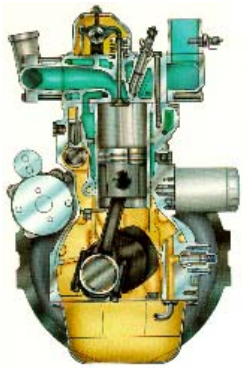
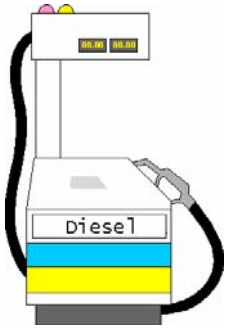


FUEL EFFECTS ON EMISSIONS FROM NON-ROAD ENGINES

IEA-AMF ANNEX XXV

Timo Murtonen

1st International Symposium on Incomplete Combustion,
Kuopio 9.-11.11.2003



Engines and Vehicles at VTT

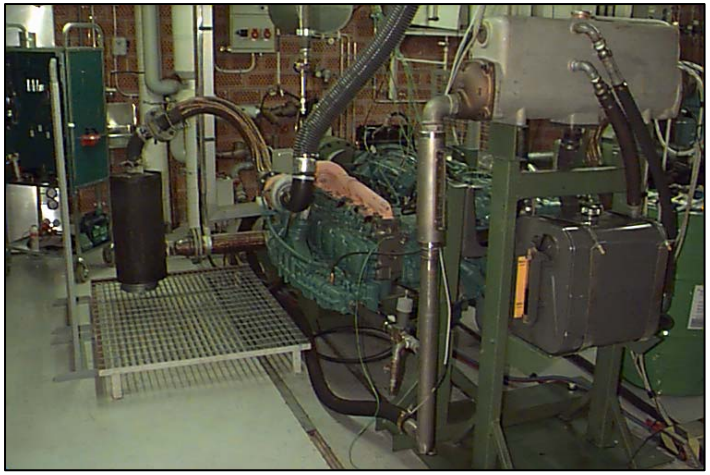
- 5 doctors and licenciates (Dtech, PhD, TechLic, PhLic)
- 8 research scientists (MSc)
- 2 trainees
- 7 engineers
- 6 technicians

- in total 28 persons (research personel)

- 2002 activities
  - turnover 4.0 M€
  - external income 74 %
  - international income 24 %

Facilities/Instrumentation..

- Light-duty vehicle research
  - climatic chamber for cold tests
- Engine research
  - steady-state and transient engine testing
- Particle research
  - CPC, DMA, 2 ELPIs, access to SEM and TEM electron microscopes
- Heavy-duty vehicle research



T125 (EN45001)

ISO 9001 DNV CERTIFICATED FIRM

Background of the project

- The emission regulations for non-road engines are less stringent than for on-road applications
- The use of low-grade heating type fuel oils is allowed in diesel machinery in many countries
- The specific emissions of spark-ignited small engines are very high
- The relative amount of emissions from non-road engines is increasing as the on-road vehicles are cleaning up rapidly

Objective

- To demonstrate that also non-road engines will benefit from improved fuel qualities and exhaust aftertreatment technologies
- To document the effects of fuel quality and exhaust gas aftertreatment on emissions from non-road machinery, both diesel and gasoline powered engines and report results publicly via IEA-AMF

Test program for diesel engines

Engines

- 2 engine versions
- pre EU Stage 1 turbocharged engine (“old engine”)
  - Valmet 411 DS MY85
- EU Stage 2 turbocharged and aftercooled engine (“advanced engine”)
  - Sisu Diesel 44EWA MY02
  - this engine also with exhaust aftertreatment

Fuels

- 5 fuel qualities, also biocomponents included
- reformulated automotive diesel S< 50 ppm
- Euro 2000 automotive diesel S< 350 ppm
- reformulated diesel + 5 % RME
- reformulated diesel + 30 % RME
- light fuel oil, S≅ 2000 ppm

Total number of fuel/engine/aftertreatment combinations: 12

Test program for gasoline engines

Engines

- 2 small spark-ignited engines
- air cooled two-stroke chain saw
  - category 50-60 cc engine
- air-cooled four-stroke engine
  - Briggs&Stratton 190cc OHV
  - suitable for generator or lawn mover use

