IEA-Advanced Motor Fuels

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Annex/Task 57

Annex 57: Heavy Duty Vehicle Performance Evaluation

Project Duration	October 2018 – May 2021
Participants **Task sharing** **Cost sharing**	 Canada, Chile, Finland, Japan, Republic of Korea, Sweden Japan and Sweden None
Total Budget	~€610,000 (~$671,000 US)
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Purpose, Objectives and Key Question

This project aims to demonstrate and predict the progress in energy efficiency of heavy-duty (HD) vehicles, thus generating information that can 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 a chassis dynamometer 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 insight to how different HDV powertrain and fuel (fossil and renewable) options perform against the CO_2 emission regulations of 2025 and 2030.

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 Chile test program included three Euro V diesel trucks in weight category under 10 tons (GVW), all of them tested in the Heavy-Duty Emission Laboratory of the Vehicle Control and Certification Center (3CV). The test program in Chile covers fuel consumption and PM emission measurements in chassis dynamometer according to the 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 tailpipe 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 was performed. 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.

Main Conclusions

The main conclusion is that the current diesel heavy-duty trucks are rather energy efficient (on average close to 46 % BTE on typical long-haul mission) and, independent of the fuel and combustion method, they have low regulated emissions. Furthermore, the HDV CO_2 regulations that focus on tailpipe emissions constitute a barrier for further development of alternative fueled trucks. This could result in a halt in development of clean and efficient engines for dedicated alternative fuels, resulting in a preference to use drop-in fuel in the legacy fleet and for electrification for new trucks entering the market. This type of legislation will have an impact on the possibility to use sustainable produced fuels in the future.

In terms of energy consumption, independent of fuel, the concepts based on compression ignition (diesel proves), including HPDI dual-fuel, deliver rather high efficiency. Spark-ignited methane engines, on an average, have close to 30% higher energy consumption compared to compression ignition engines of the same size and power. Considering CO_2 emissions, HPDI dual-fuel delivers on average close to 20% lower CO_2 emissions compared to diesel. Renewable diesel and ED95 reduce tailpipe CO_2 emissions about 5% compared to fossil diesel. This stems from small differences in the fuel hydrogen/carbon ratio. Spark-ignition (SI) methane engines deliver tailpipe CO_2 emissions equivalent to or slightly lower than those of diesel engines. No high methane slip was observed for the methane-fueled trucks independent of the combustion method. 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 not equipped with particulate filters, PN emissions can be substantially higher than in the diesel truck.

Regarding energy consumption and efforts to reduce CO_2 emissions from trucking operations, the impacts of vehicle size and relative loading are often dismissed. The simulations carried out within Annex 57 demonstrated that increasing GVWR from some 60 up to 90 tons could reduce CO_2 emissions per ton-kilometer of cargo by up to 40%. For example, currently Finland and Sweden are allowing heavy combinations: 76 tons in Finland and 74 tons in Sweden.

In order to keep ICE vehicles running on renewable fuels on the road in the future, some adjustments to vehicle CO_2 regulations are needed, and as well as some mandates for renewable fuels. Electrification is progressing rapidly, but heavy-duty long-haul trucks are not the optimum target for electrification.

Schedule

Annex 57 will be reported in IEA-AMF Executive Committee meeting 61 in May 2021. Details will be available on https://iea-amf.org/content/projects/map_projects/57.