of employees for safe and responsible operation of the installation as described in Section 4.1.6.1.1.	Enemalta personnel are given training for the safe and reliable operation of the plant. The latest Emergency Plan has been revised in 2015. As

Aspect of BAT	BAT	Status at Installation
procedures and training		part of the updated safety report, the Emergency plan is to be updated. Standard Operating Procedures are in place and have been audited internally and vetted by the regulatory affairs department. SOPs externally audited annually by the EMS auditors. Emergency response plans and communication plans for internal purposes and to/for external locations are available and are being updated as part of the Safety Report. They allow swift intervention of internal and external rescue/support teams and, therefore, might reduce any negative consequences caused by an accident. • Operating instructions are available and followed. They contain information pertaining to the operation of the installation, for precautions against malfunctions and for dealing with any that occur. • The company has, in its possession, relevant records and documentation on the storage mode (e.g. design data/drawings, inspection and maintenance records, etc.
Preventing incidents and (major) accidents **Leakage due to corrosion and/or erosion**	Corrosion is one of the main causes of equipment failure and can occur both internally and externally on any metal surface, see Section 4.1.6.1.4. BAT is to prevent corrosion by: • selecting construction material that is resistant to the product stored • applying proper construction methods • preventing rainwater or groundwater entering the tank and	As already highlighted, apart from having operators continually supervising the installation, Enemalta also has its own maintenance personnel on site which can attend to all the inspections and preventive maintenance interventions required. The installations are designed and built in accordance to established standards. So as to assess tank corrosion, ultrasonic testing of shell

Aspect of BAT	BAT	Status at Installation
	if necessary, removing water that has accumulated in the tank • applying rainwater management to bund drainage • applying preventive maintenance, and • where applicable, adding corrosion inhibitors, or applying cathodic protection on the inside of the tank. Additionally for an underground tank, BAT is to apply to the outside of the tank: • a corrosion-resistant coating • plating, and/or • a cathodic protection system. Stress corrosion cracking (SCC) is a specific problem for spheres, semi-refrigerated tanks and some fully refrigerated tanks containing ammonia. BAT is to prevent SCC by: • stress relieving by post-weld heat treatment, see Section 4.1.6.1.4, and • applying a risk based inspection as described in Section 4.1.2.2.1.	thickness on fuel tanks is carried out and as per IPPC Permit requirements and reported as part of the AER. Both HFO and DO tanks are constructed of carbon steel. Tank thicknesses have been designed with inherent redundancies to account for corrosion. To date no paint maintenance has been required. Tank 2 HFO currently going to be rehauled inside and out. No cathodic protection is installed or deemed necessary. All tanks are elevated therefore no groundwater comes in contact with the tanks. All tanks are roofed over not allowing access to rainwater from above. Water within the tank results from water within the fuel at unloading. Water is removed from tanks via drain valve following unloading of fuel. Tank wall thickness has been designed so as to allow for corrosion effects. Corrosion protective paint systems protect the tanks against corrosion. Since water within the tanks can result in internal corrosion, manual draining of fuel water contained in the fuel mixture is carried out. The water is drain into a settling tank, and treated as oily water.
Preventing incidents and (major) accidents	BAT is to implement and maintain operational procedures – e.g. by means of a management system – as described in Section 4.1.6.1.5, to ensure that:	See above. In addition, it must be pointed out that both the operators who are remotely supervising the installation as well as those supervising on-site have the required means to

Aspect of BAT	BAT	Status at Installation
Operational procedures and instrumentation to prevent overfill	• high level or high pressure instrumentation with alarm settings and/or auto closing of valves is installed • proper operating instructions are applied to prevent overfill during a tank filling operation, and • sufficient ullage is available to receive a batch filling. A standalone alarm requires manual intervention and appropriate procedures, and automatic valves need to be integrated into the upstream process design to ensure no consequential effects of closure. The type of alarm to be applied has to be decided for every single tank. See Section 4.1.6.1.6.	enable effective and timely communication. All processes are manual requiring operation by a technical team, therefore scheduled maintenance is not required. Sufficient ullage is ensured so as to receive a batch filling. During unloading the unloading master calculates and communicates the flow rates to prevent overfilling. During filling dipping is carried out. No auto closing valves are implemented in the unloading system due to there is a potential for failure of upstream systems.
Preventing incidents and (major) accidents **Instrumentation and automation to detect leakage**	The four different basic techniques that can be used to detect leaks are: • release prevention barrier system • inventory checks • acoustic emission method • soil vapour monitoring. BAT is to apply leak detection on storage tanks containing liquids that can potentially cause soil pollution. The applicability of the different techniques depends on the tank type and is discussed in detail in Section 4.1.6.1.7.	Any fuel leakage is contained within the bund. Leakage to soil is not envisaged. Release prevention barrier system is installed.
Preventing incidents and	The risk-based approach to emissions to soil from an aboveground flat-bottom and vertical, storage tank	A thickness of the tank bottom of at least 6 mm, together with an impervious barrier between the tank bottom and soil surface is

Aspect of BAT	BAT	Status at Installation
(major) accidents **Risk-based approach to emissions to soil below tanks**	containing liquids with a potency to pollute soil, is that soil protection measures are applied at such a level that there is a 'negligible risk' for soil pollution because of leakage from the tank bottom or from the seal where the bottom and the wall are connected. See Section 4.1.6.1.8 where the approach and the risk levels are explained. BAT is to achieve a 'negligible risk level' of soil pollution from bottom and bottom-wall connections of aboveground storage tanks. However, on a case-by-case basis, situations might be identified where an 'acceptable risk level' is sufficient.	implemented therefore from a risk-based approach, negligible risk is achieved.
Preventing incidents and (major) accidents **Soil protection around tanks - containment**	BAT for aboveground tanks containing flammable liquids or liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses is to provide secondary containment, such as: • tank bunds around single wall tanks; see Section 4.1.6.1.11 • double wall tanks; see Section 4.1.6.1.13 • cup-tanks; see Section 4.1.6.1.14 • double wall tanks with monitored bottom discharge; see Section 4.1.6.1.15. For building new single walled tanks containing liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses, BAT is to apply a full, impervious, barrier in the bund, see Section 4.1.6.1.10. For existing tanks within a bund, BAT is to apply a risk-based approach, considering the significance of risk from	As described in previous conclusions, the tanks are bunded.

