The European Association of Internal Combustion Engine Manufacturers

EUROMOT

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LCP BREF position for remote areas

1. General features and background

The geographical isolation of small islands from the extensive infrastructure present in continental European areas places particularly difficult challenges on the operators of island electricity supply networks to provide sustainable and reliable supplies of electricity at an affordable cost.

It is significant to note that emissions from diesel plants on islands generally have a limited impact on local population (e.g. major NOx source is from road transport) and ambient air quality is fully compliant with EU directive 2008/50/EC.

In particular, power plants in SIS (Small Isolated Systems) / MIS (Micro Isolated Systems) are required to operate an electricity supply system which is subject to extreme variations of electricity demand, on both daily and seasonal bases.

Island generators face specific challenges that may not be immediately obvious to observers more used to continental (mainland) electricity generators. For example:

- lack of economic of scale
- restricted fuel choice (e.g. no gas fuel option) for islands generators
- geographic remoteness from continental infrastructure (lack of reagent supply, industrial waste disposal system, spare part supply, etc.)
- restricted available fresh water resource supplies
- lack of land area e.g. small plant site, no area available for industry waste disposal
- need for flexibility of generating plant to operate with high variations of duty cycle resulting from daily and seasonal variations in the island's electricity demand, and increasingly, fluctuating input from renewable power sources.

The size of generators installed on islands is a compromise between the use of the larger power units for enhanced efficiency, whilst maintaining an adequate level of redundancy in case the failure of units (it is important to remember that one unit may be on maintenance; in order to prepare for sudden failure of another unit implies that two reserve units may be needed). Therefore, island power generation typically consists of a number of units, each in the typical engine range of 1MWe - 20MWe. The needed level of reserve margin is further increased by the lack of electricity storage on islands, meaning that the plant must be able to support the maximum possible peak load of the island, even whilst having one unit out of commission.

The emissions from the diesel generators used on islands have been significantly reduced in the last years through the use of low sulphur fuels and the incorporation of modern combustion technologies. For example, the emissions of nitrogen oxides (NOx) from the larger engines used for diesel generation has already been reduced by up to 40% since the beginning of the 1990s while maintaining the same (high) efficiency, as a result of extensive R&D on the engine design itself. /1/

Further reducing these emissions will be challenging, particularly because the highly fluctuating operating cycle of island power plants has important (detrimental) implications for the functioning of secondary emissions abatement techniques in a power plant.

In this document a short review on secondary emission abatement techniques is made showing that in remote areas such as SIS/MIS less strict emission limits than proposed ones in the Final LCP BREF Draft/2/ are needed for the liquid fired engine plant.

This document supports the approved split views made for the liquid fired (reciprocating engine) in chapter 12 of the Final LCP BREF Draft (June 2016) /2/. Following liquid fired engine approved split views should at least be incorporated into chapter 10 BAT Conclusions of the LCP BREF in order to make set emission limits in SIS/MIS reasonable and based on existing commercial & technical feasible techniques:

- No 54: Approved Split View on SCR Applicability BAT 36
- No 55: Approved Split View on NOx BAT 36 (table 10.20)
- (No 58: Approved Split View on indicative CO BAT 37)
- **No 60: Approved Split View on particulates BAT 39 (table 10.22)**
- No 59: Approved Split View on SO_2 BAT 38 (table 10.21)
- **No 62: Approved Split View on particulates (load impact) BAT 39 (table 10.22)**

2. Secondary Emission abatement Techniques

In above text have been listed some challenges or even some time impossibilities to use secondary abatement techniques in remote areas such as SIS/MIS. <u>Unfortunately some of the BAT conclusion emission values in chapter 10 of the LCP BREF /2/ are based on abatement techniques which applicability is restricted in remote areas such as SIS/MIS or even beyond BAT (abatement technique not mature enough or universally suitable for all oil fired reciprocating engine plants to be classified as a BAT (Best Available Technique))</u>.

In the following text application of secondary emission abatement techniques for NOx (SCR - Selective Catalytic Reduction), for SO_2 (FGD - Flue Gas Desulphurization) and for dust: (FGD with bag filter or ESP – Electrostatic Precipitator) in remote areas such as SIS/MIS are further discussed.

2.1 NOx (SCR)

Set NOx limits in table 10.20 in chapter 10 of LCP BREF /2/ especially for the new liquid fired (reciprocating) engine plant are such that a SCR is a must for fulfilment.