Fuels

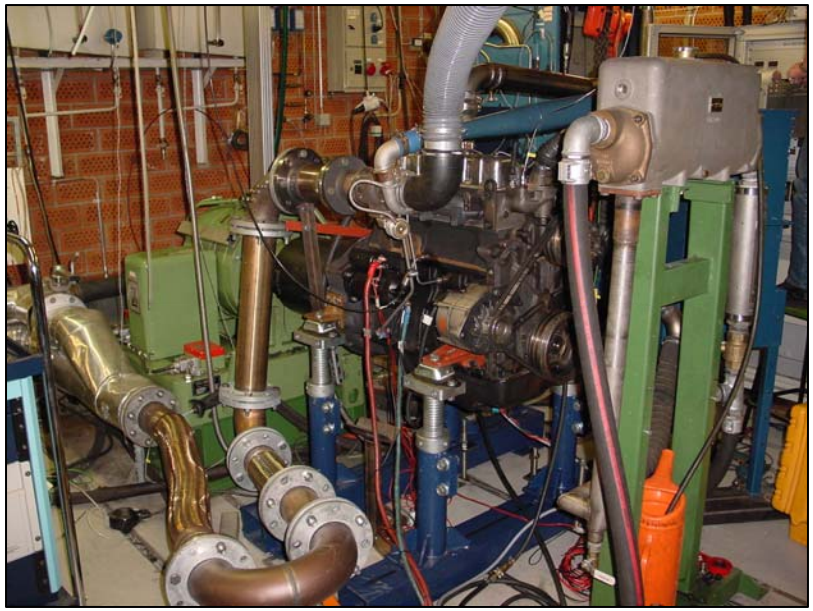
- 3 fuel qualities
- EU year 2000 gasoline
- special alkylate gasoline for small engines
- alkylate gasoline with oxygenate (ETBE)
- for the two-stroke engines, also the lubricating oil quality was varied with one fuel

Total number of fuel/engine/aftertreatment combinations: 14

Test procedures and facilities

Diesel engines

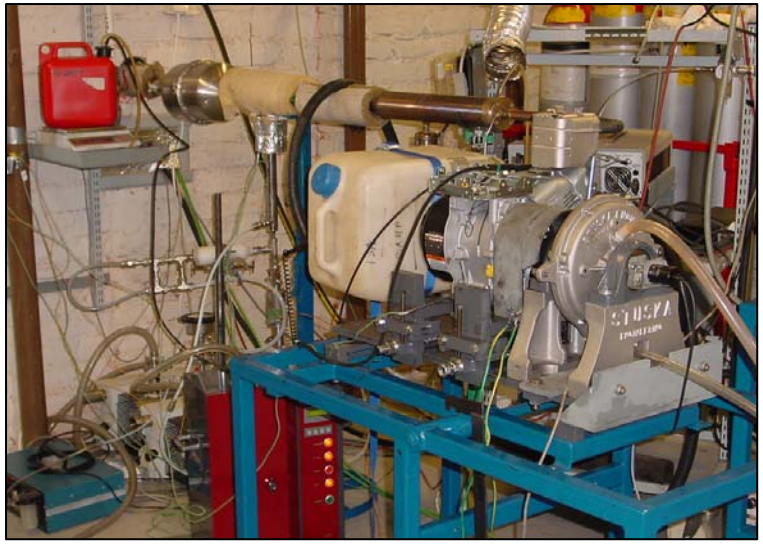
- Tests were carried out at VTT's engine laboratory according to ISO8178 standard
- In addition to the regulated emissions, particle size distribution and filter smoke number were measured
- With selected fuels, PAH and Ames analysis were done from particle mass samples



