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Electric Vehicles  
GA No. 314252



**OPTIMORE**  
**Optimised Modular Range Extender for every day customer  
usage**

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## Contents

1	Project context and objectives .....	3
1.1	Context .....	3
1.2	Concept and objectives.....	3
2	Work performed and main results achieved .....	3
2.1	Commercial Vehicle moving to efficiency in real driving cycles and approaching industrial sustainability .....	3
2.2	Modular Electric Range Extender vehicle .....	4
2.3	City Electric Vehicle.....	4
2.4	Functional Safety Development.....	4
2.5	Optimization of range extender, battery size and control for different vehicle niches	5
3	Expected final results and their potential impacts.....	5
4	Acknowledgment.....	5

# 1 Project context and objectives

## 1.1 Context

Worldwide, there is a strong trend towards highly efficient, low (preferably zero) emission vehicles, *i.e.* electrical vehicles. Electric Vehicles are able to cover almost 80% of average travel needs. However, many vehicle users require occasional longer distance travel capabilities of their vehicle. To relief this so-called “range anxiety”, there is a need for advanced plug-in hybrids and electrical vehicles with range extenders for regular customer duty. For this purpose, *highly efficient, compact, clean and low cost engines* are developed in this project

OptiMoRE focuses on solving and overcoming well known shortcomings of BEVs and further develops and optimises the range extender concepts from FUEREX (closed FP7 project) results and experiences, thereby providing an important path towards customer acceptance of electrified vehicles and increasing the market penetration.

## 1.2 Concept and objectives

Three different RE concepts of OPTIMORE will be developed and demonstrated to serve the niches from city vehicles over medium sized passenger cars up to light commercial vehicles.

The **CONCEPT** of **OptiMoRE** is based upon the following major elements:

1. Definition of real world driving conditions (driving cycles and comfort requirements) as a baseline for further optimisation and EV assessment
2. Optimisation of components and the whole RE system regarding emission, fuel consumption, cost, weight and exhaust gas after-treatment
3. Modular setup of an EV concept to fulfil a wide range of customer expectations
4. Advanced control strategies as a key for cost reduction and system optimisation
5. Functional and Electrical safety analysis and concept development to define measures necessary according to the ISO 26262 standard
6. Build-up and optimisation of three technology demonstrator vehicles covering EV aspects for delivery trucks, all-purpose vehicles and city cars.

# 2 Work performed and main results achieved

## 2.1 Commercial Vehicle moving to efficiency in real driving cycles and approaching industrial sustainability

The OPTIMORE engine configuration starts from the basis achieved in the FUEREX project, moving towards reducing cost and weight (industrial sustainability) and improving efficiency in real driving cycles: from this point of view the OPTIMORE engine is a twin cylinder gasoline one, natural aspirated version. The vehicle targets defined three main working points for the Range Extender: 20, 15 and 10 kW of electrical power at battery terminals.

In order to improve the performance of the NA engine adopted in the project, design activities have been carried out in order to optimize the compression ratio, intake and exhaust manifolds and intake MultiAIR® valve lift profile.

Next to the ICE development the following items have been under investigation:

- Electric machine design and integration,
- Cooling circuit design,
- Overall system energy balance evaluation,
- Flow chart and algorithms for APU control definition.

## 2.2 Modular Electric Range Extender vehicle

The OPTIMORE drivetrain starts from using the FUEREX ICE, rebuilding the engine to direct injection, overcharged with a turbo, change of electrical architecture to V60, control systems and transmission. The rear mounted installation to the right, which is originated from a tunnel battery and front assembled battery has been replaced by a front mounted ICE and integrated e-motor in front, instead of the rear modular approach.

### Functional Requirements Description

Functional Requirement documents for each Use-Case of the drivetrain, both hybridized and normal DCT functionalities have been aligned between all involved control units.

## 2.3 City Electric Vehicle

The tasks started at the beginning of the project with the aim to define and optimize the system layout of the city car under real world conditions. The definition of technical requirements is based on the current status which has been generated by the project FUEREX. The requirements have been extended and refined regarding drivability, fuel consumption, emissions, cost and NVH. All of these requirements have to be considered under the light of real world conditions as defined by a "Real World Driving Route".

To improve fuel consumption, exhaust gas emissions, NVH behavior and durability, main components of the range extender unit have been further developed:

- Active damping to avoid vibrations on the gearing and to reduce operating noise of the REX.
- Additional acoustic shielding at and around the RE as well as the exhaust gas system to reduce noise and to protect the whole system from thermal excess load,
- High voltage components to improve durability and to reduce costs.

Furthermore, an offline simulation environment for the whole vehicle has been established, parameterized and validated as a pre-requisite for final component and vehicle software optimization regarding emissions, fuel consumption and comfort.

## 2.4 Functional Safety Development

The deliverables *Item Definition*, *Hazard and Risk Analysis*, *Generic System FMEA* were completed.

The created deliverables form the basis for the final *Functional Safety Concept*, in which final safety requirements will be defined to be applied to the range extender electric vehicles (RE-EVs) with high voltage energy storage systems.

## 2.5 Optimization of range extender, battery size and control for different vehicle niches

This section describes the global minimization problem considered where a number of vehicle types,  $N$ , should be designed for a group of drivers so that each driver choose one type of vehicle and the total cost for all the drivers is minimized. This method can be used to select relevant driving cycles for several possible design situations.

The method has been implemented in Matlab and it is available as a ready-to-use tool. The tool allows for a fast modification of the input parameters, which facilitates performing robustness analysis of how the results change when varying the input parameters (e.g. battery price, number of vehicle niches).

## 3 Expected final results and their potential impacts

OPTIMORE delivers solutions for both short and medium term that have large impact in terms of volume (market segments and number of vehicles) and ecological footprint (reduced (CO<sub>2</sub>) emissions, well to wheel efficiency, optimised weight and costs, etc.).

Although OPTIMORE has its focus on the application in battery electric vehicles with range extenders rather than on plug in hybrids, there are many similarities between range extenders for battery vehicles and plug in hybrids.

It is therefore safe to say that OPTIMORE has an impact in accelerating the sales in both EV and PHEV markets with a focus on sub-compact passenger cars and light duty commercial vehicles. The reason for focussing also on this particular segment is the expected dramatic increase of freight transport inside high concentration urban areas during the next decade. For its specific mission profile this kind of vehicle can, of course, get the maximum benefit from the electric driving mode (noise, vibration, pollution, frequent stop&start situations) while the Range Extender approach will supply a higher flexibility in terms of fleet management.

Market introduction of RE-BEV's will be accelerated directly by the OPTIMORE auto manufacturers Volvo Cars and the FIAT group (represented by IVECO) but also through the RE engineering in the AVL group that will supply other car manufacturers with integrated RE solutions. Obviously, both exploitation routes will have beneficial effects on Europe's automotive industry in terms of competitiveness and employment.

## 4 Acknowledgment

	<p>This project is co-funded by the 7th FP (Seventh Framework Programme) of the EC - European Commission DG Research</p> <p><a href="http://cordis.europa.eu/fp7/cooperation/home_en.html">http://cordis.europa.eu/fp7/cooperation/home_en.html</a></p> <p><a href="http://ec.europa.eu">http://ec.europa.eu</a></p>
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