SCR application is not practically available especially to island generators operating across a variable power range and with frequent starting and stopping. At lower operating loads and during the starting and stopping cycles the exhaust gas temperature of the engine is too low for effective operation of the flue gas treatment equipment (SCR). The catalysts might become 'poisoned' or fouled by impurities (originating mainly from the used fuel, SCR reagent (urea/ammonia, water compositions)) in the exhaust gas, and the exhaust gas treatment system becomes ineffective, resulting in violations of the emission limits/1/, /3/ (see chapter 6.1.10.3. 3 page 360, chapter 6.5.5.4 page 406), see also attachments 1A and 1B.

The supply of needed reagents for selective catalytic reduction would imply significant costs and logistical difficulties for islands. Furthermore, the disposal of used SCR catalyst elements (elements contain heavy metals and need thus a proper disposal) would be problematic and disproportionately expensive for an island. As explained in the introduction, significant further increases in the operating costs of island power generation could have a real economic impact on island economies, given the fact that tariffs may already be much higher than for mainland power systems. In Euromot document /4/ is shown that the SCR additional electrical price raising impact might be in order of up to 25 % (table 3 /4/), or in some cases even more depending on reagent price and a cost comparison done showed an about 3 - 9 times (see page 9 /4/) higher impact than for the boiler plant case. The external (= damage cost on society) (Euro/tonnes NOx) air costs between different EU areas differ a lot /5/ with lowest costs e.g. in Mediterranean Sea (see Annex 12 page 117) where many of the SIS/MIS plants are situated and thus the emission limits in SIS and MIS should be less ambitious set compared to the main land.

A SCR reactor is big and require a certain minimum space in the power plant, in attachment 2 is a picture with main measures of an installed SCR on a 6 MWe engine shown. An SCR designed for a bigger engine will due to the bigger exhaust gas flow be bigger in size. On islands the area available for the power plant is often very restricted and consequently usage of a SCR will in many cases imply big challenges (a special design needed in order to fit, if possible at all) in the power plant. For an existing power plant a lot of extra dismantling work in order to enable place for the SCR should also occur.

SCR operation in the Maltese plant (**not** a SIS / MIS area) which is the main SCR reference for the set BAT conclusions had very unstable NH_3 slips see graphs 2 and 3 /6/ - there is always a balance between the NOx emission and NH_3 slip from the SCR – if NOx limit is set too tight NH_3 slip might increase a lot which seemed to have occurred in the Maltese plant. See also attachment 1C for measured NOx/NH_3 data of the Maltese plant. In Final LCP BREF Draft /2/ chapter 10.1.3 page 756 is stated ammonia slip from a HFO/gas oil fired engine equipped with SCR higher end range is 15 mg/Nm^3 (15 % O_2). In other oil fired reciprocating plants namely La Reunion (no 691 in the BREF database, France submitted measurement data) and Madeira (no 429-4 in database, Portugal submitted data) higher yearly average NOx data was measured as 241 mg/Nm^3 (15 % O_2) (La Reunion) and 1377 mg/Nm^3 (15 % O_2) (Madeira), to note La Reunion and Madeira are remote islands. Thus the BAT conclusions for new plants are **set too low** for the NOx emission for remote plants.

Above aspects are reflected in approved split views 54 and 55 in order to make set BAT limits technical & economical feasible also in remote areas such as SIS and MIS.

2.2 SO2 (FGD)

Set SO_2 limits in table 10.21 in chapter 10 of LCP BREF /2/ especially for new heavy fuel oil (HFO) fired (reciprocating) engine plants are such that a FGD or fuel change to a low sulfur light fuel oil (LFO)/distillate is a must for fulfilment.

The LCP BREF /2/ BAT conclusions on reachable SO_2 and dust emissions are <u>more or less related to the Maltese NaHCO3 FGD</u> which is **in practice a base load special designed plant** (full heat recovery with a steam turbine, thus engine flue gas is cooled < 170 degree C enabling use of bag filters (see pages 14 of /7/) using a novel secondary SO_2 abatement technique which <u>cannot be applied to most other oil fired engine plants</u> e.g. in "remote plants" /7/ (see Annex 1 of source /7/ for more information). To be noted also is that the heavy fuel oil burned in the Maltese plant is a low sulfur 0.7 wt-% S one. A normal flue gas temperature of a diesel engine (depending on engine type) is typically 250 - 400 degree C. An "uncooled" diesel engine flue gas would destroy the filter material of a bag house and thus emergency cooling systems or/and by-pass of the baghouse have to be installed in the plant.

