IEA-Advanced Motor Fuels
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Annex 57

Technology Collaboration Programme
by iea

Annex 57: Heavy Duty Vehicle Performance Evaluation

Project Duration	October 2018 - October 2020
Participants **Task sharing** **Cost sharing**	 Canada, Chile, Finland, Japan, Republic of Korea, Sweden Japan and Sweden
Total Budget	~€610,000 (~$671,000 US)
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Purpose, Objectives and Key Questions

This project aims to demonstrate and predict the progress in energy efficiency of heavy-duty (HD) vehicles, thus generating information to be used by transport companies, those procuring transport services and those forming transport policy. The project will encompass newest diesel technologies on different markets, but also alternative fueled vehicles and advanced powertrain configurations tested on chassis dyno and on-road.

The proposed overall activity will cover three time dimensions:

- Legacy vehicles and a reference backwards through completed AMF Annexes
- Current performance of the best-available-technology HD vehicles (HDVs) using conventional and alternative fuels
- A projection of how energy efficiency and emissions can develop, using input from the Combustion TCP as well as modelling by the AMF TCP for estimating the effects of alternative vehicle and powertrain configurations
- Cooperation with Hybrid Electric Vehicle (HEV) TCP brings the potentiality check of hybrid and electric HDVs for future projection.

Activities

Canada

The Canadian test program includes Class 7 and Class 5 trucks, which were tested both in-lab on a chassis dynamometer and on-road under real driving conditions using a portable emissions measurement system (PEMS).

The vehicles were tested with different loadings representing gross weight vehicle rating (GWVR), 50% payload, and 90% payload. Both vehicles were recent model years and included emission controls such as exhaust gas recirculation (EGR), diesel oxidation catalyst (DOC), diesel particulate filter

(DPF), and selective catalytic reduction (SCR). Both were tested with U.S. certification diesel fuel; the Class 7 truck was tested with a B20 blend.

Chile
The truck measurement program in Chile is delayed because three CV heavy vehicle laboratories have been working on the measurement of electric buses for public transport for the city of Santiago. The test program in Chile covers chassis dynamometer tests of diesel Euro V trucks on aggregated World Harmonized Vehicle Cycle (WHVC). Testing fuel is commercial diesel that meets the Euro 5 specifications.

Finland
The Finnish test program includes six different heavy-duty trucks, all in the N3 category: Two spark-ignited (SI) and fueled with methane (CNG and LNG), two diesel-fueled, one ED95, and one dual-fuel (DF) diesel-methane. Spark-ignited and ED95 trucks were type approved to Euro VI step C. Diesels and DF trucks were type approved for Euro VI step D. Each truck was tested on a chassis dynamometer; the SI-LNG, diesel and DF trucks were also tested on-road with PEMS.

Republic of Korea
Starting in 2020, CO_2 emission monitoring of HDVs will begin in Korea. Vehicle manufacturers have to report CO_2 emissions of their HDVs by using HES (Heavy-duty vehicle Emission Simulator), a Korean HDV CO_2 and fuel consumption simulation tool. Based on the monitoring results, CO_2 emission standards will be set. Mandatory CO_2 regulation of HDVs will begin between 2023 and 2025.

The HES program has been released three times and teams are now working on bug fixes. The program calculates tank-to-wheel CO_2 emission and fuel consumption based on longitudinal vehicle dynamics. A fuel consumption map, air drag coefficient, rolling resistance coefficient, and vehicle weight are the main input data of the simulation program. The error between HES results and the chassis dynamometer test results is about 5%. Correlation analysis between HES and VECTO for 21 cases of vehicle data were simulated. The same input data was used for both programs. The coefficients of linear regression and determination are 0.9845, and 0.9932.

Sweden
The Swedish test program includes nine individual heavy-duty trucks (N3): Three CNG, two LNG (dual fuel) and four conventional diesel engines fueled with Swedish environmental class 1 diesel fuel (EN590 artic class). The trucks were tested both in chassis dynamometer and with PEMS.

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Key Findings

Canada

Tailpipe CO_2 emission rates increased when the vehicles operated with increased payload. NO_x emissions decreased with increased payload likely as a function of exhaust temperature. Emissions of CO_2, CO, NO_x, and hydrocarbons (HC) were highest during the urban driving phase of the RDE tests, which included a cold start. Emission rate differences using the B20 blend compared to diesel were not significant.

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Finland

In chassis dynamometer tests, all trucks had gaseous-regulated and PM emissions under the emission limit values independent of testing cycle and load. NO_x emissions were well below the emission limit value. Spark-ignited CNG and dual-fuel trucks had high PN emissions that were higher than the Euro VI limit value. Other trucks, including the spark-ignited LNG truck, had PN emissions below the limit value.

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In PEMS testing, according to the Euro VI step C, the conformity factor for NO_x emissions varied between 0.07 and 0.43 depending on the truck. Both SI methane and diesel trucks had low PN emissions in PEMS testing. Dual-fuel trucks had PN emissions well above the emission limit value. However, the reason might be passive regeneration events during the testing.

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Sweden

For all tests and fuels, regulated emissions were within legal limits for both chassis dyno measurements and PEMS measurements. For LNG Euro VI step C vehicles, high emissions of N_2O were recorded. A plausible explanation could be a combination of urea injection strategy and SCR technology. Comparative tests with a corresponding diesel engine are ongoing. For the LNG Euro VI step D, no elevated N_2O emissions could be detected.

The CNG vehicles had an energy efficiency that was lower than that for diesel engines, but similar CO_2 emissions. Methane slip was low, except for cold start during which the emissions were slightly increased. PN emissions were significantly higher for the CNG vehicles, especially during cold start. Most of the NO_x emissions from the CNG vehicles were in the form of NO.

Main Conclusions

The main conclusion is that the current Euro VI/US 2010 trucks have gaseous (for diesel, all emissions) regulated emissions below the legislative limit values, independent of the fuel. Regarding the SI methane truck, PN emissions can be substantially higher than in the diesel truck. Energy consumption-wise, the methane-fueled, SI trucks have lower efficiency compared to diesel correspondent trucks, but the CO_2 emissions are similar to each other's, depending on the cycle. No high methane slip was observed for the methane-fueled trucks independent of the combustion method.

Schedule

Annex 57 will be reported in IEA-AMF ExCo meeting 60 in November 2020. Research activities are planned to be due during spring 2020.