DRAFT Memorandum

Stationary Engines Expert Group Kick-off Meeting under EGTEI hosted by EUROMOT

Tuesday 27.2.2008 VDMA, Frankfurt

List of participants

Jean-Guy Bartaire (VDF/EGTEI Co-chair/EDF)
Johan Boij (Wärtsilä)
Manfred Bortfeld (EMA)
Panagiotis Daskalopous (Euromot)
Albertus Dijks (Waukesha)
Stephan Fuss (MTU)
Jan Hellman (MAN, Copenhagen)
Markus Heseding (VDMA)
Dimitrios Hountalas (National Technical University of Athens)
Anneli Karjalainen (Ministry of the Environment Finland), Chair
Pieter Kroon (ECN, Netherlands)
Peter Lauer (MAN, Augsburg)
Remy Leclerc (FIM-Energetique)
Peter Meulepas (Belgium Flanders)
Anja Nowack (UBA, Germany)
Richard J. Payne (Cummins)
Michael Finch Pedersen (MAN, Copenhagen)
Kristina Saarinen (SYKE, Finland)
Udo Sander (MTU)
Peter Scherm (Euromot)
Udo Schlemmer-Kelling (CAT)
Michael Wagner (GE Jenbacher)
Julien Vincent (CITEPA, France)
Hein de Wilde (ECN, NL)
Mike Woodfield (AEA Technology/Defra, UK)
Nikos Zovanos (Public Power Corporation, Athens)

Opening of the meeting

Mr Peter Scherm (General Secretary of Euromot) opened the meeting and welcomed the participants. The participants introduced themselves.

Adoption of the agenda

Ms Anneli Karjalainen as chair of the meeting introduced the agenda, which was adopted without changes and recognizing the generous offer of Euromot to host the meeting.

Short introduction of Euromot

Mr Panagiotis Daskalopoulos (Technical Manager of Euromot) gave a short introduction of the work of Euromot and the targets of the industry in the work of the Stationary Engines Group under the EGTEI. In 2006 the total worldwide turnover of the Euromot members in the stationary engine sector only was 21.200 million Euros.

Update on International Environmental and Air Quality Programmes

Ms Karjalainen explained the scope of the work. Finland has agreed to act as Lead Country for the work on NO_x emission limit values (ELVs) for stationary engines. The work includes evaluating the present NO_x emission limit values presented in the Gothenburg Protocol Annex V Table 4 as some parties have had difficulties in applying these limit values. The target of the work is to recognize these problems and to evaluate possible options to solve them. One example of options might be to differentiate emission limit values between plant and engine sizes. The purpose is to carry out the work as an expert group for stationary engines and leave all political issues out of the work.

UNECE CLRTAP Gothenburg Protocol – current status of the work

Mr Bartaire as chair of the EGTEI explained the connection of the work on stationary engines to the UNECE CLRTAP Gothenburg Protocol. He also introduced details related to revision of the Gothenburg protocol, which has been started and will be finalized in December 2009.

An overview on the work of Stationary Engines Experts Working Group should be presented at the April 2008 Working Group of Strategies and Review (WGSR) meeting. Documents to be presented to the WGSR should be ready already 90 days before the meeting in WGSR in official languages.

Mr Bartaire also gave an introduction to the EGTEI work, which includes revision of technical annexes of the Gothenburg protocol.

Ms Karjalainen pointed out that this is the first time when a CLRTAP Protocol will be reviewed and that there exist no earlier experiences of such a work.

Environmental activities in EU, UNECE and other areas

Ms Karjalainen gave a presentation on current environmental activities in the EU, UNECE and other areas. She also gave examples on conventions where different geographical approaches have been agreed upon, such as the Regional POPs (Persistent Organic Pollutants) Protocol and Heavy Metals Protocol under the UNECE and the global POPs Convention under the UNEP as well as the global Mercury Programme.

