Annex 55: Real Driving Emissions and Fuel Consumption

Project Duration	November 2015–November 2019
Participants **Task Sharing** **Cost Sharing**	 Canada, Denmark, Finland, Sweden, Switzerland, USA No cost sharing
Total Budget	~€400,000 ($454,046 US)
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Purpose, Objectives, and Key Question

The levels of air pollutants from internal combustion engine (ICE)-powered vehicles being sold in the marketplace today are much lower than those from vehicles 4 to 10 years ago. This change is largely the result of technology forcing regulations to control the exhaust emission rates of various air pollutants, such as hydrocarbons, carbon monoxide (CO_2), oxides of nitrogen (NO_x), and particulate matter. Over time, changes to those regulations have reflected the extraordinary advances in fuels, engines, and emission control technologies produced by automotive researchers and manufacturers over the past decades. Evidence suggests that the performance of vehicles may not be fully captured in compliance or type approval tests, even though they are conducted with varying driving cycles and in an environmentally controlled chamber.

This project aims to develop an emission rate, fuel consumption, and energy efficiency inventory of vehicles driven on-road in varying countries in typical seasonal corresponding climates, using vehicles fueled with advanced, renewable, and conventional fuel. The project will investigate vehicle performance over typical regional driving conditions, such as city, highway, arterial, free-speed, and congested routes. In short, the objective of this project is to explore the real driving emissions and real-world performance of vehicles operating under a range of driving conditions worldwide.

Activities

The team finalized the Annex 55 formal text in the summer of 2017. The purpose, objectives, audience, and methodologies are defined. The team defined the following work packages (WPs):

- WP 1: Annex management

- WP 2: Literature review and world regulation review
- WP 3: Fuel and technology effects on real-world driving emissions and efficiency
- WP 4: Comparison of on-road testing to laboratory testing
- WP 5: Assessment of weather conditions on real-world driving emissions and efficiency
- WP 6: Evaluation of different emissions measurement techniques

Currently, the annex members are in the testing and data collection phase. On-road testing and dynamometer testing results have been shared and compared. Several participants defined their own real-world driving routes.

A planning conference call of annex participants in August 2018 led to the development of a timeline for completing Annex 55 activities, along with a uniform report outline for all Annex 55 member contributions. On the basis of this timeline, the Annex 55 date was extended from April 2019 to November 2019. Also, participants agreed to hold regular conference calls with technical updates; these were held in September and November 2018.

Key Findings

Canada completed on-road testing of 40 vehicles in Ottawa, Ontario, with five distinct driving segments. The vehicles were also tested in the laboratory on a chassis dynamometer with the Federal Test Procedure (FTP) and Highway Fuel Economy Test Cycle (HWFCT) drive cycles. Great variability in test results occurred during the on-road emissions testing compared to the chassis dynamometer testing. Canada found that fuel consumption from real-world testing is, on average, 22% higher than the observed fuel consumption from tests on a chassis dynamometer. Furthermore, 84% of vehicles tested on-road presented a statistically significant increase in NO_x when comparing real-world and laboratory results on a chassis dynamometer.

Denmark completed the testing of five Euro 6b class vehicles in cold weather conditions on track as well as on an 80-kilometer real driving emission route. The results showed a wide range of NO_x emissions between the different test cars in real-world driving.

Finland executed one testing campaign on chassis dynamometer for four Euro 6 diesel vehicles and one on-road Portable Emissions Measurement System (PEMS) measurement campaign for two of the vehicles. A wide variation in emissions was observed between the New European Driving Cycle (NEDC) and Worldwide Harmonized Light Vehicles Test Procedure

(WLTP) driving cycles on chassis dynamometer and on-road among the three different routes. More detailed data analysis is in process.

Sweden tested almost 200 vehicles evenly divided between diesel and gasoline (only 5 ethanol flex fuel) over several different test cycles, such as PEMS, WLTP, European Research Group on Mobile Emission Sources (ERMES), and NEDC. All 200 vehicles have not been tested in all of the cycles; for example, PEMS have been tested on almost 60 vehicles. Of the vehicles tested in the NEDC (type I) cycle, 94% had a higher recorded CO_2 value compared with the declared values, despite using the same settings on the vehicle dynamometer. The average difference was almost 7%. Emissions of CO_2 during real driving was even higher. A new test procedure, the WLTP, has been developed to better represent real-world driving. The difference between WLTP and PEMS in real driving conditions was only 3% for diesel vehicles and 11% for gasoline vehicles. However, the emissions on NO_x from the diesel vehicles was on average 6.6 times higher than the certified value. These data include results from Euro 5 vehicles. Also, some gasoline vehicles with direct injections showed high NO_x emissions during real-world driving. Emissions of particles was low from all diesel vehicles, as those vehicles are equipped with diesel particulate filters. However, gasoline vehicles, especially those with direct injection, showed rather high emissions of particles. None of the tested gasoline vehicles was equipped with a filter. A shift from diesel to gasoline might result in lower emissions of NO_x but higher emissions of particles and CO_2. On average, the difference in CO_2 emissions between similar-sized diesel and gasoline vehicles was 20%.

In Switzerland, the Swiss laboratory for exhaust emission control and ICEs of the Bern University of Applied Sciences (AFHB) performed several on-road (RDE) and chassis dynamometer measurements with two flex-fuel gasoline/ethanol vehicles (FFV E0/E85) and one hybrid electric vehicle (HEV). The FFV measurements show that the use of E85 instead of E0 fuel leads to a reduction of NO_x and PN-emissions for both investigated vehicles and in all driving conditions. The HEV-tested vehicle shows very low emissions and fuel consumption. In real world driving conditions, the HEV’s ICE works between 39% and 59% of the total cycle time.

Empa, the Swiss Federal Laboratory for Materials Science and Technology, completed the chassis dyno, the RDE testing, and the data evaluation on passenger cars (diesel and gasoline, both Euro 6b) and light-duty commercial vehicles (diesel Euro 6b) for the emission inventory project on behalf of the Swiss Federal Office for the Environment (FOEN). The reporting for this project is ongoing and will be finalized in the beginning of

2019. The field test activities for the comparison of real-world energy demand of different vehicle types (hybrid, plug-in hybrid, compressed natural gas, and electric vehicle) and auxiliary consumers during real-world operation could be finished. The data evaluation for this project on behalf of the Swiss Federal Office of Energy (SFOE) is still ongoing and is expected to be finalized in the beginning of 2019.

The U.S. tested a gasoline vehicle as well as a plug-in hybrid vehicle on three specific routes (urban, arterial, and highway) on roads in the Chicago metropolitan area. The vehicles were extensively instrumented beyond the portable emissions measurement equipment. On the basis of specific drive metrics (e.g., potential kinetic energy and accelerations), the dynamometer testing was very repeatable in energy intensity compared to the on-road testing. For the gasoline vehicle, the emissions, as well as the driving aggressiveness, in the real world were generally higher (30%–100%) than laboratory certification testing. For the plug-in hybrid vehicle, small amounts of emissions came from the engine through short operations during the charge-depleting phase. Overall, emissions are still very low in both charge-depleting mode and charge-sustaining mode.