EUROMOT

Revision of the Gothenburg Protocol - Consequences for Stationary Engines

The Euromot Position

as of 02 December 2009

EUROMOT

The European Association of Internal Combustion Engine Manufacturers

President: Michael G Hawkins

General Manager: Dr Peter Scherm

Lyoner Strasse 18, ZIP 60528
Frankfurt/M., Germany

fon 0049 69 6603-1354
fax 0049 69 6603-2354
eMail euromot@vdma.org
web www.euromot.org

ENGINES IN SOCIETY

Office registered in Frankfurt/M., No.VR4278

EUROMOT is the European Association of Internal Combustion Engine Manufacturers. It is committed to promoting the central role of the IC engine in modern society, reflects the importance of advanced technologies to sustain economic growth without endangering the global environment and communicates the assets of ICE power to regulators worldwide. For almost 20 years it has supported its members, consisting of national associations and companies from all over Europe and abroad, by providing expertise and up-to-date information and by campaigning on their behalf for internationally aligned legislation.

For further information about the Association, please visit our website:
http://www.euromot.eu – **your bookmark for engine power worldwide**

Our members are:

CASE NEW HOLLAND	**LOMBARDINI**
CATERPILLAR POWER SYSTEMS	**MAN**
CUMMINS	**MTU FRIEDRICHSHAFEN**
DAIMLER	**MWM**
DEUTZ	**ROLLS-ROYCE**
DRESSER WAUKESHA	**SAME DEUTZ-FAHR**
FIAT POWERTRAIN TECHNOLOGIES	**SCANIA**
GE JENBACHER	**SISU DIESEL**
HATZ	**STEYR MOTORS**
JCB POWER SYSTEMS	**VOLKSWAGEN INDUSTRIAL ENGINES**
JOHN DEERE	**VOLVO CONSTRUCTION EQUIPMENT**
KAWASAKI EUROPE	**VOLVO PENTA**
KOMATSU ENGINES	**WÄRTSILÄ**
LIEBHERR	**YANMAR INTERNATIONAL EUROPE**

SSIE GROUP (SMALL SI ENGINE MANUFACTURERS)

AGCO SISU POWER	**MHI EQUIPMENT EUROPE**
BRIGGS & STRATTON	**ROBIN EUROPE**
DOLMAR	**SHINDAIWA**
EMAK	**STIHL**
GGP (ALPINA)	**TECUMSEH**
HONDA EUROPE	**TORO EUROPE**
HUSQVARNA	**WACKER NEUSON**
KOHLER ENGINES	**YAMABIKO (ECHO)**
McCULLOCH EUROPE	**ZENOAH EUROPE**

Status: 2009-11-01

BACKGROUND

The current Gothenburg Protocol which entered into force 17 May 2005 also contains NOx emission limits for new stationary engines in Annex V table 4. Over the years, the engine industry has shown in a number of position papers and publications that the current emission limits for new stationary engines go *" [..]* ***beyond BAT, not technically and economically sound*** *and* ***not improving energy efficiency & usage of renewable fuels*** *"* /1, 8/, etc.

UNECE consists of 56 member states that are located in North America, Europe and wide parts of Asia. Several countries have claimed about their disability to fulfil the current limits in the technical annexes of the Gothenburg Protocol and as of 2 September 2009 only 25 countries (about half of all UNECE member states) had fully ratified the Protocol. In the current Protocol (article 3) is inbuilt a flexible mechanism "different emission reduction strategy"; by fulfilling the emission ceilings in Annex 2 of the Protocol a Party can deviate from the limit values in Annexes IV, V and VI, **but** more flexibility options seem to be needed in the Protocol in order to make it feasible.

In article 3 of the Gothenburg Protocol is also stipulated that the updating of the Protocol should start "no later than two years after entry into force of the Protocol". In beginning of 2008, the stationary engine sub-group within EGTEI was founded for the updating work of the stationary engine NOx emission limits. EUROMOT participated actively in all sub-group meetings during 2008 and 2009 (see sub-group webpage at /2/). Some proposals of EUROMOT after the first meetings in order to increase flexibility of the Protocol are presented in document /7/.