"*With a baghouse (also called a fabric filter) in operation, low flue gas temperatures result in moisture and damp ash collecting on the filter bags causing an increase in filter cake drag and decrease in cake permeability. If low temperature operation occurs for an extended period of time, there is the risk of permanently blinding the bags. Acid condensation with operation below the acid dew point can lead to premature filter bag failure. <u>These conditions can be greatly alleviated by the use of pre-coat of the filter bags</u> and/or a sacrificial chamber on initial startup.*..." /11/. Thus extra care to be taken at startups and shutdowns of FGDs with bag house filter systems.

Euromot /6/ (on page 2) also pointed out that the Maltese FGD plant should need more operation hours: " .. *A new plant in general shows excellent performance and a skewed emission picture of the performance will probable be obtained after limited operation hours. Only time and wear and tear will show the real time long term performance*" " **before any BAT conclusion based on it** can be drawn. Operation mode of the power plant was also going to be changed to natural gas in the near future and no HFO operation anymore in the future. The Maltese plant is currently being converted to a gas plant and will not operate on HFO (Heavy Fuel Oil) in the future.

The Maltese FGD is a dry FGD, no water required but has many drawbacks:

- Pre coating of filters needed: "***Clogging problems** may occur, e.**g. during start-ups <u>when oil</u>** <u>is burned</u> . The filter material is usually quite sensitive* .../7/ ". (Text is a reference to a boiler case – but shows that when burning oil extra care measures are to be taken).
- End product from the $NaHCO_3$ FGD is leachable in water and need thus to be sent to a factory for further treatment i.e. a special waste infrastructure is to exist /7, see Annex 1/. See typical process data of the $NaHCO_3$ FGD in attachment 3. It can be seen that the produced end product amount is huge.
- Enemalta (owner) report informed about dust problems due to the cyclic operation of the plant (plant was in practice a base load plant) and continued that continuous operation could have reduced such faults /8, page 8/. "

$CaCO_3$ scrubber (closed loop concept) /7, page 6/ alternative (no such oil engine reference plant found in the LCP BREF reference plant database) will need a huge clean (low chloride) water consumption about 100 .. 110 m^3/hr for a 100 MWe engine plant without heat recovery of the flue gas. Other scrubber technologies such as NaOH reagent based have a similar raw (fresh) water consumption as the $CaCO_3$ scrubber. The scrubber is such not a good alternative for an arid area or an island – should put stress on scarce raw water resources. To note is also the visible plume from a scrubber plant – flue gas temperature in the stack is about 60 degree C and thus the ambient air quality pollutant concentrations will increase in the local neighbourhood (“bad dispersion of flue gases”). **Note** that LCP BREF /2/ in chapter 10.3.2.3 BAT 38 has concluded about the wet FGD “***There may be technical and economic restrictions for applying the technique to combustion plants < 300 MWe***”, I.e. a scubber is recommended only for BIG plants. The diesel engine can be started very fast /8/ but a scrubber plant needs also some time for starting up the system if it has been standing. Wet FGD: “*A minimum number of recycle pumps should be placed in service at low load conditions to protect the system against a down draft of slurry. Generally, a recycle pump is placed in service when induced draft (ID) fans are placed in service and reagent addition placed in automatic mode. If the absorber inlet is not properly designed, the downdraft may result in slurry carryover into the inlet ductwork causing buildup.* “ /11/.

Typical end product amount formulas from the wet scrubbers and dry FGD are in attachment 3. FGD is producing a big end product amount (e.g. a 100 MWe reciprocating engine plant equipped with a wet $CaCO_3$ scrubber burning a 1 wt-% S heavy fuel oil will produce about 1500 kg/h gypsum). , a similar size engine plant burning a 1 % S HFO equipped with a wet NaOH scrubber about 20 m3/hr “black” waste water containing heavy metals, SO_3/SO_4 salts, etc. – which have to be handled in an environmentally acceptable way – an end product disposal infrastructure is to exist otherwise these will be a big cost burden for the plant.

Needed footprint need for the FGD is huge, see attachment 4, it can be concluded that the FGD + ESP systems are requiring a bigger footprint than the engine power plant building.

Above aspects are also reflected in approved split view 59 in order to make set BAT limits technical & economical feasible also in remote areas such as SIS and MIS.

2.3 Dust (FGD, ESP)

Set dust limits in table 10.22 in chapter 10 of LCP BREF /2/ especially for new heavy fuel oil (HFO) fired (reciprocating) engine plants are such that a FGD (with bagfilter) or an ESP is a must for fulfilment. In text below is shown that neither the bag filter nor ESP alternatives are mature enough techniques to fulfil the strict dust limits in table 10.22 for a new HFO fired plant. Fuel change to a “normal” max. 0.1 wt-% S LFO is not a sufficient measure for fulfilment of the set strict dust limits for the new plant.

