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#RTR2026

HEFT

Novel concept of a Low Cost, High Power Density and Highly Efficient Recyclable motor for next generation mass produced electric vehicles

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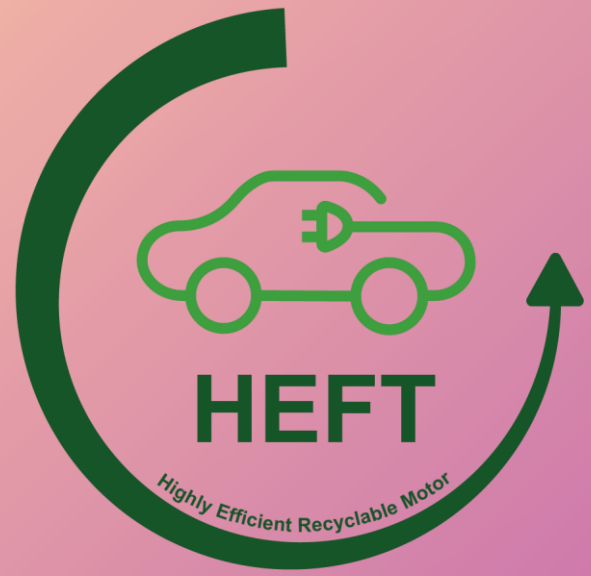

2ZERO ERTRAC CCAM European Commission | With the support of BATT4EU Batteries European Partnership

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Overall project presentation

Consortium and general information

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HEFT Project information and consortium

Project partners:

- Mondragon Unibertsitatea (Coordinator), Magneti, Sumibe, Ikerlan, University of Bologna, KU Leuven, University of Nottingham (associate partner).

Project information:

- Call Horizon-CL5-2022-D5-01-09
- Grant agreement ID:101096306.
- Start date: December 2022.
- End date: May 2026 (extension requested until November 2026)
- EU contribution: 3.476515,00 €.
- Member of E-VOLVE cluster

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Objectives and quantified targets

- Development of lower cost, higher efficiency and power density electric motors for mass produced cars and vans.
- Development of a resilient long-term strategy to face rare earth CRM (Critical Raw Material) supply chain possible issues

KPI 1. Motor Cost reduction

KPI 2. Motor Losses reduction

KPI 3.1 Continuous Power density increase kW/l (without gearbox)

KPI 3.2 Continuous Power density increase kW/l

KPI 4.1 Continuous Power density increase kW/kg (without gearbox)

KPI 4.2 Continuous Torque density increase Nm/kg

KPI 5. Use of rare earth resources reduction

KPI 6. Recyclability rate

KPI 7. Processes for economic recycling of CRM

KPI 8. Reduction in GWP in Rare Earth Elements

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Results presentation

Key exploitable results

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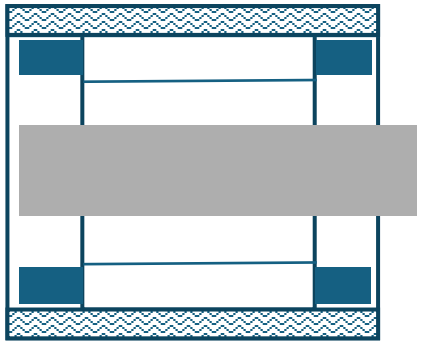
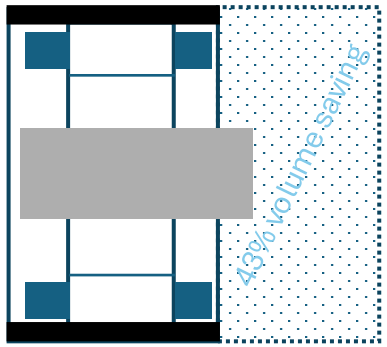
KER 1: Next generation eMotor

- Prototypes for two vehicle segment have been designed:

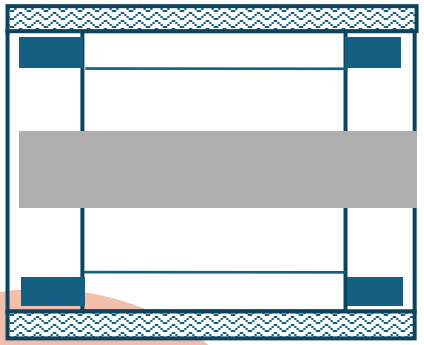
Fiat 500e motor



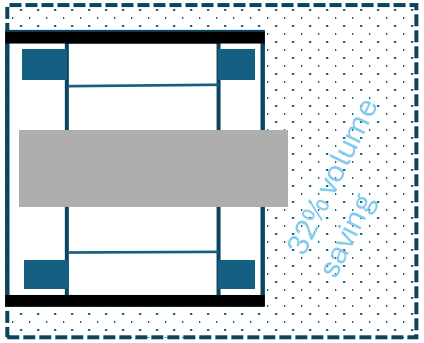
HEFT A+B motor



VW ID4 motor



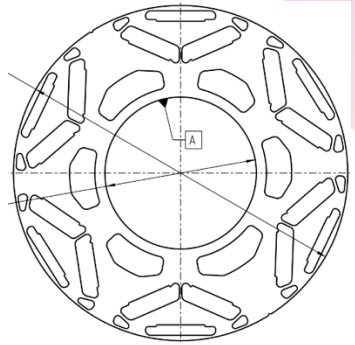
HEFT C+D+E motor



A+B HEFT motors savings VS Fiat 500e motor

- ✓ 59.74 % weight saving
- ✓ 43% volume saving
- ✓ 60% REE saving
- ✓ 170% increase of maximum continuous power
- ✓ 55,57% increase of continuous torque

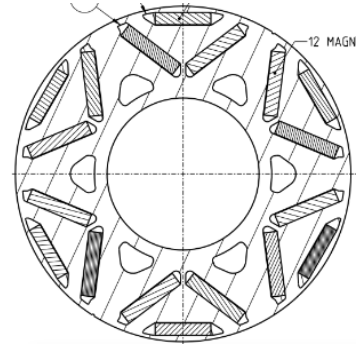
HEFT A+B motor design $7,32\ kw/kg$



C+D+E HEFT motors savings VS VW ID.4 motor

- ✓ 59.86% weight saving
- ✓ 32% volume saving
- ✓ 58% REE saving
- ✓ 129% increase of maximum continuous power
- ✓ 36,94% increase of continuous torque

HEFT C+D+E motor design $7,03\ kw/kg$



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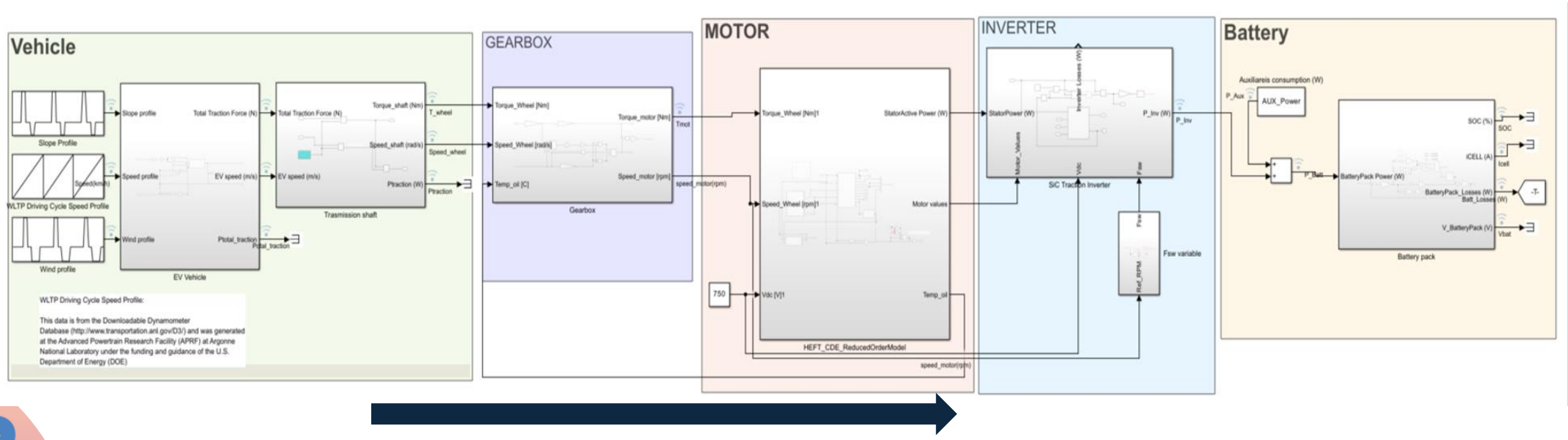
KER 1: Next generation eMotor