End of May 2009, the "Guidance document for New Stationary Engines" was finalized by the sub-group and sent to the UNECE secretariat. This document issued by UNECE can be found at /3/. Emission options proposed based on the Guidance document can be found in the "Draft Revised Technical Annex V" /4/ on pages 7 - 8 and 11 - 16. In the "Draft Revised Technical Annex V" several emission options ELV1, ELV2, ELV3 and new flexibility options are proposed for the stationary engine plant in order to make more ratifications possible.

The new Protocol should be based on an environmental quality need approach taking environmental and economical aspects into consideration in a balanced way. EUROMOT supports inclusion of new "flexibility" & emission options and by these making the Gothenburg Protocol more technical and economical feasible in comparison to the current Protocol. In below text we have shortly explained the different proposed emission & new flexibility options and given our opinion on these.

FLEXIBILITY OPTIONS IN "DRAFT REVISED TECHNICAL ANNEX V"

Emission options ELV1, ELV2 and ELV 3 in Annex V are listed in ANNEX 1. Below the meaning of the different options ELV 1 – 3 and the new flexibility mechanisms proposed is briefly explained.

Emission Options

ELV 1

ELV1 is a demanding but technically feasible option with the objective of achieving a high level of NOx reduction. The ELV1 is based on a value between the lower and upper BAT AEL from the EU LCP BREF /5/ (where it is available). **Cost impact is not taken into consideration.**

SCR aspects:

SCR is an efficient technology but has technical (e.g. infrastructural) and economical constraints (please see page 360 /5/). This option assumes that a good infrastructure exists (availability of suitable fuels, reagents, spare parts, etc.) and focuses on reducing one emission component only (namely NOx) other emission impacts (CO_2, CO, VOC) such as secondary emissions caused from reagent transportation by trucks and production are not considered. Furthermore, the cost impact of the abatement option is not taken into consideration.

Emission limits:

For all gas/liquid fired applications the only alternative to fulfil the set NOx-limits are usage of SCR with a high efficiency. The driving force for application of SCR is often the need to improve local air quality especially in severely degraded air-sheds to comply with the high reduction targets of NOx emissions.

Emission limits of the spark ignited (SG) and dual fuel (DF) engines in gas mode are close to the lower end of the EU LCP BREF BAT span /5/. For diesel and liquid mode DF engines no BAT spans were set in the EU LCP BREF document. Regarding liquid fired diesel engines the EU LCP BREF stated in paragraph 6.5.5.4 *"[..] as a result SCR is part of BAT, but no specific emission levels are associated with BAT in a general case .."* and in UNECE document /3/ *"A limitation for the applicability of SCR is given for diesel engines, which need to be operated in varying loads", "[SCR] cannot be seen as BAT for engines with a frequent load variation due to technical constraints [..]".*

Proposed emission levels are close to very strict emission limits set in countries with good existing infrastructure such as Belgium, Netherlands, France **(NB** for > 100 MWth plant) and Germany but significantly lower than the ELVs proposed for the new European Industrial Emissions Directive. For example one country has chosen to take all possible reduction measures for different sectors (including stationary engines) in order to be able to comply with the NOx ceiling set in the National Emission Ceilings Directive (NECD, 2001/81/EC). Highly efficient SCRs are needed for the diesel and liquid fired DF engines in order to comply with set NOx-limits.

ELV 2

ELV2, while technically demanding, pays greater attention to the costs of the measures for achieving reduction. ELV2 is a value based on the upper BAT AEL from the EU LCP BREF /5/ (where it is available).

Emission limits:

Emission limits of the spark ignited (SG) and dual fuel (DF) engines in gas mode are achievable with a primary abatement measure namely advanced lean burn. "Advanced lean burn" will lead to higher emissions of unburned gaseous components such as CO, HC, lower flue gas temperature (detrimental for Combined Heat and Power (CHP) applications) and an increased fuel consumption (as a consequence also higher CO_2 emissions).

For the diesel engines and liquid mode DF the only option to fulfil the set NOx limits are to use SCR (moderate – high efficiency). Some of the emission limit options for the diesel engines have two alternatives; this is due to the cost aspect. The operation and maintenance cost (O&M) of a SCR system is mainly dependent of the consumed reagent (costly good quality urea or ammonia),

the control system will adjust the reagent flow to the SCR based on the pre-programmed parameters and the measured engine loading/NOx outlet concentration, i.e. a stricter NOx-limit leads to higher reagent consumption and a higher O&M cost.