The LCP BREF /2/ BAT conclusions on reachable dust emission is based **only** on the plant data from the Maltese plant equipped with a novel $NaHCO_3$ FGD. In Euromot document /6/ graph 1 the measured dust data obtained from the Maltese plant is gathered (see also attachment 6), in source /9/ on page 17 has been shown that the gathered data indicated strongly that the dust value should be set **highe**r than 20 mg/Nm^3 (15 % O_2) to be a limit fulfilling the 95th percentile of the plant total operational time, source / 8/ reported (see page 8) big operational challenges with the FGD thus Euromot recommended a dust limit < 30 mg/Nm^3 (15 % O_2) due to the obvious immatureness (NOT yet technical feasible) of the Maltese FGD system. This dust value of 30 mg/Nm^3 is far higher than the BAT conclusion range of 5 .. 10 mg/Nm^3 (15 % O2) in table 10.22 of BAT Conclusion chapter 10 in LCP BREF document /2/.
In above “FGD” chapter 2.2 has been shown that the Maltese FGD is not a viable alternative in most HFO fired diesel engine plants especially if plant is not equipped with full heat recovery and in an area with a less developed infrastructure (reagent supply, end product disposal options lacking), etc.

Another secondary particulate reduction method candidate could be ESP (Electrostatic Precipitator) used largely in boiler plants around the world. Euromot document /7, pages 7 - 8) states: "*The current LCP BREF from 2006 ..chapter 6.5.5.2 that 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 of flue gas As a consequence the ESP performance for flue gases from boiler and diesel engine plant will be very different. Boosted demo ESP (two field type) field testing in a HFO plant indicated that about the same particulate level about 30 mg/Nm3 (15 % O2) as above achieved in the long term bag filter testing ,, could be achieved. .. ESPs for HFO engines are very large due to the need to keep the flow speed of the flue gas around 1 m/s and thus space requirement is big .. ESP cost is also high and removed ash to be disposed in an environmentally acceptable way.* … ". General information is given in source /10/ about the start up and shutdown of an ESP – document is made for a solid fired boiler plant but many of the ESP aspects are similar for a liquid fired reciprocating engine plant ESP. "*The two main concerns for startup and shutdown are the flue gas temperature as related to operation of the ESP below the acid dew point and the potential for spontaneous combustion or explosion with existence of unburned combustibles in the flue gas which could be ignited by sparking in the ESP … CO or unburned fuel caused by incomplete combustion. This can create a hazardous condition that could cause conditions for* ***spontaneous combustion or even explosion*** *particularly if there is sparking in the ESP with the ESP energized..*" /11, page 23/. Thus, in plants with varying loading/frequent start and stop conditions ESP should be used with care.

See attachment 5 for a (2 field) ESP view (connected to a 6 MWe HFO engine).

Euromot /9, page 16/ indicates that with a (primary techniques such as appropriate fuel choice at high engine loads 85 .. 100 % MCR (Maximum Continuous Rating) engine load) max. 0.5 wt-% S & low ash HFO a daily dust limit of max. 40 .. 45 mg/Nm^3 (15 % O_2) should be reachable.

Above aspects are also reflected in approved split view 60 in order to make set BAT limits technical & economical feasible also in remote areas such as SIS and MIS.
Approved split view 62 connecting dust limit with the engine loading is also vital (unfortunately granted only to an existing plant despite numerous requests made by Euromot, ("latest comment on the split views" was submitted in September 2016) to extend split view also to new plants have been rejected).

3. Sources:

/1/ Eurelectric "Emissions from diesel generation in Small Island Power Systems ..", July 2011; submitted to the UNECE Gothenburgh process, available at link
https://www.unece.org/fileadmin/DAM/env/documents/2011/eb/wg5/WGSR49/Informal%20docs/EURELECTRIC-disel_engines_and_Gothenburg_protocol-July_2011.pdf

/2/ Final LCP BREF Draft (June 2016), available at link
http://eippcb.jrc.ec.europa.eu/reference/BREF/LCP_FinalDraft_06_2016.pdf

/3/ Current LCP BREF (2006), available at link
http://eippcb.jrc.ec.europa.eu/reference/BREF/lcp_bref_0706.pdf

/4/ Euromot Position on WGSR 49 2011 at
https://www.unece.org/fileadmin/DAM/env/documents/2011/eb/wg5/WGSR49/Informal%20docs/9_UNECE_Gothenburg_EUROMOT_Position_final_2011-08-16.pdf

