# IEA-Advanced Motor Fuels
## ANNUAL REPORT 2021

# Task 57

Technology Collaboration Programme
by iea

## Task 57: Heavy Duty Vehicle Performance Evaluation

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| **Project Duration** | October 2018 - May 2021, and Webinar in October 2021 |
| **Participants**<br>**Task sharing**<br><br>**Cost sharing** | <br>Canada, Chile, Finland, Japan (LEVO), Republic of Korea, Sweden<br><br>Japan (LEVO) and Sweden |
| **Total Budget** | ~EUR 610,000 (~USD 671,000) |
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| **Website** | https://www.iea-amf.org/content/projects/map_projects/57 |

### *Purpose, Objectives and Key Question*

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

The proposed overall activity will cover three time dimensions:

- Legacy vehicles and a reference backwards through completed AMF Tasks
- Current performance of the best-available-technology 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 modeling by the AMF TCP for estimating the effects of alternative vehicle and powertrain configurations
- Cooperation with the IEA's Hybrid Electric Vehicle (HEV) TCP offers insight to how different HDV powertrain and fuel (fossil and renewable) options perform against the $CO_2$ emission regulations, from a 2025 and a 2030 perspective.

### *Activities*

**Test Programs**

Participating countries – Canada, Chile, Finland, Japan, Republic of Korea and Sweden – conducted tests and shared results in 2021.

**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 Chilean test program included three Euro V diesel trucks in the weight category under 10 tons (GVW) and 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 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 began in Korea. Vehicle manufacturers 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 rate 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.

**Webinar**
In October 2021, a webinar, “Heavy Duty Vehicles - Recent and Future Options with Regard to Energy Consumption and Pollutant Emissions,” was held to disseminate Task results but also to cover other energy efficiency and $CO_2$ emissions reduction measures for HDVs. Recent findings from work done in AMF TCP Task 57 “Heavy duty vehicle performance evaluation” were presented. The Task Manager presented an overview, which was followed by related findings of the HEV TCP and case studies from Switzerland and Finland.

The following topics were covered:

- Energy Efficiency and Emissions of Heavy-Duty Vehicles
  Petri Söderena, AMF TCP Task 57 Leader, VTT, Finland
- Electrification of Heavy-Duty Vehicles
  Özcan Deniz, HEV TCP Task 41 Leader, German Aerospace Center (DLR), Germany
- Liquefied Biomethane in HDV Transportation in Switzerland
  Elimar Frank, Eastern Switzerland University of Applied Sciences, Switzerland
- High Capacity Transport in Finland
  Otto Lahti, Finnish Transport and Communication agency, Traficom

## *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 electrification for new trucks entering the market. This type of legislation will have an impact on the possibility of using sustainably produced fuels in the future.

Energy consumption-wise, 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 or slightly lower to 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 trucks which were not equipped with particulate filters, PN emissions can be substantially higher than in a diesel truck.

Energy consumption-wise, and in 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 Task 57 demonstrated that increasing gross vehicle weight rating (GVWR) from 60 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.

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

### *Schedule*

Task 57 was reported in AMF TCP ExCo meeting 61 in May 2021.