The Gothenburg Protocol includes emission ceilings, which are nearly the same as in the National Emissions Ceilings Directive (NECD) for EU Member States. The protocol includes requirements on application of ELVs for stationary and mobile sources in the annexes, as well as on application of BAT, which is mandatory for new sources. For existing sources there is a timescale to adopt ELVs and BAT, if technically and economically feasible. The ELVs in the Gothenburg Protocol are based mainly on EU legislation adopted in 1999. 31 parties have signed the Protocol and 23 parties have ratified it. The UNECE region covers also countries outside the EU.

Mr Bartaire explained that the EGTEI is working closely with IPTS in Seville with the BAT work. The new proposed IPPC draft directive is promoting BAT, which means that EU countries following the IPPC BAT principles can nationally have stricter limits than those presented in the UNECE Protocols.

Overview of unilateral emission legislation

Mr Daskalopoulos presented emission limit values (ELVs) for stationary engines by the World Bank, OECD and some other organizations and countries. Some of these ELVs are based on different engine technologies (gas engines, diesel engines), engine sizes or where the engine is operated (rural or urban).

Euromot´s concerns on the current NO_x emission limit values in the Gothenburg Protocol

Mr Daskalopoulos presented Euromot´s main concerns on the NO_x emission limit values that are currently in the technical annex V of the Gothenburg Protocol. The stipulated NO_x ELVs for 4-stroke lean burn spark ignition (SI) engines will increase fuel consumption and lead to lower total efficiency and thus to more CO_2 emissions. Engines fired with renewable energy sources are not covered in the Gothenburg Protocol and thus there is no motivation to introduce sustainable renewable fuels in the engine market. All competing technologies (boilers and single unit gas turbines) in the Gothenburg Protocol are regulated for a power range beginning at >50 MWth. Only engines are regulated at >1/>5 MWth although in the European Directive 96/61/EC it is stated that BAT (Best Available Technique) should be used for installations >50 MWth. The contribution of stationary engine plants for NO_x emissions in the EU-15 is about 0.26%. According to Mr Daskalopoulos the stipulated limits for stationary engines in the Gothenburg Protocol would be beyond BAT and too strict.

Mr Bartaire reminded that the EU LCP BREF Document, which includes stationary engines, was not approved by the Union of the Electricity Industry (EURELECTRIC).

Stationary engine units are increasing in number in some countries, e.g. in Belgium the share is around 10% and in the Netherlands 4% at the moment.

Mrs Nowack said that the emission limit values given in Annex V for gas engines seem to be in opposite order than in TA-Luft. The limits according to the German regulation TA Luft 2002 are 500 mg/nm^3 for lean burn gas engines and 250 mg/nm^3 for all other gas engines.

TECHNOLOGY SESSION

Engine technologies, engine types and engine applications

Mr Boij from Wärtsilä started his presentation by showing the different fuels that can be used in stationary engines. The availability or choice of fuel has a considerable impact on the emissions. Mr Boij presented the principles of gas, diesel and dual fuel engines and emphasized that engine technique/type specific NO_x ELVs should be considered in the regulation.

According to Mr Boij rich burn engines have better load but in lean burn engines efficiency and power density are better. With lean burn engines on natural gas (NG) it is possible to reach 250-500 mg/nm^3 at 5% which is 90-190 mg/nm^3 at 15% O_2 without secondary measures. Other gases than NG have unhomogeneous composition and include impurities that can cause deposits in the combustion chamber. For lean burn engines lowering of NO_x emissions also causes misfiring. To reach lower NO_x emissions, secondary measures, such as SCR, are needed. However, SCR is not possible to use with non-NG gases as the catalyst use requires perfect conditions and engine tuning. The trace gases may destroy the catalyst and thus generate emissions. SCR can be considered expensive both for investment and operation. In addition, very low NO_x emissions have negative impact on CO_2 emissions and fuel costs as the total efficiency of the engine installation will be reduced.

