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Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution To Abate Acidification, Eutrophication And Ground Level Ozone

The Euromot Position – Technical Reasoning

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EUROMOT
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Euromot is the **European Association of Internal Combustion Engine Manufacturers**.

We represent the leading manufacturers of internal combustion engines used in a broad range of nonroad and marine applications (construction, mining and material handling equipment, trucks and buses, agricultural and forestry equipment, commercial marine and seagoing vessels, workboats and pleasure boats, rail traction, lawn/garden and recreational equipment, power generation).

Euromot has been working for many years with international regulatory bodies, eg European Union, the UN International Maritime Organizations (IMO) and the Central Commission for the Navigation on the Rhine (CCNR), and with national governments to provide reliable know-how on advanced internal combustion engine technologies in general and, in particular, on the feasibility of environmental as well as cost-effective product regulations.

For more information about our Association please pay us a virtual visit at **http://www.euromot.org** – **your bookmark for engine power worldwide** – and pay special attention to

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Gothenburg Protocol 1999 and its consequences
The technical reasoning of the engine manufacturers concerns

1 Description of the general problems

The UNECE Protocol agreed in Gothenburg in 1999, sets emission ceilings on four pollutants including oxides of nitrogen. It has been estimated that once the Protocol is implemented, the area with excessive levels of acidification will decrease dramatically in Europe as a whole. In Annex II of the Protocol emission ceilings per country are listed. European Union has in Directive 2001/81/EC ("On national emission ceilings for certain atmospheric pollutants") for each of the 15 member states put into force similar or stricter emission ceiling limits.

In the UNECE Gothenburg Protocol the following general principles are stated:

General part:

– "Conscious of the need for a cost-effective regional approach to combating air pollution that takes account of the variations in effects and abatement costs between countries". The Protocol seems therefore to have an environmental quality need driven approach but without sufficient consideration of balanced cost versus benefit analyses.

– "Bearing in mind that measures taken to reduce emissions of sulphur, nitrogen oxides, ammonia and volatile organic compounds should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international competition and trade".

– "Noting the important contribution of the private and non-governmental sectors to knowledge of the effects associated with these substances and available techniques, and their role in assisting in the reduction of emissions to the atmosphere".

In Article 8:

– "Emission abatement technologies and technologies to improve energy efficiency, energy conservation and use of renewable energy"

In our view, the limits for "new stationary engines" in the Gothenburg Protocol 1999 are not set according to above stated general principles and the new trend to improve energy efficiency in the lights of the Kyoto Protocol.

2 The high-efficient engine driven plant in the lights of the Kyoto Protocol

Some decades ago engine driven power plants were mostly used for short time running applications like emergency & peaking and small scale power production, but today, however, reciprocating engines are becoming popular for continuous power generation. Both, large base load engine driven power plants with an output up to 150 MW electricity and decentralised smaller combined heat and power (CHP) production plants are common today.

An engine driven plant has many advantages such as: a compact size, short construction time, flexible fuel choice, water preservation, high thermal efficiency (low fuel consumption), optimal matching at different load demands, fast load response and good load following characteristics, easy maintenance and a robust reliable design.

CO_2 emissions (in focus today due to the Kyoto Protocol) can be reduced by increasing the total efficiency of the plant or/and by using oil instead of coal and natural gas or gases from renewable sources instead of oil. Other measures to reduce the CO_2 emissions are increased combined heat and power (CHP) production in decentralised efficient power plants and replacing old inefficient power stations with new efficient solutions.

The reciprocating engines may be used in single cycle as well as cogeneration applications.

