



**FITGEN (GA-824335)** 

## FUNCTIONALLY INTEGRATED E-AXLE READY FOR MASS MARKET THIRD GENERATION ELECTRIC VEHICLES (INTERIM PROJECT RESULTS – [M1 – M26])

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#### **FITGEN** at a glance

FITGEN responds at the LC-GV-01-2018 call (Integrated, brand-independent architectures, components and systems for next generation electrified vehicles optimised for the infrastructure) aiming at:

- 1. Delivering a highly-integrated e-axle, natively brand-independent and multi-platform.
- 2. Advancing the e-axles in the areas of:
  - power electronics and charger (adoption of SiC-technology and integration of fast charge @ 120 kW peak);
  - electric motor and transmission (increase power density and mechanical integration);
  - **cooling and control** (common motor-inverter cooling circuit, oil-cooling integration, advanced control algorithm).
- 3. Demonstrate the e-axle in an A-segment fully electric vehicle platform (FIAT-500e) at:
  - TRL 7 (system prototype demonstration in operational environment), and
  - MRL 7 (*capability to produce systems, subsystems or components in a production representative environment*) reaching a production volume of 200,000 units/year by 2025 and 700,000 units/year by 2030.
- 4. Enable a driving range from 740 to 1,050 km (including 75 minutes of recharging time) and matching a cost target of 2,000 €/unit.





#### **FITGEN** concept overview

Integration of the DC/DC converter, 6-phase inverter, 6-phase permanent magnet synchronous machine, single-speed transmission and fast charge capability







#### FITGEN results (in-focus look at the e-motor/transmission – [M1-M26])

- High-speed permanent magnet hybrid synchronous motor;
- State-of-the-Art patented Formed Litz wire winding technology;
- Gravimetric power density of 5.2 kW/kg, 23,000 rpm max. speed with 27,600 rpm of sustained overspeed coupled with an oil-cooled single-speed transmission (12.5:1 reduction ratio);
- E-motor stand-alone efficiency of 96.8% measured at the bench;
- Mechanical and functional integration of the inverter-motor-transmission group.





Source: T. Dimier et. al. "Comparison of Stator Winding Technologies for High-Speed Motors in Electric Propulsion Systems", ICEM 2020.





### FITGEN results (in-focus look at the inverter – [M1-M26])

Design drivers:

- Integrated inverter-motor housing:
  - Compact system with integrated bearing for drive shaft;
  - ✓ No AC-cabling required;
  - ✓ Highly integrated cooling system;
- Cascaded 2x3-phase inverter using SiC-MOSFETs:
  - ✓ Surface mounted devices;
  - ✓ Optimized for high frequency switching;
- High power density
  - ✓ Housing volume inverter: 5.13 litres;
  - ✓ Power density above 26 kW/litre.







#### FITGEN results (in-focus look at the integrated charger concept – [M1-M26])

Innovative integrated on-board charger by exploiting:

- the 6-phase traction motor as isolation transformer;
- the SiC inverter for energy conversion;

Several solutions under investigation to achieve:

- Accurate grid current control (PF = 1, THD < 1.5%);</li>
- Negligible torque during charging stage.



Source: P. Pescetto and G. Pellegrino, "Integrated Isolated OBC for EVs with 6-phase Traction Motor Drives," 2020 IEEE Energy Conversion Congress and Exposition (ECCE), 2020.

FITGEN presentation at DOMUS and QUIET Workshop (Mar. 3rd, 2020).





# FITGEN results (in-focus look at the integrated cooling concept – [M1-M26])







#### FITGEN results (vehicle integration within the FIAT 500e / RWD – [M1-M26])







#### FITGEN results (e-axle components proto & EoL tests / motor – [M1-M26])



FITGEN presentation at DOMUS and QUIET Workshop (Mar. 3rd, 2020).





#### FITGEN results (e-axle components proto & EoL tests / inverter – [M1-M26])







#### FITGEN results (e-axle components proto & EoL tests / transmission – [M1-M26])















#### FITGEN next steps (M26 - M36)

- Finalization and testing of the V1.0 e-axle control software (WP5);
- Complete the prototyping of the stand-alone parts (motor active parts, inverter PCBs, housing, DC/DC converter, transmission, mechanical linkages) and assembly of the e-axle (WP5);
- Qualification of the e-axle at bench and refinement of the control (WP5);
- Integration in the vehicle, dyno test of the demonstrator (WLTC / range / freeway driving test), TRL / MRL assessment, LCA and LCC (WP6).





#### **FITGEN** website and contacts







# Thanks for your attention michele.degennaro@ait.ac.at





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