Aspect of BAT	BAT	Status at Installation
	product spillage to the soil, to determine if and which barrier is best applicable. This risk-based approach can also be applied to determine if a partial impervious barrier in a tank bund is sufficient or if the whole bund needs to be equipped with an impervious barrier. See Section 4.1.6.1.11. Impervious barriers include: • a flexible membrane, such as HDPE • a clay mat • an asphalt surface • a concrete surface. For chlorinated hydrocarbon solvents (CHC) in single walled tanks, BAT is to apply CHC-proof laminates to concrete barriers (and containments), based on phenolic or furan resins. One form of epoxy resin is also CHC-proof. See Section 4.1.6.1.12. BAT for underground and mounded tanks containing products that can potentially cause soil pollution is to: • apply a double walled tank with leak detection, see Section 4.1.6.1.16, or • to apply a single walled tank with secondary containment and leak detection, see Section 4.1.6.1.17.	
Preventing incidents and (major) accidents **Flammable areas and ignition sources**	See Section 4.1.6.2.1 together with ATEX Directive 1999/92/EC.	ENE fuel storage facilities have ATEX certified instrumentation installed as required by the current scenario. An ATEX assessment as per ATEX Directive 1999/92/EC is to be included as part o the updated safety report.

Aspect of BAT	BAT	Status at Installation
		Recommendations included in said report are to be adhered to and implemented.
Preventing incidents and (major) accidents **Fire protection**	The necessity for implementing fire protection measures has to be decided on a case-by-case basis. Fire protection measures can be provided by applying, e.g. (see Section 4.1.6.2.2): • fire resistant claddings or coatings • firewalls (only for smaller tanks), and/or • water cooling systems	Fuel storage tanks are protected from fire by means of sea water based foam and tank wall cooling systems. For fire fighting purposes HFO tanks are fitted with a water cooling rings coupled with top pouring foam system. For fire fighting purposes DO tanks are fitted with water cooling rings coupled with semi-sub-surface foam system. Emergency situation have been planned for in the internal Emergency response plan as per SEVESO requirements.
Preventing incidents and (major) accidents **Fire-fighting equipment**	The necessity for implementing fire-fighting equipment and the decision on which equipment to apply has to be taken on a case-by-case basis in agreement with the local fire brigade. Some examples are given in Section 4.1.6.2.3.	Fire fighting equipment has been designed to cater for site specific and installation conditions.
Preventing incidents and (major) accidents **Containment of contaminated extinguishant**	The capacity for containing contaminated extinguishant depends on the local circumstances, such as which substances are stored and whether the storage is close to watercourses and/or situated in a water catchment area. The applied containment therefore has to be decided on a case-by-case basis, see Section 4.1.6.2.4. For toxic, carcinogenic or other hazardous substances, BAT	Any extinguishing would be contained within the bunded areas.

Aspect of BAT	BAT	Status at Installation
	is to apply full containment.	

1.2 Storage of packaged dangerous substances

Aspect of BAT	BAT	Status at Installation
Safety and risk management	Operational losses do not occur in storing packaged dangerous materials. The only possible emissions are from incidents and (major) accidents. Companies that fall under the scope of the Seveso II Directive are required to take all measures necessary to prevent and limit the consequences of major accidents. They must, in any, case have a major accident prevention policy (MAPP) and a safety management system to implement the MAPP. Companies in the high risk category (Annex I of the Directive) must also draw up a safety report and an on-site emergency plan and maintain an up-to-date list of substances. However, companies storing dangerous substances not falling under the scope of the Seveso II Directive can also cause emissions from incidents and accidents. Applying a similar, maybe less detailed, safety management system is the first step in preventing and limiting these. BAT in preventing incidents and accidents is to apply a safety management system as described in Sections 4.1.6.1. The degree of detail of the system is clearly dependent on various factors such as: the quantities of substances stored, specific hazards of the substances and the location of the storage. However, the minimum level of BAT is to assess the risks of accidents and incidents on the site using the five steps described in Section 4.1.6.1	The current MAPP and safety report in accordance with Seveso II Directive is to be updated to ensure complaice with the proposed changed. A safety management system is in place for the stores at DPS.
Training and responsibility	BAT is to appoint a person or persons who is or are responsible for the operation of the store.	ENE provides the required training to store operational personnel.