Test procedures and facilities

Gasoline engines

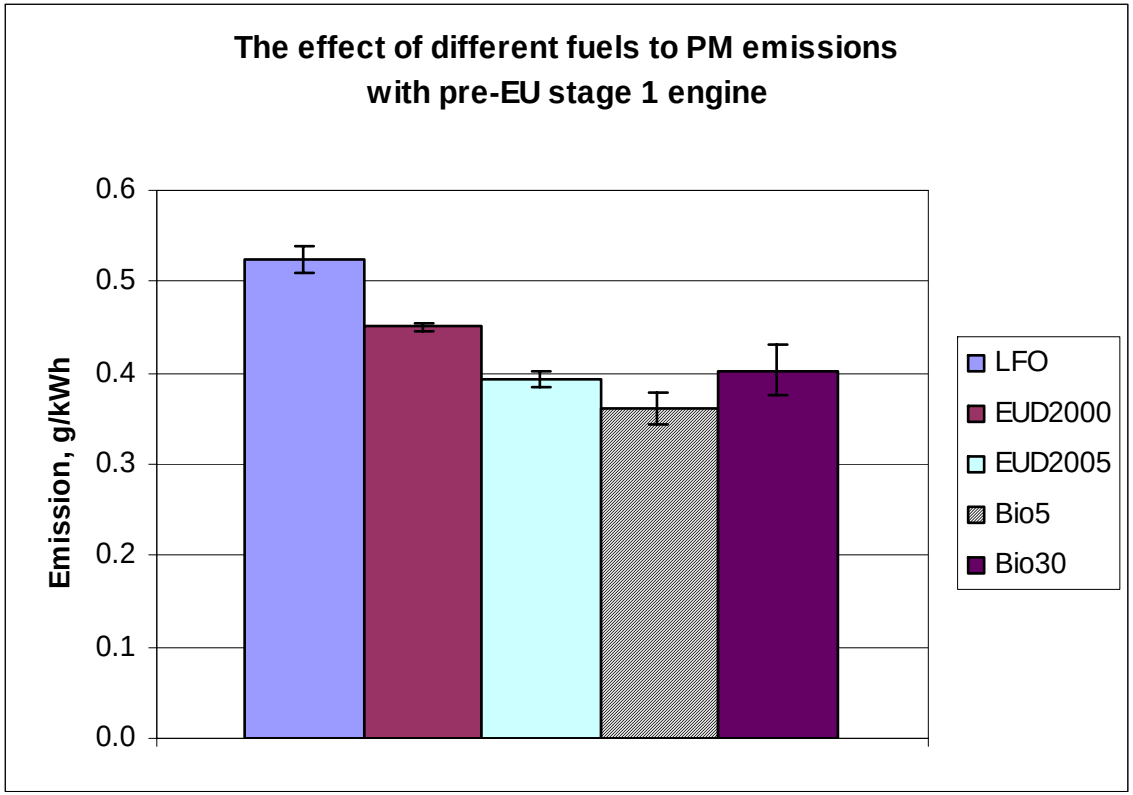
- Tests were carried out at Agricultural Engineering Research Center (Vihti, Finland) according to ISO8178 standard
- In addition to the regulated emissions, particle size distribution was measured
- With selected fuels, PAH and Ames analysis were done from particle mass samples (with 2-stroke engine)