Gas engine applications

Mr. Dijks from Waukesha presented different gas engine applications. Gas engines are predestined for generation of power and heat by reaching efficiencies up to 95%. He showed examples that in the NL engines over 2000 MW are used especially for peak shaving and to assure power supply when there are variations in the power grid. CH_4 from manure at a farm can also be used in these engines, as well as landfill/digester/mine gases.

Mr Dijks recommended for gas engines:

- To overtake the lean burn ELV for NO_x from TA Luft 2002 (500 mg/nm^3 at 5% O_2) for gas engines (natural gas) in to the Gotheburg Protocol in order to achieve affordable and reliable low emissions.
- The TA Luft ELV 500 mg/nm^{3}at 5% O_2 can be reached without installing SCR but it is very expensive to go further.
- Catalysts for NO_x reduction need perfect conditions (maintenance, fuel quality, skilled field service personnel, etc), which are not always available.
- To overtake the TA Luft 2002 emission limit values in the revised Gothenburg Protocol for gas engines fired with biogas.

Mr Wagner from GE Jenbacher presented gas engine technologies and products (natural gas and renewable gas). These are mostly cogeneration plants for decentralized power generation. Installation of stationary engines has country specific dimensions, for instance in the NL, DK and GER stationary gas engines have a remarkable segment in energy production.

Mr Wagner also showed an overview of the relation between NO_x, total HC and CO emissions depending on the air-fuel-ratio λ. Based on this Mr Wagner recommended:

- To overtake NO_x limit values between 250-500 mg/nm^3 at 5% O_2 (90-190 mg/nm^3 at 15% O_2).
- Lower NO_x limits have a negative impact on CO_2 emissions and fuel consumption.
- To define use of biogas.
- To consider impacts of NO_x limit values for renewable gases are introduced.
- To introduce NO_x limit values for biogas in the revised Gothenburg Protocol.

Mr Sander from MTU presented gas engine applications. He showed that a gas engine operated in CHP-mode (combined heat and power) can have >85% efficiency. He pointed out that it is important to have a balance between NO_x on the one hand and CO_2, THC and CO on the other hand. If carbon dioxide, CO_2 or THC emissions are reduced, NO_x emissions will increase and can be lowered only by applying SCR. The market for 1-3 MW gas engines grows annually by approximately 7%.

Diesel engine applications

Mr Lauer presented diesel engine technology and products of MAN. One half of engine production covers ship propulsion engines (IMO regulations) and the other half power plants (World Bank regulations). Mr Lauer showed possibilities to reduce NO_x emissions by primary (10-15% for 2-stroke engines, 20-25% for 4-stroke engines) and secondary measures (15-85% depending on site conditions and investments). NO_x can be lowered by fuel water emulsion 15-25%, air humidification 40-60% and SCR 80-85%, which is limited only to low-sulphur fuel. Fuel qualities around the world are in many regions above 2 S-%, only in Western Europe and America 1 S-% or lower fuels are used. In Belarus and eastern regions sulphur content can be up to 3.5%. According to the ISO standard even distillate diesel fuel may contain 2% S. In the EU sulphur limit for fuels to be used without any abatement is 1%. Temperature-dependent mechanism requires sulphur content less than 1% for SCR. This has been the problem and reason to why many parties do not ratify the protocol. Regarding the price of the fuel it is not possible to buy by countries outside Europe. For high sulphur content fuels application of SCR is not possible.

Mr Lauer recommended:
- Introduction of NO_x limit values for diesel engines according to the current EHS Guidelines of the World Bank and/or according to the IMO regulation.
- Introduction of NO_x limit values for dual fuel engines in gas mode (natural gas) between 200-400 mg/nm^3 at 15% O_2 (200 mg/nm^3 is possible with increased fuel consumption and increase in CO_2 emissions)
- To be careful with setting NO_x limits for renewable gases as there are not very much experiences.