/5/ ECM BREF 2006 at http://eippcb.jrc.ec.europa.eu/reference/BREF/ecm_bref_0706.pdf

/6/ Euromot Position "Comments on Maltese Plant Data Submitted by EEB (European Environmental Bureau) on December 2014", January 2015 at link http://euromot.org/download/54da4c2cb49b86c3cbe73ca9

/7/ Euromot Position " Draft D1 Large Combustion Plants BREF – BAT AELs for HFO-fired Engines", September 2013 at link http://euromot.org/download/54383683de278fdcb4d093b1

/8/ Euromot "Comments to CEFIC Comments", November 2014 at link http://euromot.org/download/5478c1c83efeb631842bcb77

/9/ Euromot Position "EU LCP BREF Feedback on Liquid Fuel Engines", May 2015 at link http://euromot.org/download/569feccc44870c9d77a05ff5
/10/ "ESP startup and shut down", by EPRI at link http://sites.epri.com/ESP/startup%20and%20shutdown.htm
/11/ "Guidance Document on Startup and shutdown .." by ICAC: link at http://c.ymcdn.com/sites/www.icac.com/resource/resmgr/White_Papers/MATS_SS_Guidance_Document_Fi.pdf

4. Attachments:

1. A: SCR aspects B: SCR deterioration factors C: Maltese measurement NOx/NH_3 data
2. SCR reactor typical main dimensions for a 6 MWe engine
3. Typical Wet limestone, NaOH and $NaHCO_3$ FGD process values
4. Wet $CaCO_3$ FGD plant overview – Reference: 10xW18V46, Power plant in Guatemala
5. ESP view in connection with a 6 MWe HFO diesel engine
6. Maltese measured dust data

Attachment 1A: SCR aspects /3/ (chapter 6.1.10.3. 3 page 360)

When considering the applicability of SCR in diesel power plants the following four points must be considered:

- firstly, focus should be put on the exhaust gas temperature in order to avoid salt formation on the catalyst elements. A certain minimum flue-gas temperature, which depends on the sulphur content of the fuel, has to be maintained. Some trace metals which might be present in the fuel can act as 'catalyst poisons' and, therefore, the ash content of the fuel to be used should preferably be analysed before the method is installed if low grade heavy fuel oil is utilised. Most diesel plants today equipped with SCR run on low sulphur oils or natural gas. Experience has shown that when operating on heavy fuel oil or other residual fuels, a soot blowing sytem is to be installed in the SCR reactor in order to keep the elements clean and avoid pressure drop increases over the SCR

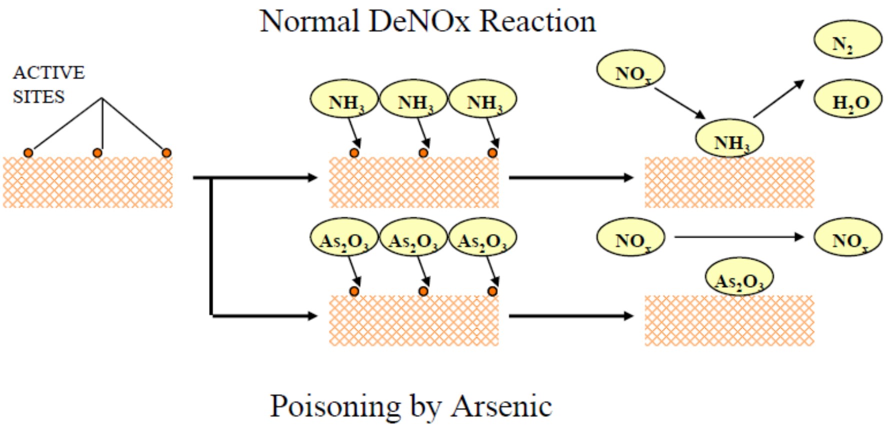
- secondly, by using urea the transportation and storage risks associated with ammonia can be minimised. In some places, the supply of reagent may be limited by the lack of proper industrial infrastructure

- thirdly, the SCR technology has high capital and operating costs. Each engine has, in general, to be equipped with its own SCR unit due to technical reasons. Operating costs depend on the amount of reagent needed and on the frequency at which the catalytic elements need to be replaced or newly added to maintain the design efficiency of the SCR (after a few years of operation). The used catalytic elements need to be properly disposed of