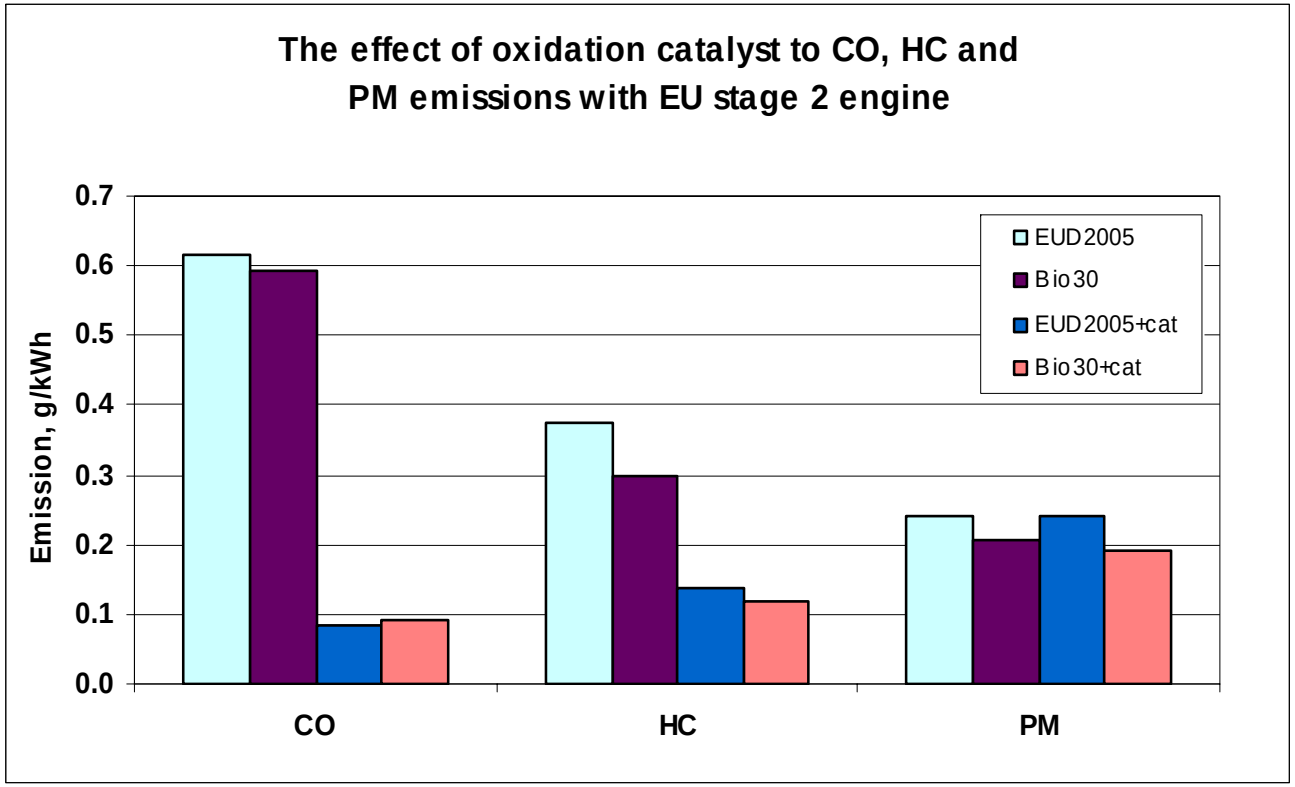
Results from diesel engine measurements

- With both engines the fuel effects were very similar
- The effects on gaseous emissions were in generally only marginal
- With good quality fuel some 30 to 40 % reductions were gained on particle mass emissions
- With low sulphur and low aromatics fuel the PAH and Ames analysis results were lower (even 50 to 60% in best cases)