Aspect of BAT	BAT	Status at Installation
	BAT is to provide the responsible person(s) with specific training and retraining in emergency procedures as described in Section 4.1.7.1 and to inform other staff on the site of the risks of storing packaged dangerous substances and the precautions necessary to safely store substances that have different hazards.	
Storage area	BAT is to apply a storage building and/or an outdoor storage area covered with a roof, as described in Section 4.1.7.2. For storing quantities of less than 2500 litres or kilograms dangerous substances, applying a storage cell as described in Section 4.1.7.2 is also BAT.	All stores are roofed over as per BAT. The oil store is located outside. The area is bunded via a gutter with a pit for catchment.
Separation and segregation	BAT is to separate the storage area or building of packaged dangerous substances from other storage, from ignition sources and from other buildings on- and off-site by applying a sufficient distance, sometimes in combination with fire-resistant walls. Member States apply different distances between the (outdoor) storage of packaged dangerous substances and other objects on- and off-site; see Section 4.1.7.3 for some examples. BAT is to separate and/or segregate incompatible substances. For the compatible and incompatible combinations see Annex 8.3 of the BREF. Member States apply different distances and/or physical partitioning between the storage of incompatible substances; see Section 4.1.7.4 for some examples.	The store located adjacent to the workshop are separated from ignition sources by a distance greater than 7.5m. The stores are separated from the workshop by a storage area containing no flammable substances such as equipment for maintenance purposes. Chemicals are separated and stored so as to avoid incompatible combinations. Flammable chemical such as Hydrocloric acid HCl and sodium chlorite $NaCl0_2$ are stored over 150m from the stores within roofed over and bunded areas.
Containment of	BAT is to install a liquid-tight reservoir according to	All chemicals are stored within the necessary bunded areas.

Aspect of BAT	BAT	Status at Installation
leakage and contaminated extinguishant	Section 4.1.7.5, that can contain all or a part of the dangerous liquids stored above such a reservoir. The choice whether all or only a part of the leakage needs to be contained depends on the substances stored and on the location of the storage (e.g. in a water catchment area) and can only be decided on a case-by-case basis. BAT is to install a liquid-tight extinguishant collecting provision in storage buildings and storage areas according to Section 4.1.7.5. The collecting capacity depends on the substances stored, the amount of substances stored, the type of package used and the applied fire-fighting system and can only be decided on a case-by-case basis.	For transportation or temporary storage of 45 gallon drums a temporary bund is used.
Fire-fighting equipment	BAT is to apply a suitable protection level of fire prevention and fire-fighting measures as described in Section 4.1.7.6. The appropriate protection level has to be decided on a case-by-case basis in agreement with the local fire brigade.	The stores are equipped with a number of fire portable powder and CO_2 extinguishers. A number of sea-water and freshwater fire-hydrants are located around the stores are located around the site. The transformers of the administration block are separated from the stores via a 120min fire rated wall. The stores are fitted with fire-alarm and smoke detection systems.
Preventing ignition	BAT is to prevent ignition at source as described in Section 4.1.7.6.1.	Smoking is to prohibited. All hot works are coved by a hot-works permit. Vehicles used in stores consist of electric fork-lifters.

Aspect of BAT	BAT	Status at Installation
		No heating systems are used within the stores. No shrink Wrapping operations are carried out within the stores.

1.3 Basins and lagoons

Aspect of BAT	BAT	Status at Installation
Basins and lagoons	Basins and lagoons are used for the storage of, e.g. manure slurry in agricultural premises and water and other non-flammable or volatile liquids in industrial facilities. Where emissions to air from normal operation are significant, e.g. with the storage of pig slurry, BAT is to cover basins and lagoons using one of the following options: • a plastic cover; see Section 4.1.8.2 • a floating cover; see Section 4.1.8.1, or • only small basins, a rigid cover; see Section 4.1.8.2. Additionally, where a rigid cover is used, a vapour treatment installation can be applied to achieve an extra emission reduction, see Section 4.1.3.15. The need for and type of vapour treatment must be decided on a case-by-case basis. To prevent overfilling due to rainfall in situations where the basin or lagoon is not covered, BAT is to apply a sufficient freeboard, see Section 4.1.11.1. Where substances are stored in a basin or lagoon with a risk of soil contamination, BAT is to apply an impervious barrier. This can be a flexible membrane, a sufficient clay layer or concrete, see Section 4.1.9.1.	This section is not applicable – No basins or lagoons operated by ENE.

1.4 Atmospheric mined caverns

Aspect of BAT	BAT	Status at Installation
Emissions to air from normal operation	Where a number of caverns with a fixed waterbed storing liquid hydrocarbons are present, BAT is to apply vapour balancing, see Section 4.1.12.1.	This section is not applicable since no atmospheric mined caverns are operated by ENE on site.
Emissions from incidents and (major) accidents	By their intrinsic nature, caverns are by far the safest way of storing large quantities of hydrocarbon products. BAT for storing large quantities of hydrocarbons is, therefore, to apply caverns wherever the site geology is suitable, see Sections 3.1.15 and 4.1.13.3. BAT, in preventing incidents and accidents, is to apply a safety management system as described in Section 4.1.6.1. BAT is to apply, and then regularly evaluate, a monitoring programme which at least includes the following (see Section 4.1.13.2): • monitoring of the hydraulic flow pattern around the caverns by means of groundwater measurements, piezometers and/or pressure cells, seepage water flowrate metering • assessment of cavern stability by seismic monitoring • water quality follow-up procedures by regular sampling and analysis • corrosion monitoring, including periodic casing evaluation. For preventing the stored product from escaping out of the cavern, BAT is to design the cavern in such a way that at	This section is not applicable since no atmospheric mined caverns are operated by ENE on site.

Aspect of BAT	BAT	Status at Installation
	the depth at which it is situated, the hydrostatic pressure of the groundwater surrounding the cavern is always greater than that of the stored product, see Section 4.1.13.5. For preventing seepage water entering the cavern, BAT is, apart from a proper design, to additionally apply cement injection, see Section 4.1.13.6. If seepage water that enters the cavern is pumped out, BAT is to apply waste water treatment before discharge, see Section 4.1.13.3. BAT is to apply automated overfill protection, see Section 4.1.13.8.	