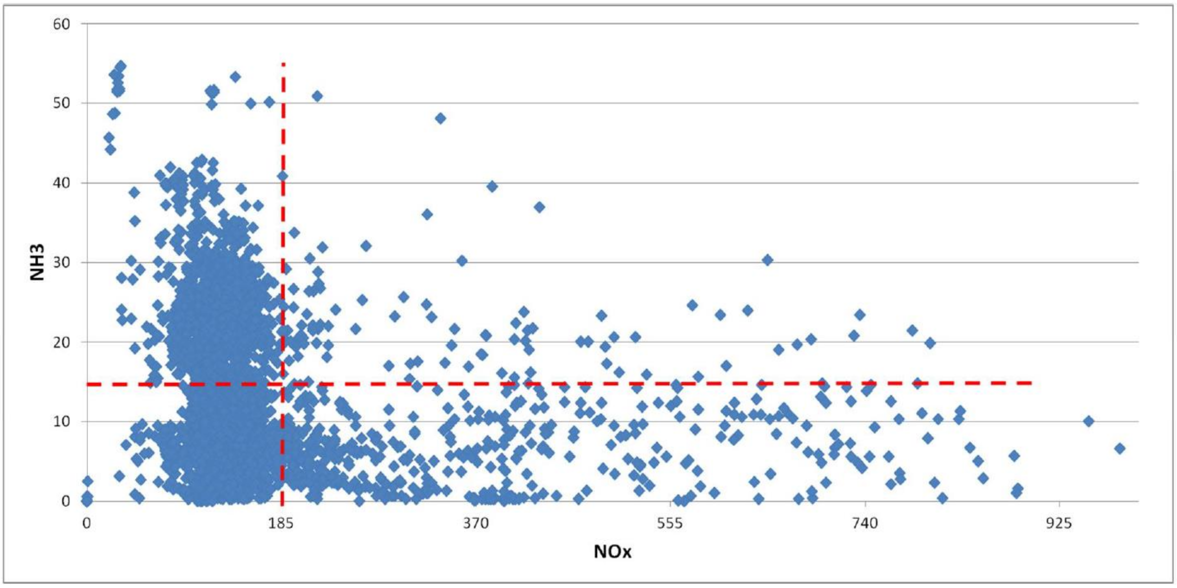
- finally, the SCR system is recommended to be subject to regular planned maintenance or inspection, e.g. annually, in order to prevent ammonia slip. For instance, with high ammonia 'slips' harmful salt deposits can occur on the internal surfaces of the components sited after the reactor, such as, for example, on the boiler.

Attachment 1B: SCR deterioration factors

Chemical	- Na, K, Ca, Mg, As, Se
Physical	- deposits and erosion
Thermal	- sintering



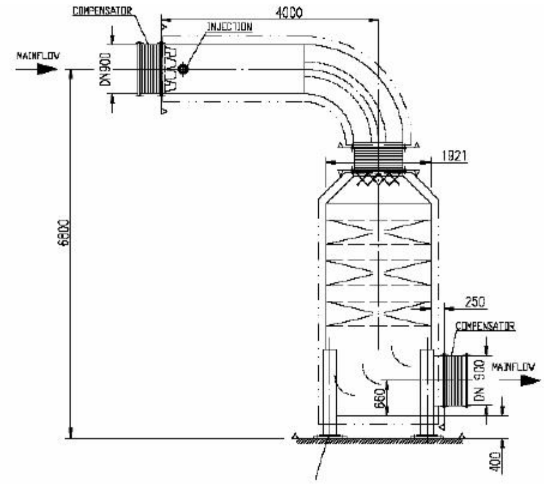
Attachment 1C: Maltese NOx/NH_3 measurement data /6/



Graph 2: Stack “6B” measured NH_3 and NOx one-hour averaged values year 2013, emission unit mg/Nm^3 (15 % O_2). With “filter lines” (see Annex 1 for more information): for NH_3 15 mg/Nm^3 and NO_x 185 mg/Nm^3. Concentration reference point 15 % O_2.

Attachment 2: SCR reactor picture of a 6 MWe diesel engine

SCR for Wärtsilä® 12V32 engine installation



Attachment 3: Typical wet limestone, NaOH and $NaHCO_3$ FGD process values

Wet limestone ($CaCO_3$) FGD – Flue Gas Desulphurization		
Abatement		
✓ SO_2 capture typically 80 – 90 %.		
Reagent		
✓ Limestone ($CaCO_3$) powder of reactive FGD quality		
Consumables*		
✓ Limestone as 100 %	~7.5	kg/MWhe /1% S_{fuel}**
✓ Process water	~1	m^3/MWhe (closed loop operation)***
✓ Electricity	1.5-2	% as parasitic
By-products		

- ✓ Gypsum ~2 x actual limestone consumption.
- ✓ *Disposal of by-products to be handled in environmentally acceptable way.*

* *Values are only indicative and given for a typical FGD case: Only own consumption boilers, wet stack and no booster-fans.*
** *Typical actual consumption of reagent is obtained by multiplying the value with the mass-% of sulfur in dry fuel.*
*** *The fresh* process water to be of good quality (low chloride etc.). If full-scale WHRS is included the water consumption is 40-50 % less.

