D6.4 – E-Axle Prototype

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Publishable summary

Heavy-duty vehicles are widely used in the transport sector in Europe. Heavy-duty vehicles transport 75% of freight over land in Europe (1). Because of their load capacity and annual mileage, heavy-duty vehicles are also a significant source of greenhouse gas (GHG) emissions in Europe. Therefore, any reduction in the emissions of these vehicles will aid in overall reduction of GHG.

Ford Otosan proposed the hybridization of the long haul tractors as a solution to support the efforts to reduce GHG emissions of heavy-duty vehicles.

The hybrid truck proposed by Ford Otosan will include an e-axle as the key component of electrified powertrain. The e-axle is a powerpack that consists of electric motor(s), a multi-speed gearbox and a differential. Project partners Ford Otosan and FEV will design and implement an e-axle to the baseline truck within this work package, in order to reach the project targets of at least 10% energy saving and zero emission drive.

In the first phase “Requirements - Target Definition and Concept Study”, several concept design options were reduced to two distinct topologies. For both topologies, the optimum gear numbers and gear ratios were identified in order to meet the vehicle performance and efficiency targets. Their performance and efficiency were evaluated in different drive cycles. Furthermore, the most promising topology was implemented in a hybrid F-max tractor analytical model. The energy saving through hybridization with an e-axle was calculated in the reference cycles (2).

In the second phase “Layout Design”, the most promising topology was further detailed. Successfully completed activities in this layout design phase include: e-Motor selection, evaluation of vehicle level requirements with traction curve analyses, development of a duty cycle from Ford Otosan target drive cycles, 3D layout modeling; gear design, modeling of system deformations; safety analyses of transmission components such as gears, bearings, shafts and splines; housing concept design, lubrication system development, shifting system development, and initial supplier selection for sensors. According to the results of the layout design phase, the selected concept can be implemented in an e-axle system that will satisfy the project targets hence could evolve into the final product.

In the third phase “Detailed Design”, all work conducted so far has been elaborated and deepened with additional activities such as the finite element analysis of the housing, multibody simulations of the shifting system and additional detail design work such as generation of the drawings and tolerance stack up analyses being performed.

The activities planned in this phase of the project have been successfully executed. Unit e-axle complete list of materials has been prepared. Technical drawings and request for quotations (RFQs) have been shared with multiple suppliers. After the supplier selection phase, all mechanical parts like gears, casings and bearings have been purchased as well as the control system components like sensors, actuators and control unit hardware. In parallel manufacturing guidelines and manuals have been prepared to be used for unit e-axle assembly. Although the Covid-19 pandemic affected the delivery times from the suppliers and some quality issues observed on some parts which had required update, the first physical prototype has been assembled.

By the next phase of the project, the effects of Hydrotreated Vegetable Oil (HVO) will be evaluated. A 13lt, Gen 1.5 Ecotorq Euro6 engine will be installed to the engine dyno. Back to back tests will be run wth HVO fuel and conventional diesel fuel. The activity will be the pre-assessment of the vehicle testing

with HVO usage. A report which will summarize the effect of usage HVO in Ecotorq engine will be shared.

According to the current status of the development process, the hybrid F-Max tractor with the proposed e-axle concept can satisfy the project targets with the proposed project timing.

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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 Enegeies 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
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29	UNIAQ	UNIVERSITA DEGLI STUDI DELL'AQUILA
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