1.5 Pressurised mined caverns

Aspect of BAT	BAT	Status at Installation
Emissions from incidents and (major) accidents	By their intrinsic nature, caverns are by far the safest way of storing large quantities of hydrocarbon products. BAT for storing large quantities of hydrocarbons is, therefore, to apply caverns wherever the site geology is suitable, see Sections 3.1.16 and 4.1.14.3. BAT, in preventing incidents and accidents, is to apply a safety management system as described in Section 4.1.6.1. BAT is to apply, and then regularly evaluate a monitoring programme which at least includes the following (see Section 4.1.14.2): • monitoring of the hydraulic flow pattern around the caverns by means of groundwater measurements, piezometers and/or pressure cells, seepage water flowrate metering • assessment of cavern stability by seismic monitoring • water quality follow-up procedures by regular sampling and analysis • corrosion monitoring, including periodic casing evaluation. For preventing the stored product from escaping out of the cavern, BAT is to design the cavern in such a way that at the depth at which it is situated, the hydrostatic pressure of the groundwater surrounding the cavern is always greater than that of the stored product, see Section 4.1.14.5. For preventing seepage water entering the cavern, BAT is,	This section is not applicable since no pressurised mined caverns are operated by ENE on site.

Aspect of BAT	BAT	Status at Installation
	apart from a proper design, to additionally apply cement injection, see Section 4.1.14.6 If seepage water that enters the cavern is pumped out, BAT is to apply waste water treatment before discharge, see Section 4.1.14.3. BAT is to apply automated overfill protection, see Section 4.1.14.8. BAT is to apply fail-safe valves in the event of a surface emergency event, see Section 4.1.14.4.	

1.6 Salt leached caverns

Aspect of BAT	BAT	Status at Installation
Salt leached caverns	By their intrinsic nature, caverns are by far the safest way of storing large quantities of hydrocarbon products. BAT for storing large quantities of hydrocarbons is, therefore, to apply caverns wherever the site geology is suitable. For more detail see Sections 3.1.17 and 4.1.15.3. BAT, in preventing incidents and accidents, is to apply a safety management system as described in Section 4.1.6.1. BAT is to apply, and then regularly evaluate a monitoring programme which at least includes the following (see Section 4.1.15.2): • assessment of cavern stability by seismic monitoring • corrosion monitoring, including periodic casing evaluation • carrying out of regular sonar evaluations to monitor eventual shape variations, particularly if undersaturated brine is used. Small traces of hydrocarbons may be present at the brine/hydrocarbon interface due to filling and emptying the caverns. If this is the case, BAT is to separate these hydrocarbon products in a brine treatment unit and to collect and dispose of them safely.	This section is not applicable since no salt leached caverns are operated by ENE on site.

1.7 Floating storage

Aspect of BAT	BAT	Status at Installation
Floating storage	Floating storage is not BAT, see Section 3.1.18.	This section is not applicable since no floating storage is operated by ENE on site.

Part 2: Transfer and handling of liquids and liquefied gases

2.1 General principles to prevent and reduce emissions

Aspect of BAT	BAT	Status at Installation
Inspection and maintenance	BAT is to apply a tool to determine proactive maintenance plans and to develop risk-based inspection plans such as, the risk and reliability based maintenance approach; see Section 4.1.2.2.1.	ENE makes use of its own maintenance employees for both preventive maintenance and repairs. Maintenance approach described in pervious sections.
Leak detection and repair programme	For large storage facilities, according to the properties of the products stored, BAT is to apply a leak detection and repair programme. Focus needs to be on those situations most likely to cause emissions (such as gas/light liquid, under high pressure and/or temperature duties). See Section 4.2.1.3.	Operations personnel supervise the installations on a 24X7 basis. In addition, remote supervision of the tank levels is monitored from the central control room.
Emissions minimisation principle in tank storage	BAT is to abate emissions from tank storage, transfer and handling that have a significant negative environmental effect, as described in Section 4.1.3.1. This is applicable to large storage facilities, allowing a certain time frame for implementation.	VOC adsorption filtering systems are installed on the HFO tanks. DO tanks do not require VOC filtering systems since fuel is at ambient conditions.
Safety and risk management	BAT in preventing incidents and accidents is to apply a safety management system as described in Section 4.1.6.1.	ENE compiles a safety report and has an on-site emergency plan and a major accident prevention policy in line with the Seveso II Directive (Council Directive 96/82/EC of 9 December 1996 on the control of major accident hazards involving dangerous substances). It also is in the process of establishing a safety management system. As per BAT requirements the safety management system

Aspect of BAT	BAT	Status at Installation
		includes: • a statement of tasks and responsibilities • an assessment of the risks of major accidents • a statement of procedures and work instructions • plans for responding to emergencies • the monitoring of the safety management system • the periodical evaluation of the policy adopted..
Operational procedures and training	BAT is to implement and follow adequate organisational measures and to enable the training and instruction of employees for safe and responsible operation of the installation as described in Section 4.1.6.1.1.	Necessary SOPs are in place and implemented accordingly. The company has, in its possession, relevant records and documentation on the storage mode Training and instruction of employees are both carried out on a regular basis. Employees are informed, among other things, about hazards to the workforce and potential consequences for the environment. In May 2015 training in Oil spillage response was provided to Plant Maintenance officers and team-leaders.

