# D2. 5 – Assessment of the Dual Fuel (liq/liq) combustion

Research Innovation Action

**EUROPEAN COMMISSION**
Grant Agreement No. 874972

HORIZON 2020 PROGRAMME
Topic LC-GV-04-2019
Low-emissions propulsion for long-distance trucks and coaches

| | | |
|---|---|---|
| **Deliverable No.** | **LONGRUN D2.05** | |
| **Related WP** | WP2 | |
| **Deliverable Title** | Assessment of the Dual Fuel (liq/liq) combustion | |
| **Deliverable Date** | 2021-09-30 | |
| **Deliverable Type** | REPORT | |
| **Dissemination level** | Confidential – member only (CO) | |
| **Written By** | Kai Deppenkemper, Sandra Glück (FEV), Rajesh Kumar (IFPEN) | 2021-08-17 |
| **Checked by** | Florence Duffour (IFPEN) | 2021-08-31 |
| **Reviewed by (if applicable)** | Marco Günther (RWTH), Andreas Kolbeck (Shell) | 2021-09-20 |
| **Approved by** | Lukas Virnich (FEV) | 2021-09-24 |
| **Status** | Final | 2021-09-30 |

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 874972.

## Publishable summary

The project partners (OEMs, engineering partners and fuel suppliers) discussed about possible sustainable fuels and combustion systems which are promising with regards to high thermal efficiency, low engine-out emissions and suitability for current and modified fuel infrastructures. The results have been presented in deliverable D2.1.

Methanol was one of the fuels selected being the best compromise in the tradeoff between fuel production cost and transportability. In contrast to typical spark-ignited methanol combustion, a new combustion concept was selected where methanol is burned diffusively in a compression ignition (CI) engine. To enable CI of methanol, a diesel pilot is used to preheat the combustion chamber (called Dual Direct Injection Compression Ignition, DDI CI). The resulting process allows to operate on a high compression ratio thereby achieving high thermal efficiency.

In addition to engine testing, the diffusive combustion of methanol was investigated via Computational Fluid Dynamics (CFD), enabling to vary a broader range of parameters in a less cost-intensive manner. The main simulation objective is the optimization of pilot injector spray target and strategy. The pilot fuel share, pilot injection timing and the rail pressure for pilot as well as for main injection are the calibration parameters for the desired combustion system. Methanol injection timing will be adjusted to maintain the center of combustion.

The tests on FEVs Single Cylinder Engine (SCE) showed for best efficiency point that the diffusive dual fuel combustion concept is promising regarding efficiency (~50 %) and especially $NO_X$ emissions (e.g. 6 g/kWh requires almost no EGR). Moreover, combustion is soot free and unburned fuel and CO emissions remain on a low level typical for diffusive combustion. Those thermodynamic tendencies could be found also at different engine operation points. Potential to further improve the combustion concept lies especially in the pilot injection timing and quantity. The potential was numerically evaluated by IFPEN.

The CFD simulations performed by IFPEN reproduced the experimental results and lead to the following key conclusions: The minimum pilot fuel quantity, while maintaining a minimum flow rate for injector cooling, should be injected. It reduces $NO_X$ production and increases efficiency. SOI pilot should be as close to SOI main as possible, maintaining an optimum CA50. As EGR increases, overall $NO_X$ production decreases. $NO_X$ coming from pilot injection combustion is almost eliminated at higher EGR rate (>20 %) and $NO_X$ is mainly produced during main combustion. The pilot injection can be further optimized by reducing the hydraulic flow rate to allow small quantity of diesel injection and by targeting optimization (reducing the cone angle). As the results were very promising overall, the partners suggest investigating the DDI CI concept in more detail in future projects.

# 9 Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

**Project partners:**

| # | Partner | Partner Full Name |
|---|---|---|
| 1 | FEV | FEV EUROPE GMBH |
| 2 | DAF | DAF TRUCKS NV |
| 3 | FPT | FPT INDUSTRIAL SPA |
| 4 | FORD | FORD OTOMOTIV SANAYI ANONIM SIRKETI |
| 5 | IRIZAR | IRIZAR S COOP |
| 6 | IVECO | IVECO S.p.A. |
| 7 | VOLVO | VOLVO TECHNOLOGY AB |
| 8 | VDL | VDL ENABLING TRANSPORT SOLUTIONS BV |
| 9 | ABEE | AVESTA BATTERY & ENERGY ENGINEERING |
| 10 | AVL | AVL LIST GMBH |
| 11 | EATON | EATON ELEKTROTECHNIKA SRO |
| 12 | GARR | GARRETT MOTION CZECH REPUBLIC SRO |
| 13 | IDIADA | IDIADA AUTOMOTIVE TECHNOLOGY SA |
| 14 | IFP | IFP Enegies Nouvelles |
| 15 | AVL | AVL MTC MOTORTESTCENTER AB |
| 16 | NESTE | NESTE OYJ |
| 17 | PRIMA | PRIMAFRIO SL |
| 18 | SHELL | SHELL GLOBAL SOLUTIONS (DEUTSCHLAND) GMBH |
| 19 | SIE | SIEMENS INDUSTRY SOFTWARE SAS |
| 20 | TECHNA | FUNDACION TECHNALIA RESEARCH & INNOVATION |
| 21 | TOTAL | TOTAL MARKETING SERVICES |
| 22 | UMIC | UMICORE AG & CO KG |
| 23 | UNR | UNIRESEARCH BH |
| 24 | JRC | JRC -JOINT RESEARCH CENTRE – EUROPEAN COMMISSION |
| 25 | CHALM | CHALMERS TEKNISKA HOEGSKOLA AB |
| 26 | RWTH | RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN |
| 27 | TU/e | TECHNISCHE UNIVERSITEI EINDHOVEN |
| 28 | TUG | TECHNISCHE UNIVERSITAET GRAZ |
| 29 | UNIAQ | UNIVERSITA DEGLI STUDI DELL'AQUILA |
| 30 | VUB | VRIJE UNIVERSITEIT BRUSSEL |

## 9.1 Disclaimer



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 874972. The information and views set out in this publication does not necessarily reflect the official opinion of the European Commission. Neither the European Union institutions and bodies nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained therein.