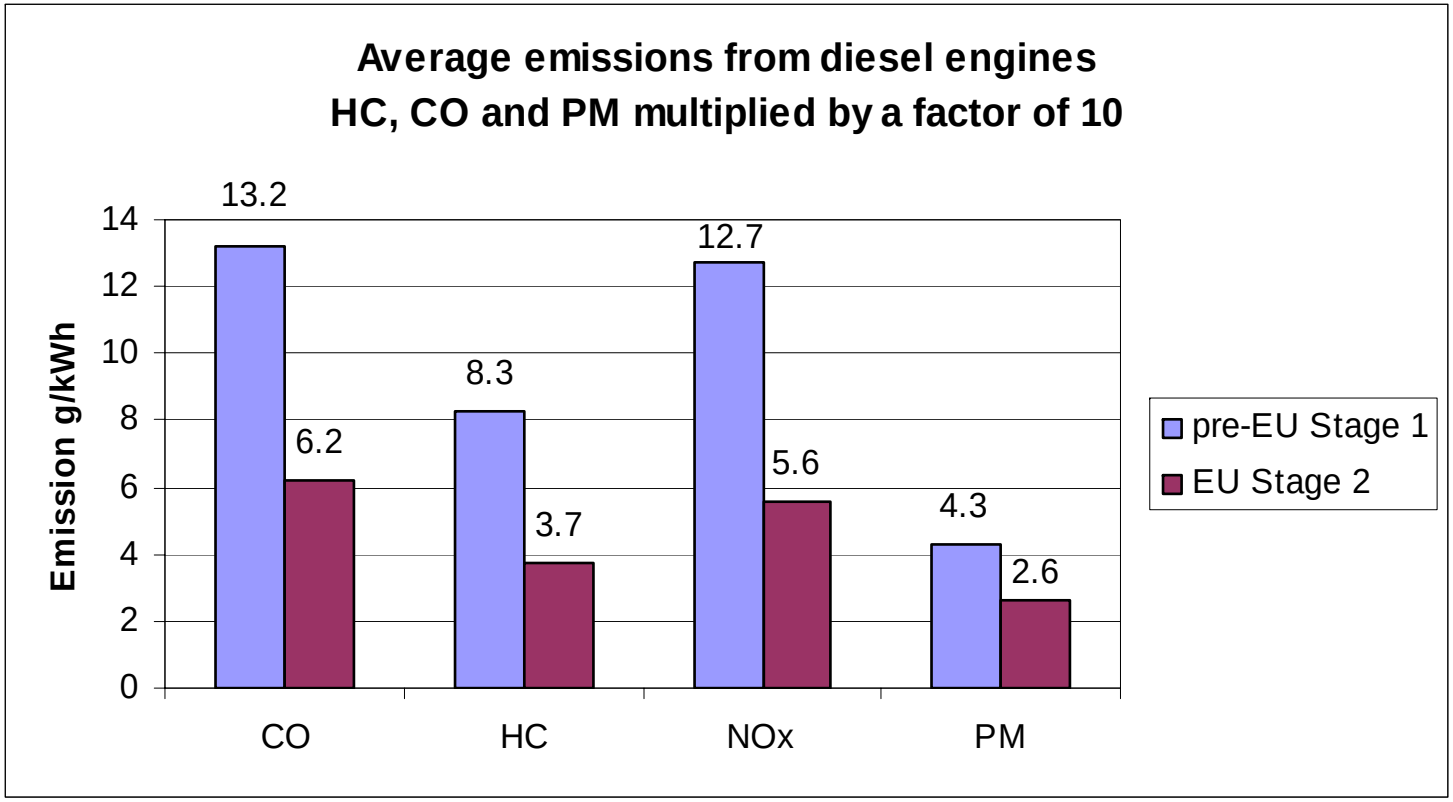
Results from diesel engine measurements



Results from diesel engine measurements