Mr Schlemmer-Kelling from Catepillar told that the engine industry has reduced NO_x emissions significantly and continuously in the last years. The emission reduction trend is driven by the fuel quality. Mr Schlemmer-Kelling showed the relation between NO_x and CO_2 (=efficiency) emissions, and that there is only a narrow area where NO_x and CO_2 emissions are in balance by simultaneous high engine efficiency. Today achievable NO_x concentrations without secondary measures are around 1000 ppm in 15 O_2%, the target is around 750 ppm in 15 O_2%. A specific problem for diesel engines is that when soot and CO_2 go down, NO_x increases. One possibility to reduce emissions is the LEE concept: tuning the engine by diesel compression or doing more Miller cycles. However, increasing load is risky and requires further development of engine technology, which is not available for serious power production today. Further decrease of NO_x emissions with secondary measures today also increases fuel consumption dramatically. It can be estimated that better technology is available only in the next 10-20 yrs.

Mr Schlemmer-Kelling summarised that a 20% NO_x reduction in general is possible by 2011 and even 40% by 2016

NO_x abatement techniques – boundary conditions

Mr Boij presented secondary NO_x abatement techniques. The SCR includes a reactor with catalyst and NH_3 injection (which needs good urea quality). Also, a minimum flue-gas temperature that is dependent on the S-content has to be maintained. Some trace metals (Na, K, Ca, Mg, As, Se), which might be in the fuel as impurities can act as catalyst poisons. Soot blowing system needs to be installed in the SCR. There are high capital and investment costs and catalyst disposal costs. Reagent infrastructure is needed, as well as regular maintenance by skilled service personnel to avoid ammonia slips, which are harmful for internal surfaces. In the LCP BREF Document SCR is not defined as BAT for engines with load variations (start-up and shut-downs, frequent temperature variations) There are no BAT associated emission levels for other stationary engines. Mr Boij also showed an overview for investment and operation (maintenance) costs for SCR installations

High speed Diesel engine applications

Mr Payne from Cummins presented information on high-speed diesel engines that are used mainly for stand-by, peak shaving, short-term applications at the longest for 2 years. These engines have a maximum thermal input of 10 MW and are based on engines that are used for automotive or non-road mobile machinery. For instance, in Eastern Europe these engines are used as temporary solutions and can be moved to another location later. Mr Payne presented technologies that are used in order to reduce emissions of high-speed diesels:

- High pressure electronically controlled injection
- Cooled exhaust gas re-circulation
- Miller cycle
- SCR

The fuel used in the engine has to be clean. According to Mr Payne, Miller cycle is more suitable for larger engines with lower speeds but not appropriate for highly transient operation (long expansion stroke, take a lot of energy out of exhaust). SCR as a secondary measure needs urea supply. It can be used only for low sulphur fuel and includes complex control systems and a lot of space. SCR has also high initial purchase price and does not scale with engine size or last the life of an engine. In addition, SCR requires good technical support (spare parts and expertise to operate and maintain).

Mr Payne made a comparison between NO_x limit values for European non-road and on-road limit values and the current NO_x limit values for stationary engines in the Gothenburg Protocol.

Summary of technology session

Diesel engines

Mr Daskalopoulos summarised that the industry has worked intensively on stationary engines in order to improve their efficiency and to reduce the NO_x emissions. Fuel quality that is alternating worldwide, has a considerable impact on emissions. The fuel quality has a considerable impact on emissions and it is alternating worldwide. The flue gas temperature has an impact on the SCR performance and is not always BAT. In order to reach strict NO_x limits SCR is the only technical option regardless of the cost or location where the plant is situated.

Gas engines

Mr Daskalopoulos pointed out for gas engines that biogases create deposits in the combustion chambers, which act as catalyst poison. Efficient engine operation with low fuel consumption and thus lower CO_2 emissions by use of renewable sources leads to increased security of fuel supply and reduces greenhouse gases. The proposed limits are not in accordance with the new trend to improve energy efficiency and use of renewable fuels in the spirit of the Kyoto Protocol, and are beyond the BAT levels, as well as technically/economically not feasible.

