Heavy Duty Vehicle Performance Evaluation

Participants

- Environment and Climate Change Canada
- Korea Automotive Technology Institute (KATECH), Korea
- Ministry of Energy and Ministry of Transport & Telecommunications of Chile
- Organization for the Promotion of Low Emission Vehicles (LEVO), Japan
- Swedish Transport Administration (STA), Sweden
- VTT Technical Research Centre of Finland LTD, Finland (Operating Agent)

Policy Relevance

The trucking industry is a key enabler to modern society and global economic activity. Trucks transport a multitude of goods including: construction and raw materials, fuels, refuse and commodities from their points of production to processing locations or to their final point of sale. Thus, energy consumption and pollutant emissions of the state-of-the-art heavy-duty vehicles (HDVs), along with different fuel options, provide valuable information for decision making.

Major Conclusion

All new fuel options, namely, diesel, Spark Ignition (SI) methane, High Pressure Direct Injection (HPDI)-methane and ED95 were evaluated. **Independent of fuel type, the concepts based on compression ignition (diesel process), including HPDI dual-fuel, deliver rather high efficiency.** The results of vehicle testing indicate the engines of the best heavy-duty diesel tractors reach an **efficiency of about 45% on the engine crankshaft**. **In regards to tailpipe (TTW) CO_2 emissions, HPDI dual-fuel delivers on average close to 20% lower emissions than diesel**. Results of regulated emissions showed that each engine concept independent of fuel type is capable of reaching **emissions clearly below the legislative target values**. However, testing revealed that N_2O emissions might be problematic for vehicles equipped with specific selective catalytic reduction (SCR) systems.

Background

The 2017 IEA report "The Future of Trucks: Implications for Energy and the Environment" states that road freight transport makes up 32 % of the total transport-related energy demand. In addition, the report found that road freight transport primarily uses petroleum-derived fuels, which accounts for more than 97 % of the sectoral final energy usage.

With a focus on energy efficiency of heavy-duty trucks, for the first time, the Annex 57 combined chassis dynamometer measurements, on-road measurements and simulations, with the aim to present a snapshot of the performance of contemporary vehicles as well as to present projections of performance up to the year 2030.

There are many different fuel and engine technology options currently available for HDV's. In addition, there are also renewable fuel options such as: hydrotreated vegetable oil (HVO) for diesel powertrains, biomethane for SI and HPDI methane powertrains and ED95 for dedicated ethanol-diesel engine. **Combined with state-of-the-art HDV powertrains, renewable fuels provide an effective measure for reducing greenhouse gas (GHG) emissions in well-to-wheel (WTW) bases.**

In long haulage the energy consumption and CO_2 emission reduction measures are often restricted to the powertrain and vehicle level in areas such as air drag and rolling resistance. However, **the impacts of vehicle size and relative loading are often dismissed.** Increasing high capacity transportation **(HCT) with an increased gross vehicle weight rating (GVWR) from the typical Eurpean 42 ton trucks would be a cost effective way for reducing CO_2 emissions** per ton-km transported goods.

Research Protocol

The Annex 57 covered in total 17 medium and HDVs performance tests (energy consumption, and emissions) on chassis dynamometer and on-road conditions performed by the partners according to jointly developed testing procedures. In addition, vehicle simulation methods were developed for modelling HDV's energy consumption and CO_2 emissions. The WHVC test cycle was used in chassis dynamometer studies while the Euro VI ISC test procedure was used in on-road testing. The recommended load was set at 50 % of the full load for the chassis dynamometer and on-road measurements. The chassis dynamometer testing was performed starting with cold and fully warmed engines. In on-road vehicles were tested using cold engine starts. In addition, partners were free to perform additional tests i.e. different test cycles, loadings and fuels.

Simulation models for the HDV's energy consumption and CO_2 emissions were created by Korea. While the HCT vehicles energy consumption and CO_2 emissions simulation model was generated by Finland.

Annex 57 encompassed **joint activity with IEA Hybrid and Electric Vehicles (HEV) TCP** for **evaluation of energy consumption and CO_2 emissions with different powertrains and fuel options** on typical long-haulage vehicle.