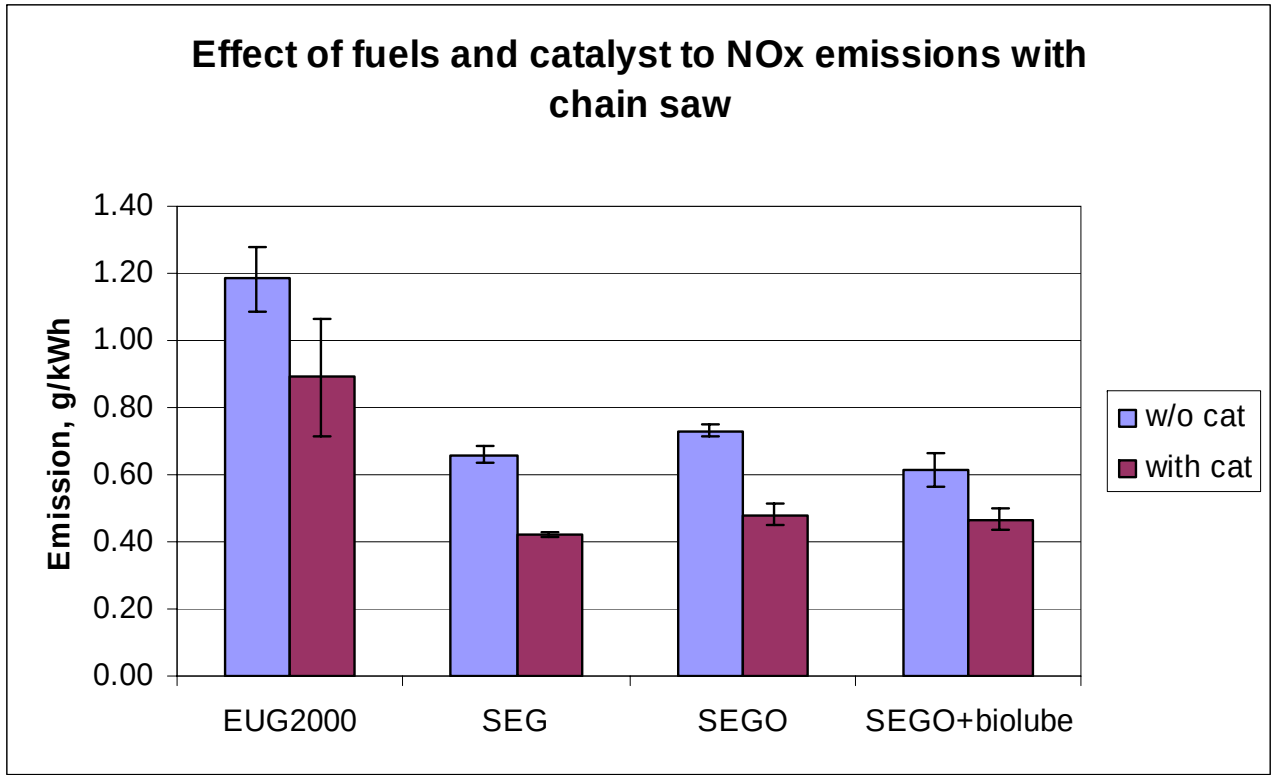
Results from diesel engine measurements



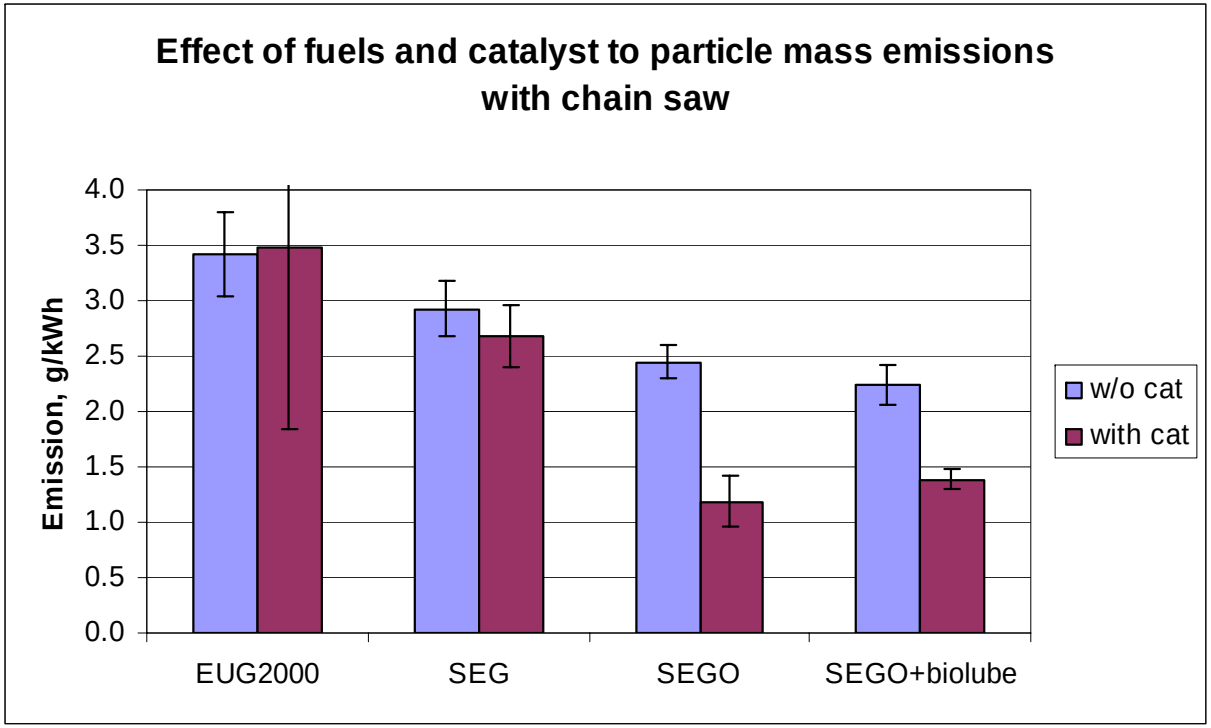
Results from gasoline engine measurements