Proposed emission levels for diesel engines are close to countries with strict emission limits and good existing infrastructure such as France, Italy and Germany. For the gas fired lean burn spark ignited (SG) and dual fuel (DF) engine types the limits are a mix of the EU LCP BREF document BAT range and "split views" by the industry (see table 7.36 /5/).

ELV 3

ELV 3 represents current good practices based on the legislation of a number of parties to the Convention.

- Spark ignited (SG) lean burn gas engines:
  - The lean burn principle representing BAT is used to keep the NOx-level at 190 mg/Nm^3 (15 % O_2), similar to law requirement in Germany. This emission level is also according to the IPPC (Integrated Pollution Prevention Principle) principle (optimized conditions): low fuel consumption and unburned gaseous emissions (CO, VOC, etc.) and high flue gas temperature (relevant for CHP applications).

- Dual fuel (DF) engine in gas mode:
  - The lean burn principle representing BAT is used to keep the NOx-level at 380 mg/Nm^3 (15 % O_2), similar to emission law in France (< 100 MWth plant). The Portuguese NOx-limit is also close by /13/. This emission level is also according to the IPPC (Integrated Pollution Prevention Principle) principle (optimized conditions): low fuel consumption and unburned gaseous emissions (CO, VOC, etc.) and high flue gas temperature (relevant for CHP applications).

- Liquid fired engine:
  - DF-type:
    - Optimized low-NOx rated engine. NOx emission 2000 mg/Nm^3 (15 % O_2) at optimized fuel consumption, lower NOx-level of 1850 mg/Nm^3 can be reached by use of injection retard at a higher fuel consumption. Emission limit minimum requirement as used by OECD /6/. Many countries participating in the UNECE work do not have emission legislation for stationary engine plants and therefore the minimum requirement as used by OECD is chosen. Public development financial institutions such as OECD Export Credit Agencies and European Development Finance Institutions and leading banks worldwide have publicly referenced the use of the IFC performance standards in which EHS Guidelines /9/ and /10/ are integrated.
  - Diesel Engine:
    - Diesel (Medium/Slow Speed), 5- 20 MW: NOx level of 1600 mg/Nm^3 (15 % O_2) can for medium speed four stroke engine types be fulfilled by a primary method

as the latest design Low-NOx generation < 400 mm cylinder bore engine at optimized fuel consumption. For some other engine types a wet method with increased fuel consumption or SCR is the option. Emission limit minimum requirement as used by OECD /6/, for more information see above. In some EU countries like UK/11/, Portugal /13 and Finland /12/ about similar NOx-limits are applied to plants < 50 MWth.

NOx-level of 1300 mg/Nm3 are a future option for some engine types, (NOx level measured in some first laboratory trials) **BUT further big development efforts which will take years** are needed before commercial release is possible.

- Diesel (Medium/Slow Speed), > 20 MW: NOx level of 1850 mg/Nm^3 (15 % O_2) can be fulfilled by a primary method as the current design Low-NOx tuned ≥ 400 mm cylinder bore engine by injection retard (for medium speed engines), for a two stroke engine some wet method both with an increased fuel consumption is an alternative. Future four stroke and two stroke engine generations are expected to reach NOx-level without an increased heat rate. Emission limit minimum requirement as used by OECD /6/, for more information see above.

  NOx-level of 750 mg/Nm^3 can only be reached by using SCR, this is a NOx-emission limit as per TA-LUFT 1986 for diesel engines which has been used by several countries when setting national standards (e. g. Italy).

- Diesel (high speed) > 5 MW: NOx level of 900 mg/Nm^3 (15 % O_2) can be fulfilled by a primary method. NOx level corresponds to US Tier 2 requirements for which engines are optimized. Engine design modifications are needed in order to reach the NOx-level of 750 mg/Nm^3 with an increase in fuel consumption.

New proposed flexible mechanisms

Existing infrastructure

For certain geographical areas such as remote islands/other areas where the existing infrastructure is poor (commercial availability of good fuel quality [e.g. no gas], reagents, etc. is restricted) or plant application such as peak-load operation and varying loads restricts available abatement methods, a time limited transition period during which the upper ELV 3 limits are applied is granted.