Mr Daskalopoulos encouraged to look for specific ELVs achievable for each prime mover, to express ELVs in 15 O_2%, to introduce plant size dependent limits, or regional distribution of ELVs, and to take into account efficiency correction bonuses for high efficient engines. Euromot has prepared position papers related to the Gothenburg Protocol. The recommendations of Euromot are based on other already existing regulations that are publicly available on Euromot´s homepage. According to Mr Daskalopoulos the current World Bank (EHS Guidelines) and OECD emission limit values could be used as base limits in the revised Gothenburg Protocol.

Ms Karjalainen summarized the first views on where there seems to be problems and how to proceed in the work. A paper for further discussions will be prepared by Finland based on the presentations and discussion. From the technology session presentations a very rough conclusion can be drawn that ELVs in the Gothenburg Protocol can be reached by gas engines firing natural gas, but ELVs for liquid fired diesel engines are problematic because the current limits always require application of SCR.

Country specific views

The Netherlands

Mr Pieter Kroon from the Netherlands explained the Dutch situation. In the Netherlands both the population density and air pollution are high. The national BEES B legislation concerns stationary engines and gas turbines (1-50MW) as well as boilers (0.9-50 MW). There is also a national NO_x trading scheme. Update of BEES B will bring emissions back to BAT level, i.e. the same ELVs for all combustion plants and CHP installations. Implementation is scheduled for new installations from 1st January 2009, existing installations from 1st January 2015 restricting emissions of NO_x, SO_2, PMs and VOCs. This means also changes to present ELVs for new installations. There are not many diesel engines in the NLs. The new legislation will include all stationary engines and all fuels but only expressed with one NO_x limit value. The new limits will include also methane slips from gas engines (methane is a greenhouse gas). The limit will be 2,3% for gas engines. It has not been decided whether the reference oxygen content for the ELVs will be 5 or 15%. All gas engines must be equipped with SCR and will have low VOC emissions including methane slip. The desulphurisation of biogas is required. All diesel engines should be equipped with highly efficient SCR, which means at least 90% of NO_x removal (also for bio fuel). The reduction costs are updated in the BEES B, 4 to 5 euros/kg NO_x. The solution to reduce emissions is considered to be a combination of techniques.

Greece (submitted after the meeting by Mr Hountalas)

According to Mr Hountalas from the Greek national power provider (Public Power Corporation PPC) Greece is the biggest user of large stationary 4-stroke and 2-stroke stationary engines that are used on the Greek islands. The main issue beside the NO_x emissions is the engine efficiency of the units (CO_2 emissions, fuel consumption) and the reliability of the engine, which is very important for people living on the Greek islands.

The engines on the Greek islands are operated with heavy fuel oil, which makes the application of some primary techniques for NO_x reduction difficult. Also the use of SCR is thus a problem (catalyst poisoning, temperature fluctuation etc.) as well as the costs Furthermore, application of urea in emission removal is difficult to develop on the Greek islands. As SCR may not be Mr Hountalas recommended to consider two emission limits: one with and a second without SCR.

The IMO provides a distinction in NO_x ELVs between 2 and 4 stroke engines using their operating speed. Based on this PPC recommends to define different limits for these types of engines using speed as criteria.

CONCLUSIONS AND FURTHER ACTIONS

Finland presented a draft for data collection form on stationary engines. The form will be circulated for the participants of the meeting for comments before sending it to UNECE countries. Replies for the questionnaire will be requested by the end of April. A background paper will also be prepared to enable further discussions.

Mr Woodfield's proposal to include the questionnaire an invitation to comment emission factors proposed in the updated version of the EMEP/Corinair Emissions Inventory Guidebook was welcomed.

Mr Vincent and Mr Bartaire agreed to update the EGTEI website with information on the Stationary Engines Working Group with material presented at the meeting.

Finland will organize a one-day meeting for the stationary engine Working Group in Helsinki between 9 – 13 June 2008.