2.2 Considerations on transfer and handling techniques

Aspect of BAT	BAT	Status at Installation
Piping	BAT is to apply aboveground closed piping in new situations, see Section 4.2.4.1. For existing underground piping it is BAT to apply a risk and reliability based maintenance approach as described in Section 4.1.2.2.1. Bolted flanges and gasket-sealed joints are an important source of fugitive emissions. BAT is to minimise the	Wherever possible welded pipes are used and flanged connection are minimised. The implemented DO and HFO pipelines are of a closed piping aboveground system. Where possible all piping routes are kept above ground except in areas such as road crossings. In such cases the pipes are passed through a

Aspect of BAT	BAT	Status at Installation
	number of flanges by replacing them with welded connections, within the limitation of operational requirements for equipment maintenance or transfer system flexibility, see Section 4.2.2.1.	culvert so as to allow for visual inspection. Bolted flange connections have been kept to a minimum. All Fuel pipes other than (at strainers, pumps and valves) are welded.
	BAT for bolted flange connections (see Section 4.2.2.2.) include: • fitting blind flanges to infrequently used fittings to prevent accidental opening	Blind flanges are fitted to infrequently used fittings such as spare nozzles/manifolds/drains to prevent accidental opening.
	• using end caps or plugs on open-ended lines and not valves	End caps or plugs are used on open-ended lines and not valves. In most cases valves are fitted prior to the end-caps/plugs making the system doubly isolated.
	• ensuring gaskets are selected appropriate to the process application • ensuring the gasket is installed correctly • ensuring the flange joint is assembled and loaded correctly	Gaskets are selected appropriate to the process application and installed correctly. Flange joints are assembled and loaded correctly
	• where toxic, carcinogenic or other hazardous substances are transferred, fitting high integrity gaskets, such as spiral wound, kammprofile or ring joints.	Where toxic, carcinogenic or other hazardous substances are transferred high integrity gaskets are fitted.
	Internal corrosion may be caused by the corrosive nature of the product being transferred, see Section 4.2.3.1. BAT is to prevent corrosion by: • selecting construction material that is resistant to the product • applying proper construction methods • applying preventive maintenance, and • where applicable, applying an internal coating or adding corrosion inhibitors.	So as to minimise internal corrosion all lines are designed so that flow velocities are limited so as to reduce the effects of erosion.
	To prevent the piping from external corrosion, BAT is to apply a one, two, or three layer coating system depending	So as to minimise external corrosion HFO lines are painted with silverene for protection. DO To prevent the piping from atmospheric corrosion, the system is normally painted with a one, two or three layer coating system

Aspect of BAT	BAT	Status at Installation
	on the site-specific conditions (e.g. close to sea). Coating is normally not applied to plastic or stainless steel pipelines. See Section 4.2.3.2.	
Vapour treatment	BAT is to apply vapour balancing or treatment on significant emissions from the loading and unloading of volatile substances to (or from) trucks, barges and ships. The significance of the emission depends on the substance and the volume that is emitted, and has to be decided on a case-by-case basis. For more detail see Section 4.2.8. For example, according to Dutch regulations, the emission of methanol is significant when over 500 kg/yr is emitted.	ECM is not carried out.
Valves	BAT for valves include: • correct selection of the packing material and construction for the process application • with monitoring, focus on those valves most at risk (such as rising stem control valves in continual operation) • applying rotating control valves or variable speed pumps instead of rising stem control valves • where toxic, carcinogenic or other hazardous substances are involved, fit diaphragm, bellows, or double walled valves • route relief valves back into the transfer or storage system or to a vapour treatment system. See Sections 3.2.2.6 and 4.2.9.	The following BAT for valves are implemented: • Correct selection of the packing material and construction for the process application • With monitoring, focus on those valves most at risk (such as rising stem control valves in continual operation) • Variable speed pumps instead of rising stem control valves are implemented only on D3. • Where possible route relief valves back into the transfer or storage system or to a drain tray depending on the specific case requirements. Where positive displacement pumps are utilised minimum recirculation lines are installed to divert the fuel flow back to the suction of the pump to maintain minimum flow. Along the piping system relief valves are install that drain into a drains tray for collection and treatment via the

Aspect of BAT	BAT	Status at Installation
		interceptors.
Pumps and compressors **Installation and maintenance of pumps and compressors**	The design, installation and operation of the pump or compressor heavily influence the life potential and reliability of the sealing system. The following are some of the main factors which constitute BAT: • proper fixing of the pump or compressor unit to its base-plate or frame • having connecting pipe forces within producers' recommendations • proper design of suction pipework to minimise hydraulic imbalance • alignment of shaft and casing within producers' recommendations • alignment of driver/pump or compressor coupling within producers' recommendations when fitted • correct level of balance of rotating parts • effective priming of pumps and compressors prior to start-up • operation of the pump and compressor within producers' recommended performance range (The optimum performance is achieved at its best efficiency point.) • the level of net positive suction head available should always be in excess of the pump or compressor • regular monitoring and maintenance of both rotating equipment and seal systems, combined with a repair or replacement programme.	The design, installation and operation of the pumps are to established standards. Personnel are adequately trained in plant operations. All D2a and D2B fuel pumps are of the centrifugal type. The seals provided consist of single mechanical seals. Fuel from DPS main storage tanks is gravity fed to D3 forwarding pumps. As per BAT all pump or compressor units: • are fixed properly to base plates • having connecting pipe forces within producers' recommendations • proper design of suction pipework to minimise hydraulic imbalance • alignment of shaft and casing within producers' recommendations • alignment of driver/pump or compressor coupling within producers' recommendations when fitted • correct level of balance of rotating parts • effective priming of pumps and compressors prior to start-up • operation of the pump and compressor within producers' recommended performance range • the level of net positive suction head available should always be in excess of the pump or compressor • regular monitoring and maintenance of both rotating equipment and seal systems, combined with a repair or