"Grid stability plants"

For engines operating 500 - 1500 hr/year the upper ELV 3 limits are applied. It is expected that these kinds of plants will be needed due to the large increase in renewable energy production (e.g. wind and solar power) in order to stabilize the electrical grid. These power plants will typically have frequent start-up/shut-down periods and operate on varying loads (making usage of SCR infeasible).

Others

Sudden unforeseen gas supply interruption: for a limited time period or in an overriding need to maintain energy supplies derogation from emission limits when operating on back-up fuel.

Emission NOx bonus for efficient engines generating less CO_2 according to a formula based on a reference efficiency,

CONCLUSION

The stationary engine plant contributes according to EU statistics **less than 0.26 % of the total NOx emissions in Europe (EU 15 area)** /8/. According to Annex IV of the IPPC Directive /14/: "*Considerations to be taken into account generally or in specific cases when **determining best available techniques**, as defined in Article 2 (11), **bearing in mind the likely costs and benefits** of a measure* and *… the consumption and nature of raw materials (including water) used in the process and their energy efficiency*".

Thus, we believe that ELV 1 – which focuses solely on the reduction of a single pollutant namely NOx and does not consider the impact of other emissions nor efficiency and costs – does not represent BAT or the IPPC approaches. We consider this emission option to be closer to a LAER (**L**owest **A**chievable **E**mission **R**ate) used in degraded air sheds ("nonattainment" in US).

Furthermore, we observe following: when comparing e.g. emission NOx-limits for **> 1 MWth unit** gas engines in the UNECE document /4/ to a big gas turbine **single > 50 MWth unit** we note that gas engines from a very small size have a stricter NOx-limit of 35 mg/Nm^3 (15 % O_2) compared to the big gas turbine unit limit of 50 mg/Nm^3 (15 % O_2). Liquid/gas fired boiler plants < 50 MWth are not regulated either but stationary engines already from a small (1 .. 5 MWth depending on engine type and fuel) unit size.

ELV 2 takes cost and benefits into account, especially the higher limit options are closer to BAT (**B**est **A**vailable **T**echnique) approach for industrialized/urban areas with a good existing infrastructure.

ELV 3 is BAT especially for areas with a restricted existing infrastructure (such as remote areas or islands) and smaller plants < 50 MWth in rural air sheds. It should be noted that this option (higher values) is according to the OECD minimum approach and limits used by several EU countries today for plants < 50 MWth.

EUROMOT supports an environmental quality driven approach which takes into account environmental, technical and economical aspects. In our opinion ELV 3 represents the preferred way especially for smaller plants in remote areas in EU and in general for countries in an economic transition. Industrial/urban areas with higher air emissions could apply the ELV 2 option (higher values) and by this be close to a BAT approach. In our opinion, ELV 1 should only be applied in "special" areas with a degraded airshed where an overriding need to improve the air quality exists and the cost aspect is considered less important (similar to a LAER approach in non attainment areas in US).

Vaasa / Frankfurt/M., 2009-12-02

Johan Boij
WG Chairman

Paul Zepf
Technical Manager

SOURCES

/1/ Euromot position: Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to abate Acidification , Eutrophication and Ground Level Ozone, April 2003, at http://www.euromot.org/alfresco/d/d/workspace/SpacesStore/b4ebe3ed-d1d5-410b-81ce-05a27985ff0e/UNECE%20CLRTAP%20ABC%20analysis%202003%2004.pdf

/2/ EGTEI Stationary Engines Sub-group webpage at http://www.citepa.org/forums/egtei/egtei_Stationary_engines.htm

/3/ New stationary Engines" Guidance document can be found at: http://www.unece.org/env/lrtap/WorkingGroups/wgs/docs45th%20session.htm, click on "Other and Informal Documents" button and then click on "Draft Guidance document on control techniques for emissions of Sulphur, NOx, VOCS, dust from stationary sources" and then go open document 7-42 and you will find it.

/4/ http://www.unece.org/env/documents/2009/EB/wg5/wgsr45/ece.eb.air.wg.5.2009.18.e.pdf

/5/ EU LCP BREF, July 2006 at ftp://ftp.jrc.es/pub/eippcb/doc/lcp_bref_0706.pdf

/6/ “Recommendation on Common Approaches on Environment and officially Supported Export Credits”, 2007.

