

Annex 50: Fuel and Technology Alternatives in Non-Road Engines

Project Duration	May 2014–June 2017
Participants Task Sharing Cost Sharing	Canada, Finland, Germany, Sweden, Switzerland None
Total Budget	More than €200,000 (\$312,145 US)
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Purpose, Objectives, and Key Question

Non-road mobile machinery is used to produce food, feed, and industrial material. Based on several different studies (mostly U.S. and European), this sector is often responsible for between 10% and 25% of diesel consumption and contributes significantly to overall emissions. However, discussions on alternative fuels and greenhouse gas emissions, both general and within the AMF TCP, have focused on road vehicles.

The purpose and first objective of Annex 50 are to put some focus on the non-road sector. This includes the collection of existing fuel consumption and emission data, measurements of real driving performance, studies of hybridization, and possible measures to reduce fuel consumption and emissions from non-road mobile machinery. This approach is undertaken for different engine technologies, fuel specifications, and machinery applications, including the consideration of engine load cycles.

Activities

Annex 50 activities are divided into nine different work packages covering areas from global emission regulations to the local level. For the local level, the work packages cover the national emission situation in some of the participating countries, in-lab emission measurements, as well as measurements during real operation of machinery. Two of the work packages deal with the possibility of reducing the fuel consumption of non-road mobile machinery by either political or technical measures.

In addition to the Annex 50 Final Report, a two-page summary written for a non-scientific audience will be published.

Key Findings

The results and deliverables of Annex 50 will be a written final report presenting data on fuel consumption and emissions from various types of non-road mobile machinery. It will cover emissions stages, technology and alternative fuels, and machinery operation.

For most road vehicles, such as passenger cars, buses, and heavy-duty trucks, the normal usage/driving pattern can be represented by a fairly limited number of cycles. Non-road mobile machinery consists of a much broader group of applications with a highly variable usage pattern. Thus, the usage of non-road mobile machinery cannot easily be described by a few general test cycles. Studies of wheel loaders conducted within Annex 50 show a significant reduction in emissions of air pollution with increasing emission standards. Tests on a wheel loader with a pre-Stage V engine have shown that emissions are kept at an acceptable low level at all tested usage patterns — from low loads to highly transient operation. One of the new requirements for Stage V emission regulations is in-use testing, which can be compared with real driving emissions currently under discussion for passenger cars or implemented for heavy-duty vehicles in Europe.

Tests with hydrotreated vegetable oil (HVO) have shown good drivability and reduced air pollutant emissions compared with conventional diesel (fulfilling EN 590). Emissions of particulate matter were reduced by up to 10% on a Stage IV engine without a diesel particulate filter (DPF). On the same engine, emission of nitrogen oxides (NO_x) was reduced by up to 15% with HVO during normal operation with a warm engine.

Main Conclusions

Emission Class of Engines

- Stage V technology (DPF, selective catalytic reduction, and heat management) are needed to obtain low real-world emissions.
- Going from Stage II or Tier 2 to Stage IIIB/IV or Tier 4i/4f does not necessarily deliver real emission benefits; one should leapfrog directly to Stage V regulations to get real-life low emissions.
 - This has implications for regions that are contemplating more stringent emission regulations, as well as for procurement of non-road mobile machinery.

Fuel Quality

- The older the engine (lower emission classification), the bigger reduction potential with high-quality fuel, both in test cell and in real-world operation.
- Sustainable produced advanced renewable diesel fuel, such as HVO, can reduce carbon dioxide emissions for all engine emission classes.

Real-World Operation

- Non-road mobile machinery consists of a significant variation in types of machinery that can be used in many different operations.
- Fuel consumption and exhaust emissions are dependent on the type of machinery, operation, emission classification, and fuel specification.

Publications

The following national project reports have been presented:

- TEST REPORT OMT 4005, 2015, On-board Emission Measurement on Wheel Loaders with Different Emission Standards, Sweden, AVL MTC.
- TEST REPORT OMT 5005, 2016, On-board Emission Measurement on Wheel Loaders in Different Test Cycles, Sweden, AVL MTC.
- Simulation of Wheel Loader – Energy Consumption, 2017. VTT-R-05718-16, VTT Technical Research Centre of Finland Ltd. Fuel and Technology Alternatives for Non-road Mobile Machinery – Finland’s Contribution to IEA AMF Annex 50, 2017, VTT-R-00044-17, VTT Technical Research Centre of Finland Ltd.