Aspect of BAT	BAT	Status at Installation
		replacement programme.
Pumps and compressors **Sealing system in pumps**	BAT is to use the correct selection of pump and seal types for the process application, preferably pumps that are technologically designed to be tight such as canned motor pumps, magnetically coupled pumps, pumps with multiple mechanical seals and a quench or buffer system, pumps with multiple mechanical seals and seals dry to the atmosphere, diaphragm pumps or bellow pumps. For more details see Sections 3.2.2.2, 3.2.4.1 and 4.2.9.	As per pervious point, all D2A and D2B fuel pumps are of the centrifugal type. The seals provided consist of single mechanical seals. It is to be noted that all pump systems are located on skids therefore containing any leaks within drip trays.
Pumps and compressors **Sealing systems in compressors**	BAT for compressors transferring non-toxic gases is to apply gas lubricated mechanical seals. BAT for compressors, transferring toxic gases is to apply double seals with a liquid or gas barrier and to purge the process side of the containment seal with an inert buffer gas. In very high pressure services, BAT is to apply a triple tandem seal system. For more detail see Sections 3.2.3 and 4.2.9.13.	This section does not apply since compressors are not utilised by ENE in the installation.
Sampling connections	BAT, for sample points for volatile products, is to apply a ram type sampling valve or a needle valve and a block valve. Where sampling lines require purging, BAT is to apply closed-loop sampling lines. See Section 4.2.9.14.	Needle valves are installed within enclosures. ENE does not carry out purging of sampling lines.

[1] There is a split view from three Member States, because in their view, on sites where significant VOC emissions are to be expected (e.g. refineries, petrochemical plants and oil terminals), BAT is to calculate the VOC emissions regularly with validated calculation methods, and because of uncertainties in the calculation methods, emissions from the plants should be monitored occasionally in order to quantify the emissions and to give basic data for refining calculation methods. This can be carried out by using DIAL techniques. The necessity and frequency of emission monitoring needs to be decided on a case-by-case basis.

[2] There is a split view from industry, that this technique is not BAT because in their view:
a) there is no definition of ‘ volatile’ in this BREF
b) there is no test of environmental significance
c) products which may be dangerous to the environment, but not classed as toxic, are not captured
d) it can be demonstrated that other emission control measures may provide a higher level of environmental protection taking into account the costs and advantages of the various techniques
e) there are no commonly understood performance criteria for a vapour treatment installation
f) this does not take into account the cost, or advantages of other techniques
g) this does not provide the flexibility to take into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions
h) there is no proportionality in this conclusion.

[3] There is a split view from industry, that this technique is not BAT because in their view:
a) there is no definition of ‘volatile’ in this BREF
b) there is no test of environmental significance
c) products which may be dangerous to the environment, but not classed as toxic, are not captured
d) it can be demonstrated that other emission control measures may provide a higher level of environmental protection taking into account the costs and advantages of the various techniques
e) there are no commonly understood performance criteria for a vapour treatment installation
f) this does not take into account the costs or advantages of other techniques
g) this does not provide the flexibility to take into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions
h) there is no proportionality in this conclusion.

[4] There is a split view from industry, that this technique is not BAT because in their view:

a) there is no definition of 'volatile' in this BREF

b) there is no test of environmental significance

c) products which may be dangerous to the environment, but not classed as toxic, are not captured

d) it can be demonstrated that other emission control measures may provide a higher level of environmental protection taking into account the costs and advantages of the various techniques

e) there are no commonly understood performance criteria for a vapour treatment installation

f) this does not take into account the costs or advantages of other techniques

g) this does not provide the flexibility to take into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions

h) there is no proportionality in this conclusion.

C2.3 BAT MEASURES – DPS3 PLANT AS PER IP002/07/E

Comparison of Delimara extension proposal with BAT as specified in the BREF

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Particulate matter (BAT for storage and handling of fuel and additives)	The use of good design and construction practices and adequate maintenance	Storage facilities shall be designed to established construction and installation standards, e.g. • above ground atmospheric cylindrical tanks either to EN 14015: 2004, or API 650, or API 620, depending on required process parameters; • Unfired pressure vessels or heat exchangers to the appropriate standard such as EN13445, or ASME VIII Codes, or PD 5500. • Piping and piping parts to various manufacturing and design standards as applicable. • Fabrication materials to the appropriate standards as required in order to satisfy process conditions.
	Storage of lime or limestone in silos with well designed, robust extraction and filtration equipment.	Lime is not proposed to be used in this extension.

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Water Contamination (BAT for storage and handling of fuel and additives)	The use of liquid fuel storage systems that are contained in impervious bunds that have a capacity capable of containing 75 % of the maximum capacity of all tanks or at least the maximum volume of the largest tank. Tank contents should be displayed and associated alarms used and automatic control systems can be applied to prevent the overfilling of storage tanks.	The existing HFO & GDO storage facilities shall be used except for additional small transfer tanks. Additional liquid duel storage facilities shall be contained within appropriate bunded area in accordance with good construction recommendations and industry practices. The new urea and FO bunded areas will satisfy the 110% obligation. All tanks shall have both local and remote gauging facilities. The current and proposed tanks have alarms and automatic control systems to prevent overfilling of storage tanks.The new tanks high level alarms in the tanks will raise an alarm in the control room by the DCS (Distributed Control System) In the event of high-high alarms, pumps will be stopped so that risks of spillages are minimised.