- The effect of fuel was detected on HC, NO_x and particle mass emissions with both engines
- Catalyst with 2-stroke engine was not as efficient as expected (the best conversion ratios some 50 %)
- Catalyst with 4-stroke engine turned out to be quite efficient (conversion ratios from 45 % to over 90 %)
- With low sulphur and low aromatics fuel the PAH and Ames analysis results were 20 to 85 % lower

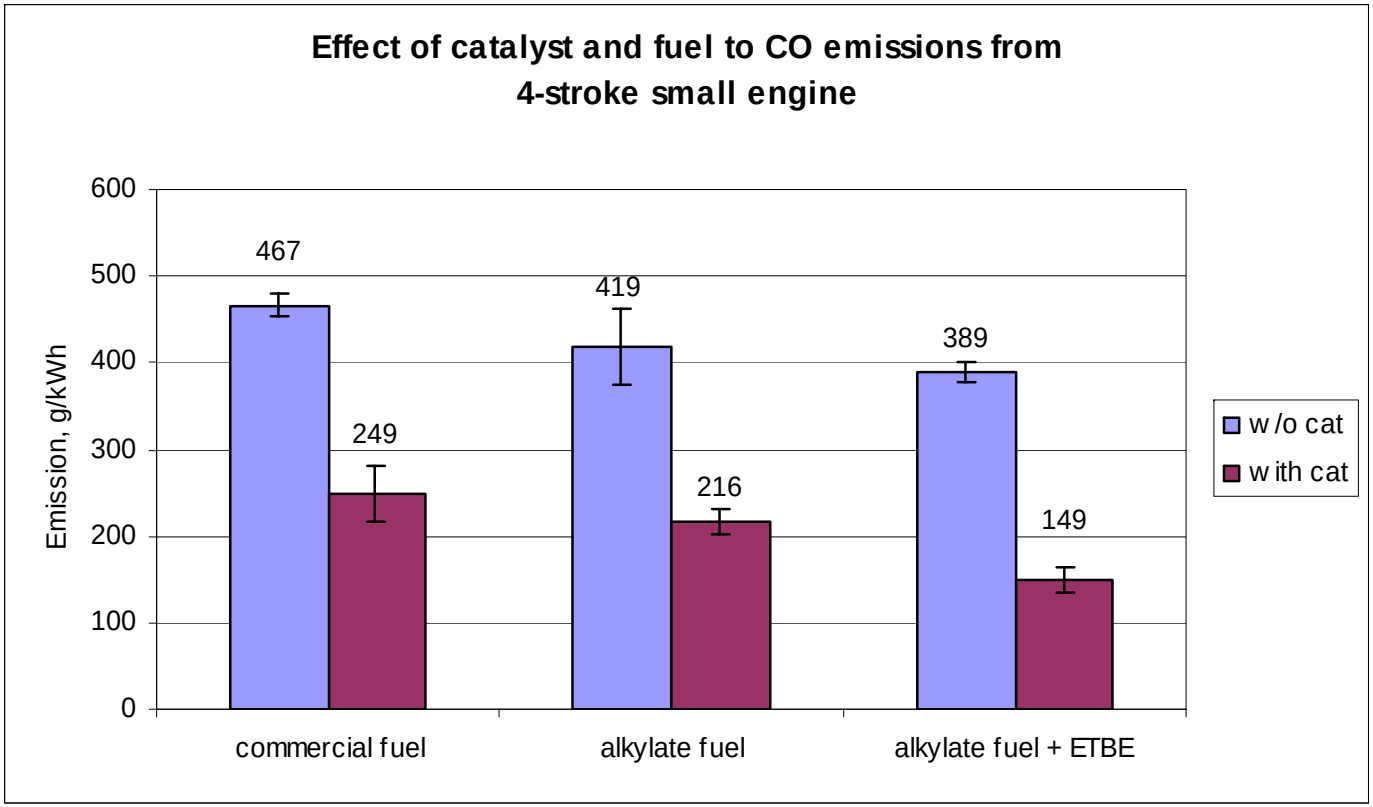
Results from gasoline engine measurements