Single cycle application:

Single cycle applications are benefiting from the high electrical efficiency (at alternator terminal), ranging from about 40% for the smaller engines to about 45% for the bigger engines (calculated on their fuel lower heating value). High efficiency results in low emissions of CO_2, the most important "greenhouse gas". A comparison between technologies in terms of single cycle CO_2 emissions is given in **figure 1.**

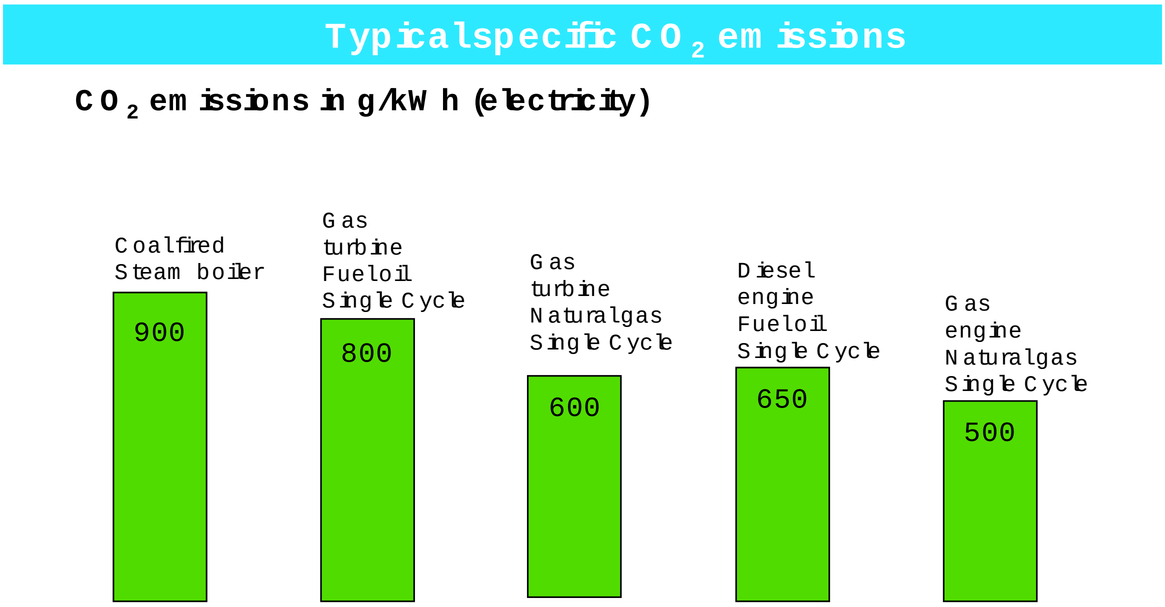

Fig 1: Typical CO_2 emissions for different prime movers (single cycle)

Combined heat and power (CHP)

One practical way to decrease CO_2 emissions is to increase the total efficiency of the power plant, for instance by increased combined heat and power (CHP) production of simultaneous electricity and heat. These CHP plants can be in urban locations or industrial areas close to the heat and electricity consumers, thus the need for transmission lines is reduced and associated energy losses and land need can be minimized.

In European Union (EU) CHP is in focus for environmental and economic reasons, as stated in in Directive 2001/80/EC: "The Community is committed to a reduction of carbon dioxide emissions. Where it is feasible the combined production of heat and electricity represents a valuable opportunity for significantly improving overall efficiency in fuel use".

The reciprocating engines are perfectly suited for cogeneration (CHP) i.e. for hot water production, steam generation (sometimes with an additional steam turbine for enhanced electrical efficiency), desalination of sea water, district cooling systems and for air conditioning (heating, etc.). The total fuel efficiency is, up to 90% in some applications. The heat to power ratios for the engine CHP-applications are typically from 0.5 to 1.3. As an example, specific CO_2 emission for cogeneration (CHP) plants is 370 g/kWh (produced electricity + recoverable heat) when operating on HFO (heavy fuel oil) at a total plant efficiency of about 80%.

The UN-ECE Gothenburg Protocol deals only with at-site emissions of "regulated pollutants" for "new stationary engines" not considering non-regulated emissions like the green house gas CO_2. Other regulations consider additionally both the at-site emission of such unregulated gases and that emissions occur also during fuel production and distribution: lower fuel consumption leads to lower environmental burden that may be taken into consideration e.g. by an efficiency bonus, as in e.g. UK. In the UK (20 .. 50 MW_{th} engine plant, "The Environmental Protection Act 1990, Part 1 (1995 Revision)") legislation an efficiency correction of the stipulated emission limits is granted.