- Digital twin
  - Objective: to provide the correct thermal characterization of the eMotor to avoid early deterioration or failure and estimate efficiency of powertrain components
  - Estimate components temperatures in critical points Target is to maintain the eMotor in the temperature range desired to avoid shortening the lifespan of the machine.



Power transfer unidirectional in EV, from the wheel to the motor

KER 2: Permanent magnets with REE reduction or recycled magnets

- Manufacturing of new magnets by Magneti:
  - Manufacturing of N38H magnets from recycled magnets. 
  - Manufacturing of N38H magnets with Cerium 
  - Manufacturing of N42SH (ongoing)
    - Without GBD requirements are hard to achieve
    - Some samples done with GBD but we have barriers to get the equipment.

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KER 3: Advanced Rotor/Stator sub-systems

- Magnet overmoulding, plastic housing, centrifugal and spray oil cooling, continuous winding

Manufacturing of Stators (UoN)

Ongoing

Over-moulding of Stators(SUMIBE)

Manufacturing of Wave Winding Stators (UoN)

Production of Housings (SUMIBE)

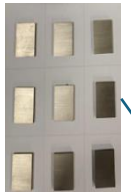
Ongoing

Manufacturing of Components (MGEP)

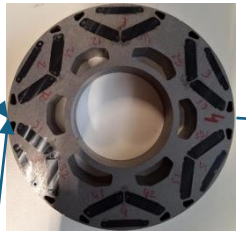
Completed

Manufacturing of Rotor (MGEP)

Magnet Production (MAGNETI)

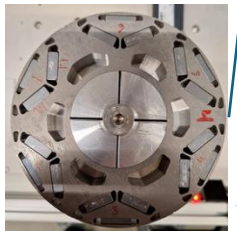


Fixing Magnets (SUMIBE)



Assembly of Rotors (MGEP)

Rotor Stacks (MGEP)