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
	Pipelines placed in safe, open areas aboveground so that leaks can be detected quickly and damage from vehicles and other equipment can be prevented. For non-accessible pipes, double walled type pipes with automatic control of the spacing can be applied (liquid and gaseous fuels).	Noted. Piping diagrams for the Fuel and oily water systems: 1. **Annex 18 - 2970-S2-F01-001: Fuel supply (LOT191)** 2. **Annex 19 - 2970-S2-K01-001: Oily water & sludge (188)** Corrosion protection details: Pipes are designed and assembled as per EN standards and are painted for proper corrosion protection. Urea solution handling pipes are made of stainless steel.
Fugitive emissions (BAT for storage and handling of fuel and additives)	Using fuel gas leak detection systems and alarms.	The same systems as installed in the existing plant shall be used for the extension.
Efficient use of natural resources	Using expansion turbines to recover the energy content of the pressurised fuel gases.	Flue gas heat recovery boilers are used to run a steam turbine to generate electricity and for process heating purposes.
	Preheating the fuel gas by using waste heat from the boiler or gas turbine.	See above.
Health and safety risk regarding ammonia	For handling and storage of pure liquefied ammonia: pressure reservoirs for pure liquefied ammonia >100 m^3 should be constructed as double wall and should be located subterraneously; reservoirs of 100 m^3 and smaller should be manufactured including annealing processes.	Not applicable, as urea is proposed to be used (not ammonia).

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
	From a safety point of view, the use of an ammonia-water solution is less risky than the storage and handling of pure liquefied ammonia.	Not applicable, as urea is proposed to be used.
Fuel pre-treatment	For liquid fuels, the use of pretreatment devices, such as diesel oil cleaning units used in gas turbines and engines, are BAT. Heavy fuel oil (HFO) treatment comprises devices such as electrical or steam coil type heaters, de-emulsifier dosing systems, etc.	Noted. See remarks below.
	In order to ensure correct pumping and operating conditions, diesel engines need a continuous supply of cleaned and filtered fuel oil at the correct flow and viscosity (for HFO typically below: 730 cSt at 50 ^{o}C). For heavy fuel oil, HFO treatment plants similar to those for gas turbines are applied, but with the following differences: only centrifugal separators are used and electrical or steam coil type heaters for heating up the HFO to the appropriate temperature (in order to achieve the required injection viscosity typically 12 – 20 cSt for a good atomisation at the nozzle); and in normal cases, de-emulsifier dosing systems (for breaking up the oil emulsion) are not used, and neither are dosing systems, for raising the melting point of vanadium products.	Fuel oil shall be subjected to a process of filtration, centrifuging and heating as necessary to condition fuel as to the prime movers requirements. De-emulsifiers shall not be used. **Prime mover requirements:** This refers to the requirements of the diesel engines. **Viscosity control:** HFO is heated to achieve required viscosity. Control of this parameter is automatic. **Expected viscosit**y at diesel engine inlet: 20-24 cSt.
Thermal efficiency	Electrical efficiency (at the alternator terminals) ranges from 40-45%	Efficiency is rated at 46%.

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Dust emissions	For de-dusting off-gases from new and existing combustion plants, BAT is considered to be the use of an electrostatic precipitator or a fabric filter.	Fabric filters are used. Fabric filters: >97% dust removal efficiency. The filtering performance stated by the manufacturer is enough to reach the dust emission limits set in the contract which are in accordance with BREF limits for diesel engine based plants. The abatement efficiency stated is expected to reduce with a cleaner fuels due to lower input concentration of pollutants concerned. The abatement performance is in accordance with BREF limits for diesel engine based plants using different kinds of fuel. Filter bags in Glass Fibre with ePTFE membrane and PTFE thread, type GORE High Durability Membrane. The reduction performed is: 1. Particulate matters before bag filter : approx. 1600mg/Nm^3 2. Particulate matters after the bag filter :≤50mg/Nm^3 at 15% O_2 3. Reduction: Min 97%, max design approx 99%. Each bag filter unit is equipped with 580 bags each 12m long . One bag filter house per 2 diesel engines. Goretex membrane material built in bag filters. Please refer to Annex 20: 3650_filter_bag_HD_fiberglass_ptfe:746
	For diesel engines running on HFO, BAT AEL is <50 mg/Nm^3 (Table 6.47).	Noted. BREF BAT value is at 15% O_2

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Heavy metals	Generally the application of high performance de-dusting devices such as ESPs or FFs.	Fabric filters are used.
Sulphur dioxide	As a first choice the use of low sulphur fuel (< 0.5%) or natural gas is considered as BAT. If these are not available FGD is considered as BAT.	FGD is used. FGD: 80% SO_2 removal efficiency. The SO_x emission limit to be reached is in accordance with TA LUFT limits for Diesel engine based plants. The $DeSO_x$ unit has been designed to achieve these required emission limits. "When liquid mineral fuels are used, only heating oils listed in Din 51603 Part1(version March 1998) with a sulphur mass contenent for light heating oil pursuant to the 3.BImSchV as currently applicable...... may be used or equivalent measures shall be applied." This infers that either heating oil with a max of 0.2%sulphur content shall be used (DIN 51603 pt. 1 light heating oil –current in 2007) or equivalent measures adopted to bring the emissions of sulphur oxide equivalent to fuel containing 0.2% Sulphur. Please refer to Annex 21: "DIN 51603 Light fuel Oil.

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
	Wet scrubber (reduction rate 92 – 98 %), and the spray dry scrubber desulphurisation (reduction rate 85 – 92 %). Dry FGD techniques such as dry sorbent injection are used mainly for plants with a thermal capacity of less than 300 MWth. The wet scrubber has the advantage of also reducing emissions of HCl, HF, dust and heavy metals. Because of the high costs, the wet scrubbing process is not considered as BAT for plants with a capacity of less than 100 MWth.	Dry type FGD are used.
	Most of the DESOX references in diesel power plants so far are wet scrubbers using a NaOH (about 50 wt-%) water solution as the reagent.	Not applicable.

<table>
<tr><th>Aspect of BAT</th><th>BAT conclusion</th><th>Proposal for Delimara extension</th></tr>
<tr><td></td><td>The BAT conclusion for wet scrubbing desulphurisation is related to the application of a waste water treatment plant. The waste water treatment plant consists of different chemical treatments to remove heavy metals and to decrease the amount of solid matter from entering the water. The treatment plant includes an adjustment of the pH level, the precipitation of heavy metals and removal of the solid matter.