In the UNECE Gothenburg Protocol "onshore combustion turbines" (single turbine > 50 MW_{th}) have an efficiency correction for the given NO_x-limit. A stationary engine driven plants is not granted any efficiency correction in the same Protocol.

3 Economic and technical consequences in applying the Gothenburg Protocol 1999 provisions

Annex V of the Gothenburg Protocol, table 4 stipulates emission limits for new stationary engines (> 1 MW_{th} spark ignition (SI) and > 5 MW_{th} compression ignition (CI) engines).

3.1 Energy efficiency of the spark-ignited lean-burn engine driven plant will decrease

The required NO_x-limit will increase the fuel consumption for spark-ignited lean-burn engines with about 2 ... 3 %. The flue gas temperature of the engine will decrease (this has a detrimental effect on the total efficiency of the CHP-plant) and other unburned emissions (such as CO, NMHC, etc.) increase due to the needed NO_x tuning. This is in contradiction to the same UNECE Gothenburg Protocol (Article 8 (h) "Emission abatement technologies, and technologies and techniques to improve energy efficiency, energy conversation and use of renewable energy".

European Union (EU) has ratified the Kyoto Agreement (about reduction of greenhouse gases) in the beginning of summer 2002 and the Gothenburg Protocol SI engine NO_x emission limit requirement leads to a contradiction. An increase in fuel consumption will lead to a higher CO_2 (and other unburned gaseous) emissions and lower the total efficiency for the spark ignited engine driven power plant.

3.2 NO_x-limit regardless of power plant size and location

According to EU Directive 96/61/EC, Best Available Techniques (BAT) is required in big thermal power plants (> 50 MW_{th}). BAT is taking both environmental and economic aspects into consideration. EU Directive 2001/80/EC on Large Combustion Plants (LCPD) stipulates emission limits for big boiler and gas turbine power plants. Engine driven power plants are often regulated by national limits, e.g. in UK, France and Portugal emission limits for the engine driven plants are dependent on the plant size, small plants have leaner limits and bigger ones stricter ones. In UK engine driven plants 20 .. 50 MW_{th} are following the BATNEEC (Best Available Techniques Not Entailing Excessive Cost) and big engine driven plants (> 50 MW_{th}) have to use the BAT (Best Available Techniques) approach.

In the Gothenburg Protocol only big (> 50 $MW_{th=thermal\ fuel\ input}$) boiler and single gas turbines are regulated, smaller sizes are not covered. New stationary engine plants however are (> 1 MW_{th} spark ignition engines, > 5 MW_{th} diesel engines operating more than 500 hours/per year) very strictly regulated. Diesel engines have to use costly and sensitive (to fuel impurities) SCR (Selective Catalytic Reduction) in order to reach the stipulated NO_x-value, while other competing prime movers can largely manage with low-cost NO_x-reduction primary methods.

E.g. note that limits for a big single gas turbine (> 50 MW_{th}) on gas in CHP-mode is 75 mg/Nm^3 (15 % O_2) = about 36 ppm-v (15 % O_2) and the limit for a very small spark ignited (SG) gas engine (> 1 MW_{th}) is 250 mg/Nm^3 (5 % O_2) = 121 ppm-v (5 % O_2) = 45 ppm-v (15 % O_2).

Surprisingly the NO_x limits in the Gothenburg Protocol 1999 for spark ignited lean-burn engines and heavy fuel oil fired diesel engines seem to be very similar to those of the current French legislation (BUT for liquid fired engines the new limit in force from 2003) for > 100 $MW_{thermal\ input}$ engine driven plants.

Thus the Gothenburg Protocol completely ignores the cost-impacts (not a BAT approach) and the step-wise approach in Article 2 of the Protocol is not followed.