/7/ Euromot Proposal for the proceedings in the revision process of the technical annexes in the Gothenburg Protocol, 2008 at http://www.euromot.org/alfresco/d/d/workspace/SpacesStore/6c02a43e-7266-4609-8aa3-97a4acf2a724/UNECE%20CLRTAP%202008%2006.pdf

/8/ Protocol to the 1979 Convention on Long-Range Transboundary, Air pollution to Abate Acidification, Eutrophication and ground Level Ozone – Alternative Reduction Strategy Need in Order to reach BAT, 2005 at http://www.euromot.org/alfresco/d/d/workspace/SpacesStore/d5f61e8f-49c0-402d-83a9-2431302e6ab5/UNECE%20CLRTAP%202005%2005.pdf

/9/ IFC General EHS Guidelines, 2007 at http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_GeneralEHS/$FILE/Final+-+General+EHS+Guidelines.pdf

/10/ IFC Thermal Power Plants EHS Guidelines, 2008 at http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_ThermalPower/$FILE/FINAL_Thermal+Power.pdf

/11/ UK “Environmental Protection Act 1990, part 1 (1995 revision), PG 1/5 (95): Secretary of state’s Guidance-compression Ignition Engines, 20-50 MW Net rated Thermal input

/12/ Best Available Techniques (BAT) in Small Applications 5 – 50 MW Combustion Plants in Finland at http://www.ymparisto.fi/download.asp?contentid=3708&lan=fi

/13/ Portugal: Order No 677/2009 dated June 23 2009

/14/ IPPC Directive 96/61/EC at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0061:EN:HTML

ANNEX 1

Table 1:

Different NOx emission options for new stationary engines, NG=Natural Gas, HFO=Heavy Fuel Oil, LFO= Light Fuel Oil .

Engine Type, Power, Fuel Specification	ELV1 (a),(b),(c) mg/Nm^3(dry 15 % O_2)	ELV 2 (a),(b),(c) mg/Nm^3(dry 15 % O_2)	ELV 3 (a) mg/Nm^3(dry 15 % O_2)
Gas engines>1 MWth Spark-ignited, all gaseous fuels	35	95	190
Dual fuel engines > 1 MWth All gaseous fuels All liquid fuels 1 – 20 MWth > 20 MWth	 35 (e) 225 225	 190 (e) 750 450	 380 (e) [1850] [2000] [1850] [2000]
Diesel engines >5 MWth Slow (< 300 rpm) / Medium (300-1200 rpm) speed 5 – 20 MWth HFO & bio-oils LFO & NG > 20 MWth HFO & bio-oils LFO & NG High speed(> 1200 rpm)	 225 150 190 150 [130] [150]	 [450] [750] 190 [225] [450] 190 190	 [1300] (d) [1600] [1300] (d) [1600] [750] [1850] [750] [1850] [750] [900]

(a) These values do not apply to engines running less than 500 hours a year

(b) Where SCR cannot currently be applied [certain geographical areas, like remote islands] or the unavailability of good fuel or raw material quality not guaranteed, a transition period of [x] yrs can be granted. During this transition period upper value of ELV 3 can be applied.

(c) A flexibility option for engines running between 500 to 1500 operational hours per year is to apply [the upper value of ELV 3] [achievable with primary measures]

(d) Limit of primary measures under development (Currently only first laboratory tests done on some engine type)

(e) A derogation from the obligation to comply with the emission limit values can be granted to combustion plants using gaseous fuel which have to resort exceptionally to the use of other fuels

because of a sudden interruption in the supply of gas and for this reason would need to be equipped with a waste gas purification facility. The exception time period shall not exceed 10 days except there is an overriding need to maintain energy supplies.

[Since engines running with higher energy efficiency consume less fuel and emit these for less CO_2 and since a higher efficiency of the engines can lead to higher temperatures and therefore to higher NOx concentrations in the flue gases, a NOx bonus using the formula [ELV * actual efficiency / reference efficiency] could be justified[*]]

[*] See e.g. UK "Environmental Protection Act 1990, part 1 (1995 revision), PG 1/5 (95): Secretary of state's Guidance-compression Ignition Engines, 20-50 MW Net rated Thermal input /11/ (prescribes efficiency correction from 40 %)