Key Findings

- HDV CO_2 regulations that **focus on tailpipe emissions constitute a barrier** for further **development of alternative fuelled 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 prospect to use sustainably produced fuels in the future.
- State-of-the-art **diesel trucks** reach **approx. 45 % engine thermal efficiency** on typical long-haul operation. With the **use of renewable fuel,** the well-to-wheel (WTW) **GHG emissions and energy consumption can be very low (Figure 1).**
- The **HPDI dual-fuel** methane technology delivers on average **close to 20% lower CO_2 emissions in tailpipe levels when compared to diesel**.
- Renewable diesel and ED95 delivers around 5 % lower tailpipe CO_2 emissions compared to fossil diesel. While SI-methane engines deliver tailpipe CO_2 emissions equivalent to those of diesel engines.
- **State-of-the-art trucks are clean**. Independent of the fuel and combustion process **regulated emissions are on a low level.**
- New **SI and HPDI methane** fuelled trucks are emitting **lower CH_4 emissions** compared to previous generations.
- Based on the simulations within Annex 57 increasing gross vehicle weight rating (GVWR) from some 60 up to 90 tons could r**educe CO_2 emissions per ton-kilometre of cargo by up to 40%**. Thus, **HCT offers an effective way for reducing** specific e**nergy consumption and CO_2 emissions**.

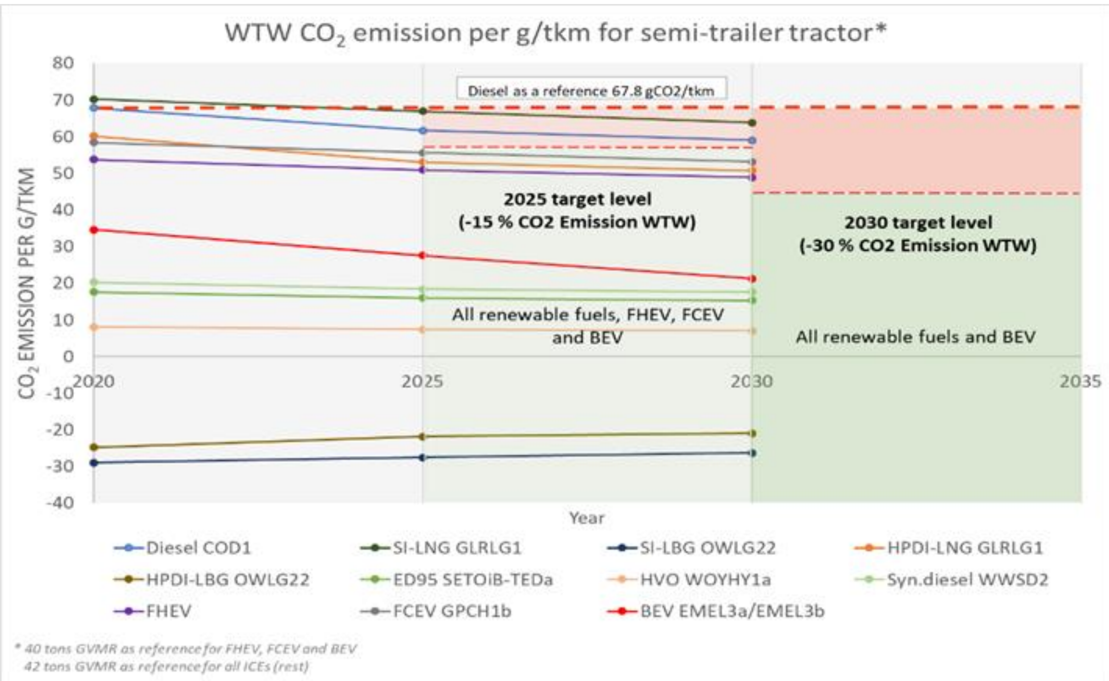

Figure 1: CO_2 emissions in WTW basis per ton-kilometer for different powertrain and fuel options.