3.3 Consultations of engine manufacturers would have avoided misunderstandings and misperceptions

If the engine manufacturing and operating industry would have been consulted in the development of the Protocol several misperception of this technology could have been avoided. It even appears that limits are discriminating reciprocating engines. Engines fired with **renewable energy sources (bio-gas, etc.) have not been considered.**

3.4 "Artificial" emission reference point

Emission reference oxygen for "new stationary engines" is in the Gothenburg Protocol set to 5 vol-%, which is not a logical approach. In the EU LCPD Directive 2001/80/EC reference points (dry oxygen vol-% of the flue gas) are set to:

- Liquid/gas fired boilers   3 vol-% O_2
- Solid fired boilers   6 vol-% O_2
- Liquid/gas fired gas turbines   15 vol-% O_2

Emission limits are usually expressed close to "actual" oxygen content of the flue gas, because this expresses best the requirement on possible future secondary cleaning device. The emission reference O_2 is therefore to be close to this value to ensure an optimal design of the possible future exhaust gas cleaning equipment, the EU approach for boilers and gas turbines is following this principle. "Actual" (real) dry oxygen content of flue gases are typically:

- Liquid/gas fired boiler   2 – 6 vol-% O_2
- Solid (coal) fired boiler   5 – 8 vol-% O_2
- Liquid/gas fired gas turbine   12 - 16 vol-% O_2
- Oil fired engines (> 1.5 MWe)   13 – 16 vol-% O_2
- Gas fired engines (> 1.5 MWe)   11 – 15 vol-% O_2

To be noted is that UK, World Bank and India have stipulated the emission reference oxygen percentage to 15 vol-% O_2 for engine driven plants which follows the logical principle close to "actual conditions". In Japan the reference oxygen for liquid fired diesel engines is 13 vol-% O_2.

Stack emissions from engine driven power plants shall be given at 15 vol-% O_2 in order to have a similar treatment as for other competing prime movers techniques.

3.5 The NOx-limits for new stationary engines are not taking into account the cost of action and are not driven by environmental quality need aspects

Emissions from a thermal power plant are to a high degree dependent on the existing fuel infrastructure in the specific country. If natural gas is available, emissions of SO_2

and particulate are very low. Also in respect of NO_x, emissions are lower for instance compared to the oil case. In many countries the fuel infrastructure for natural gas does not exist and the only realistic fuel alternatives for continuous power production are domestic coals or fuel oils (e.g. high-sulphur heavy fuel oil, due to the existing refineries). Some secondary emission reduction techniques are sensitive to fuel impurities and should therefore be used with care. For instance SCR (Selective Catalytic Reduction) is sensitive to SO_2 and some heavy metals, which might be present in the fuel. In addition, SCR requires that an existing reagent infrastructure (high quality urea or ammonia) exists and spare parts are available, which is not the case in all places around the world.

The installed stationary engine driven power plant capacity (operating 500 hours a year or more) is when comparing to the total installed power plant (including boilers, gas turbines, etc.) capacity relatively small in Europe. It is therefore not feasible to restrict only the use of engines for stationary power generation with very strict stack limits, this will not have a greater enhancing effect on the ambient air quality in overall (which is the major aim with the Protocol) in Europe.

Alignment of emission legislation is of high economic importance without any disadvantage whatsoever to the environment. This is the common view not only of industry but of regulators working in the technical field and even politicians who realize its global attraction around the world. It is important that European Union emission rules are reasonable and fair to all techniques, which the UNECE Gothenburg Protocol unfortunately is not in respect of stationary engine plants.

It will be unfortunate if the limit values of the Protocol may be adopted on a wrong technical and economic basis by other countries outside Europe with a less favourable infrastructure and international financial institutions. A unilateral Protocol should preferable take into account local conditions and be cost-effective via an environmental quality driven need . Unfortunately the emission limits for the “new stationary engine driven plant” in the UN-ECE Protocol are not sufficiently taking into account of the state-of-the-art technology and a cost-effective environmental quality need approach.

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