Associated emission levels:
<table>
<tr><th colspan="2">Emissions to water from a wet FGD waste water treatment plant (mg/l)</th></tr>
<tr><td>Solids</td><td>5 – 30</td></tr>
<tr><td>COD</td><td><150</td></tr>
<tr><td>Nitrogen compounds</td><td><50</td></tr>
<tr><td>Sulphate</td><td>1000 – 2000</td></tr>
<tr><td>Sulphite</td><td>0.5 – 20</td></tr>
<tr><td>Sulphide</td><td><0.2</td></tr>
<tr><td>Fluoride</td><td>1 – 30</td></tr>
<tr><td>Cd</td><td><0.05</td></tr>
<tr><td>Cr</td><td><0.5</td></tr>
<tr><td>Cu</td><td><0.5</td></tr>
<tr><td>Hg</td><td>0.01 – 0.02</td></tr>
<tr><td>Ni</td><td><0.5</td></tr>
<tr><td>Pb</td><td><0.1</td></tr>
<tr><td>Zn</td><td><1</td></tr>
</table>
Table 4.71: Emission levels associated with the use of a BAT- FGD waste water treatment plant given as a representative 24 hour composite sample</td><td>Not applicable.</td></tr>
<tr><td>**Nitrogen oxides**</td><td>SCR is regarded as BAT.

However primary methods such as the ‘Miller concept’ (base engine optimised for low NOX), fuel injection retards, the addition of water (water injection directly into the combustion space or water-in-fuel emulsion or humidification of the combustion air) are also acceptable.</td><td>An SCR plant for each engine is used. SCR: 92% NO_x removal efficiency.</td></tr>
</table>

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
	Catalyst lifetime of 40,000 to 80,000 operating hours can be reached by periodical washing.	On reduced catalyst reactivity, Enemalta have the option of either change or regenerate (wash) the catalyst. The SCR catalyst will not be washed on site; catalyst washing (regeneration) entails treatment at a specialised factory. Regeneration can be used to extend the lifetime of the catalyst, Catalyst composition: WO_3 $+V_2O_5<10\%$ ($V_2O_5<3\%$), TiO_2~80%, Vitreous Fibres/SiO_2~10%. The expected lifetime of one catalyst layer without washing is 19,000hrs. No catalyst off-site washing facility has been identified as yet. A replacement catalyst will be kept sealed on site (stored). The washing / replacement of the catalyst is based on initial use of three layers in each SCR unit. When the combined activity of the three layers reaches the lower limit, a fourth layer is inserted - thus raising the combined activity. Only when the combined activity of all four layers reaches the lower limit, one layer is replaced. However this will depend on the recovered activity from the regenerated catalyst and catalyst degradation rate. The molar ratio shall be approximately 1. However, the actual ratio shall be known during the plant commissioning. Expected time required For SCR startup is 45min from cold /15min from warm
	NH_3/NO_X ratio: 0.8 – 1.0 NH_3 slip: <5 mg/Nm^3 Energy Consumption as % of electric capacity: 0.5%	

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Carbon monoxide	Good maintenance of engine. Primary measures aiming at complete combustion.	Noted.
Water contamination	Any surface run-off (rainwater) from the storage areas that washes fuel particles away should be collected and treated (settling out) before being discharged. Small amounts of oil contaminated (washing) water should be treated using oil separation wells.	Drains discharge into oil separators which are regularly monitored and maintained.
	The BAT conclusion for wet scrubbing desulphurisation is related to the application of a waste water treatment plant. The waste water treatment plant consists of different chemical treatments to remove heavy metals and to decrease the amount of solid matter from entering the water. The treatment plant includes an adjustment of the pH level, the precipitation of heavy metals and removal of the solid matter.	Not applicable.
Waste and residues	Utilisation and re-use is priority. There are many different utilisation possibilities for different by-products such as ashes. Each different utilisation option has different specific criteria. The quality criteria are connected to the structural properties of the residue and the content of harmful substances, such as the amount of unburned fuel or the solubility of heavy metals, etc.	Please refer to documents: **C3.1.1 DPS P3 07 Waste** **C3.1.3 DPS P3 08 Waste disposal ~ recovery**
	The end-product of the wet scrubbing technique is gypsum. It can be sold and used instead of natural gypsum (e.g. in the plasterboard industry). The purity of gypsum limits the amount of limestone that can be fed into the process.	Not applicable.

Aspect of BAT	BAT conclusion	Proposal for Delimara extension
Noise	The major sources of noise are various rotating machines, transformers and valves. Since increased distance from the source lowers noise, planning of land use both on a community level and within a specific industrial site is perhaps the best preventive measure to avoid noise problems. Inside the building, the same principle applies, i.e. the layout design should separate the working areas from noisy equipment.	Please refer to documents: **C3.7 DPS P3 14 Noise & Vibration Chapter EIA VOL I & C3.7 DPS P3 13 Noise Generated by New Plant**

Base load: plant/s run for 24 hours; **two-shift operation:** Plant/s run for 16 to 18 hours per day. Operation mode depending on electricity demand and availability of other plants. The catalyst elements will remain hot during the night shutdown as there would be no airflow through the exhaust ducts in this shutdown period. However some cooling is envisaged to occur and the urea cannot be injected in the SCR immediately as the engine is started. The time required for the reinstatement of the DeNox process is expected to be short and will be determined during the commissioning process. Enemalta intends to use both HFO and diesel for start-up. Diesel will be only used following prolonged shut down. Expected time required for SCR start-up is 45 minutes from cold and 15 minutes from warm.