A-B Completed

C+D+E Ongoing

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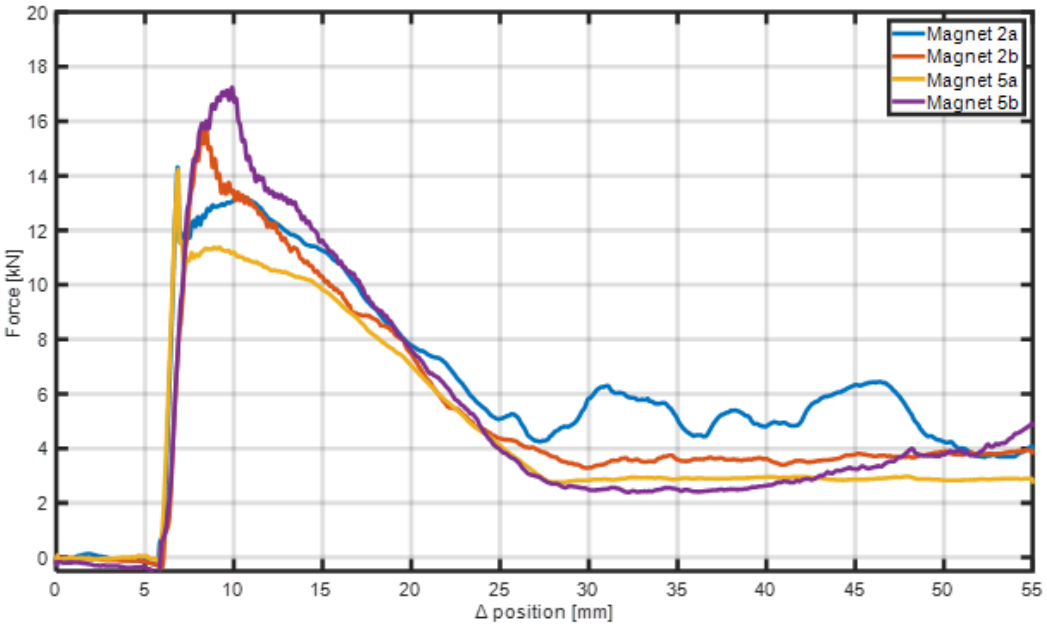
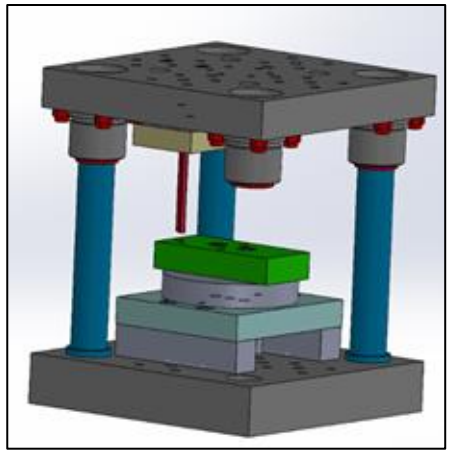
KER 4: Processes for Dismantling/ Reuse or recycling magnets.

- Tool for extraction designed and process for extractions set
  - The rotor is placed in an oven at 300 °C for 1 hour.
  - Aim to degrade the magnet and epoxy (magnet fixation) to facilitate removal.
  - Magnets are extracted in cold after the degradation process (using a 100 kN hydraulic press).
  - Magnets are easily removed from the rotor but coated with adhesive. Chemical cleaning





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Mid to long term expected impacts of the project

Horizon-CL5-2022-D5-01-09 topic outcomes (TO) and impacts

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Mid to long term expected impacts of the project

- TO1. Lower cost, higher efficiency and power density electric motors for mass produced cars and vans, with a design-to-X approach enabling easy dismantling and recyclability and a reduced use of (rare) resources through the development or application of alternative materials or advanced configurations.
  - Stator manufactured in an Automatic manufacturing line for **continuous winding.**
  - **Design tools** to maximize the KPIs.
- TO2. Lower electric vehicles (EV) cost and improved range.
  - 800 V system to improve range of EV.
  - **Optimized control** and **digital twin** to minimize losses.
- TO3. Improved motor design and development processes, considering a full product life-cycle assessment in a circular economy environment.
  - **Direct reusing** magnet route: magnets extraction is technically feasible
  - Direct **recycling route:** End-of-life magnets have been recycled in order to produce new magnets with a magnetic grade of N38H.
- TO4. European job creation/retention.
  - Job retention: designing and **manufacturing electrical motors in Europe.**
  - Job creation: **New business models** and companies in the **circular routes of reusing and recycling magnets**

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Mid to long term expected impacts of the project

	A+B vehicle	C+D+E vehicle	Impact
KPI 1. Motor Cost reduction	> 25%	> 25%	**TO1, TO4**
KPI 2. Motor Losses reduction	20 %	20 %	**TO1, TO2**
KPI 4.2 Continuous Torque density increase Nm/kg (motor & gear box)	34.25 Nm/kg (call target >20 Nm/kg)	44.74 Nm/kg (call target >20 Nm/kg)	**TO1**
KPI 5. Use of rare earth resources reduction	60%	58%	**TO3, TO4**

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