Wet NaOH FGD – Flue Gas Desulphurization

Abatement

- ✓ SO_2 capture typically 90 %.

Reagent

- ✓ Aqueous sodium hydroxide (NaOH) as 50 % solution.

Consumables*

✓ NaOH (as 100 %)	5-5.5	kg/MWhe/1% S_{fuel}**
✓ Process water***	~1	m^3/MWhe
✓ Electricity	0.5-1	% as parasitic

By-products

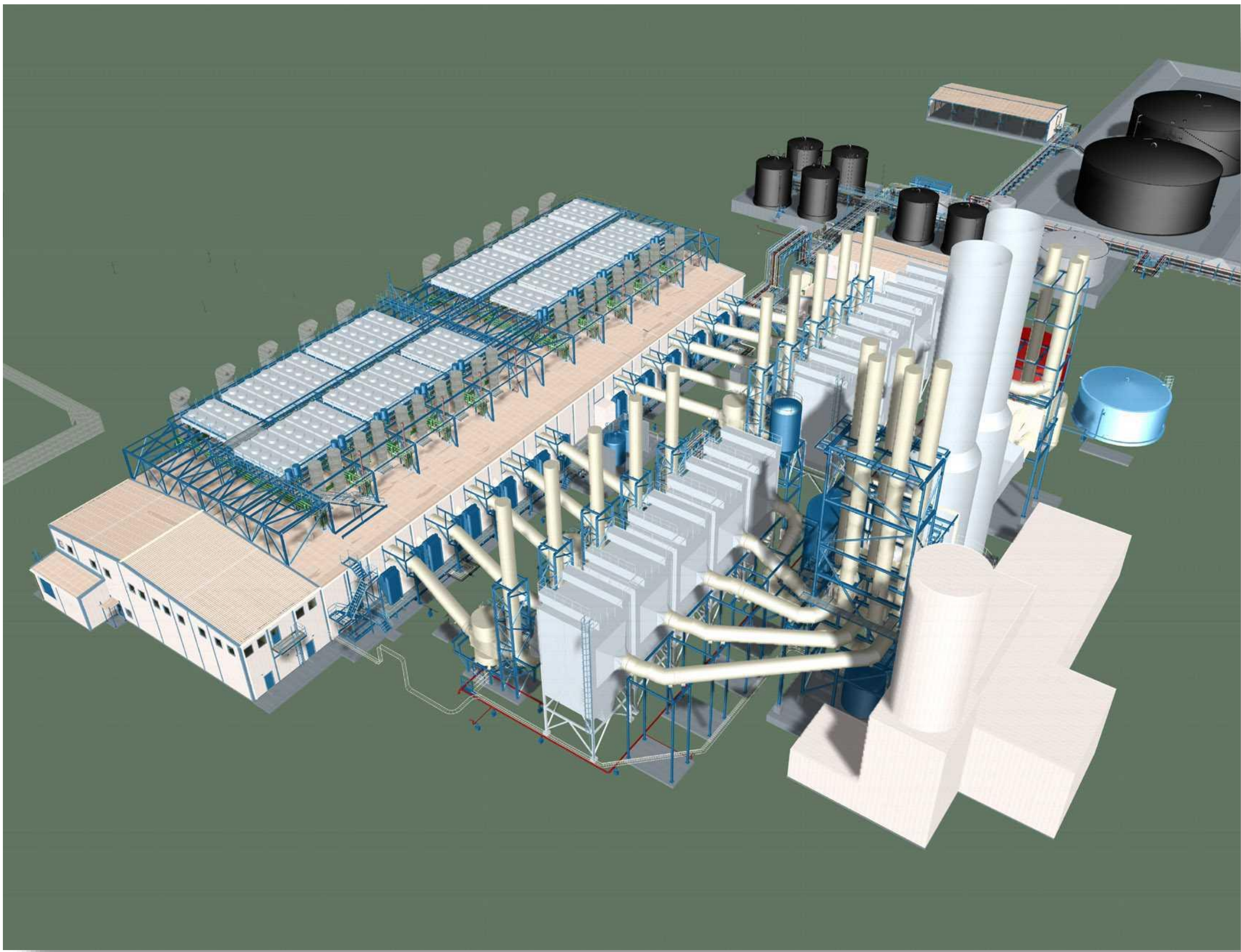
- ✓ Waste water typically ~10 (-20) % of process water flow and legislative requirements might restrict possible projects
- ✓ *Treatment and disposal of by-products to be handled in environmentally acceptable way.*