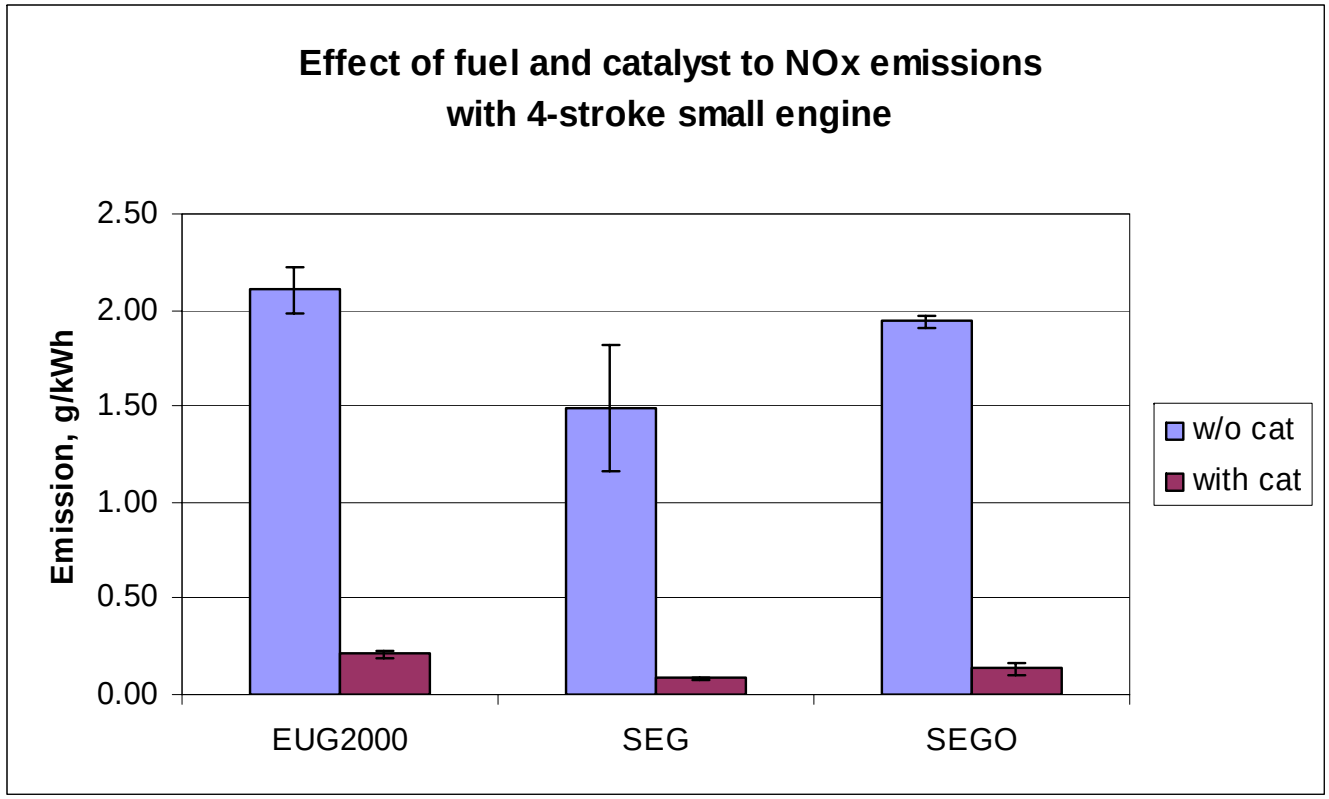
Results from gasoline engine measurements



Results from gasoline engine measurements



Results from gasoline engine measurements



Conclusions

- Project has shown that a good quality fuel (e.g. low sulphur, low aromatics) makes a difference to the exhaust gas emissions from non-road engines
- Improving the engine technology of small gasoline engines is limited (price, weight, etc.) so using catalyst and good quality fuel is the easiest way to reduce the exhaust emissions
- With diesel engines a significant reductions in particle emissions were achieved with a good quality fuel

Conclusions

- It is possible to effect to the quality of exhaust particles by lowering sulphur and aromatics content of fuel (with diesel and gasoline)
- The harmful effects of particles with different fuel qualities should be studied more
- The full report is for the use of the participants only but a short version of final report can be found on IEA-AMF web pages:

  http://www.vtt.fi/virtual/amf/annex_xxv/reports.htm

Acknowledgements

- Agence de l´Environnement et de la Maîtrise de l´Energie (ADEME), Institut Français du Pétrole (IFP), France
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