* *Values are only indicative and given for a typical FGD case: Only own consumption boilers, wet stack and booster-fans.*
** *Typical actual consumption of reagent is obtained by multiplying the value with the mass-% of sulfur in dry fue*
*** *The fresh* process water to be of good quality (low chloride etc.). If full-scale WHRS is included the wa consumption is 40-50 % less.

NAHCO$_3$ FGD operating on a 0.7 wt-% S HFO:

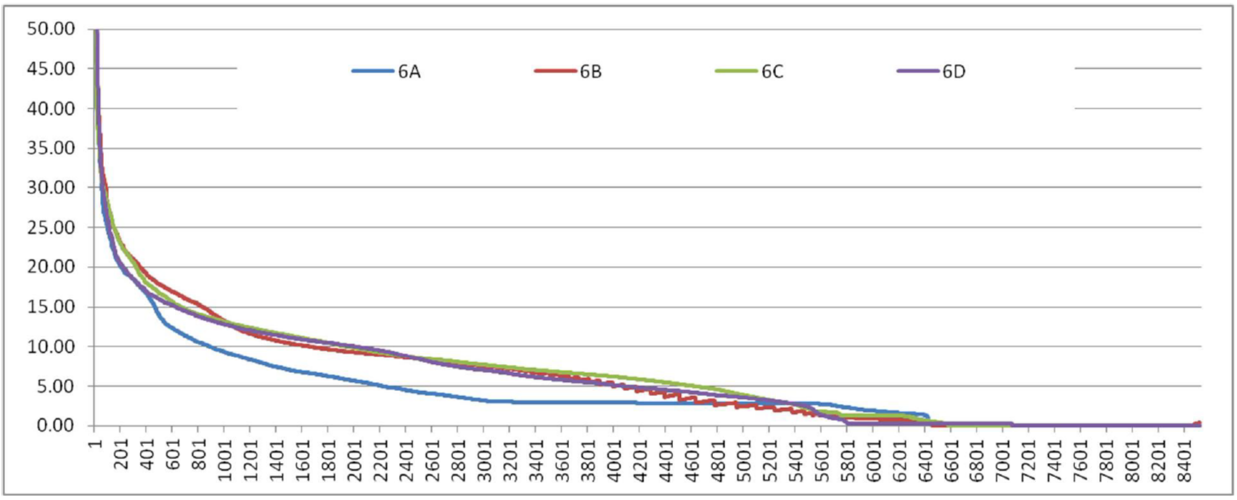
- CO_2 emission factor 0.56mt/MWh$_e$
- Average Specific Fuel Consumption 0.180mt/MWh$_e$
- Lube Oil Consumption 0.621l/MWh$_e$
- Sodium Bicarbonate for FGD 6.5kg/MWh$_e$
- Urea for SCR 8.9kg/MWh$_e$
- Solid Waste generation 5.8kg/MWh $_e$
- Solid waste composition (dry):
  - Sodium Sulphate (Na_2SO_4) 78%
  - Sodium Carbonate (Na_2CO_3) 17%
  - Fuel Ash 5%
- Oil Sludge (remixed with boiler fuel) 3m^3/day
- net electrical output (perf. test) 145.2 MW$_e$ @ 48.1% net eff.
- Net Heat Rate (perf. test) 7486MJ/MWh$_e$
- Internal consumption (perf. test) 4.4MW$_e$ (2.9% of gross output)
- Gross Power Output 149.6MW$_e$
- Fresh water production 1500m3/day

Attachment 4: Plant with Wet $CaCO_3$ FGD + ESP – Reference in Guatemala, 10xW18V46 equipped with FGD and ESP



Attachment 5: ESP (designed for 50 mg/Nm^3 (15 % O_2 dust) after a 6 MWe diesel HFO diesel engine

Attachment 6: Measured Dust data year 2013 in Maltese HFO plant /6/



Graph 1: Frequency of measured 1 hour averaged Dust values ("raw measurement data") in unit mg/Nm^3 (15 % O_2) for the different stacks during year 2013. On the y-axis dust emission and on the x-axis operational hours of the year.

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