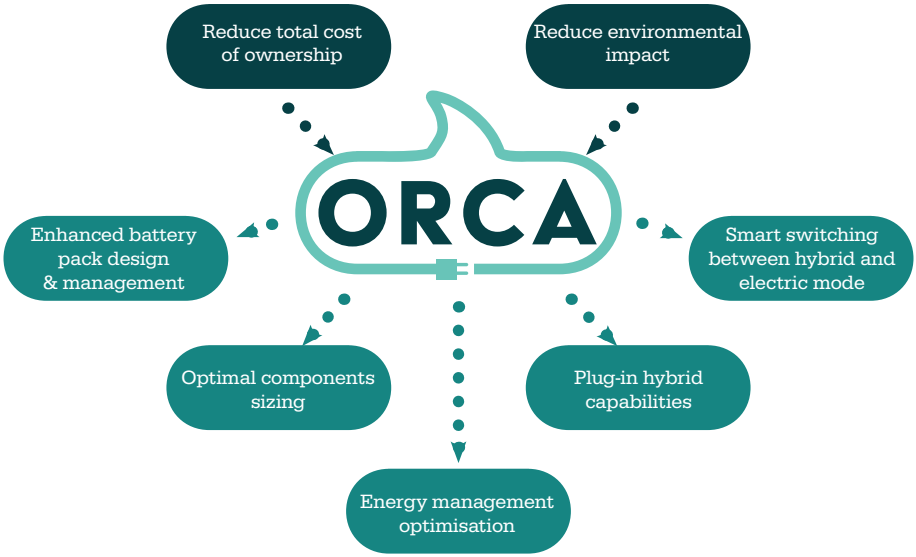
ORCA

FURTHER GREENER BETTER

Optimised Real-world Cost-Competitive Modular Hybrid Architecture for Heavy Duty Vehicles



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WP1: Requirements and specifications (BOSCH)

Task 1: HD vehicle specifications, requirements and user profiles specification

Task 1.2: Investigation and selection of RES cell technologies

Task 1.3: Demonstrator validation/ verification plan

WP7: Project Coordination and Management (TNO)

WP2: Optimization Framework & Methodology (VUB)

Development of virtual simulation platform

Sizing and modelling of the different vehicle components

Optimisation of energy management strategy

Total cost of ownership and environmental impact minimisation

WP3: Prototype Multimodal Bus (IVECO)

WP4: Prototype Regional Distribution Truck (VOLVO)

WP5: Validation/ Verification & Demonstration Assessment (TNO, Manufacturers)

WP6: Dissemination & Exploitation (VUB)

Dissemination activities and actions (2016-2020)

Exploitation plans and measures (2016-2020)

Horizon2020 projects:
- Ecochamps

FP7 projects:
- Odin
- Transformers convenient
- NO Waste

Advisory Board End User Group

WP2: Optimizations Framework & Methodology (VUB)

Task 2.1 Definition of Virtual Simulation Platform

Task 2.3 Virtual Development Simulation Framework

Task 2.2 Sizing and modelling of the different components and systems

	Bus	Truck
RES technologies	x	x
DC-DC convertor	x	x
Charger	x	
Modular electrical axle		x
Waste Heat Recovery	x	
CNG	x	x

Task 2.6 TCO and LCA Optimisation Framework for heavy duty vehicles

Task 2.4 Modular Multi-level and Multi time-scale Energy Management Strategy

Task 2.5 Virtual investigation of the usage of a CNG engine instead of ICE

Further

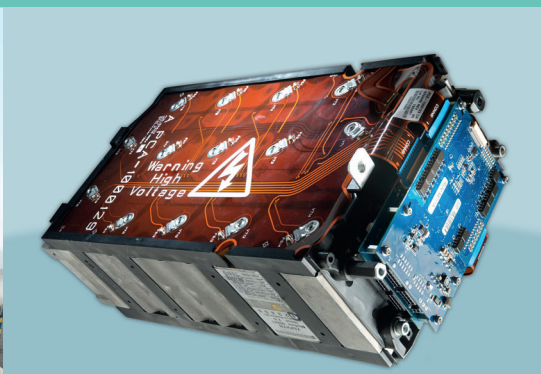
- Improve the hybrid powertrain efficiency by at least 5% compared to actual IVECO hybrid bus and conventional truck.
- Improve the electric range of (at least) 30km by adding the Plug-in capabilities and optimising the RES capacity.

Greener

- Reduce the fuel consumption by 40% compared to an equivalent conventional HD vehicle (bus & truck).
- Case study assessment to replace a diesel engine by a CNG engine for future heavy-duty vehicles.

Better

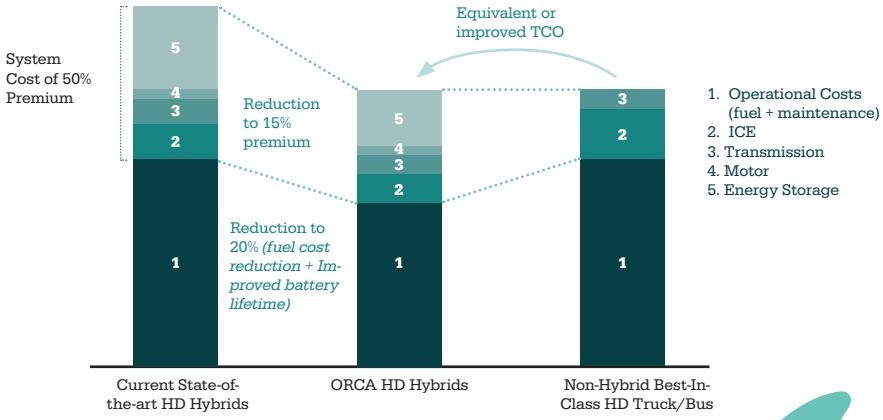
- Reduce the total cost of ownership (TCO) to the same as that of a diesel vehicle, targeting over 10% system cost premium reduction compared to actual IVECO hybrid bus and VOLVO conventional truck with the same performances, same functionalities and operative cost, and also targeting up to 10% rechargeable energy storage (RES) lifetime/energy throughput improvement.
- Downsize the ICE by at least 50% compared to reference IVECO hybrid buses and VOLVO conventional trucks.



ORCA has set itself specific targets:

- **To assess the technology development regarding efficiency, cost, weight and volume** through estimating the average TCO of dedicated conventional HD vehicles for a defined set of transport missions and evaluating the actual vehicle requirements to fulfil these transport missions. This will be the baseline for comparison.
- **To devise a modular pre-standard framework**, the ORCA project will develop a modular simulation framework performing a system co-design dedicated for a defined set of transport missions. This will allow optimising hybrid vehicle topology, component/systems sizes as well as for dedicated optimal control strategies in order to reduce the TCO up to the same diesel TCO level while taking into account a premium for hybridisation at 10%. The proposed pre-standard simulation framework will allow speeding up the optimization process of the HD vehicles up to 20%.
- **To select and optimize advanced subsystems in terms of rechargeable energy storage** (RES) technologies with higher energy and power densities and long lifetime for enabling a longer range and **to reduce the total cost of the RES system by 10%**.
- **To improve the total energy** efficiency up to 5% of the vehicle system through the advanced developed waste heat recovery technology, generic energy management and efficient RES technology.

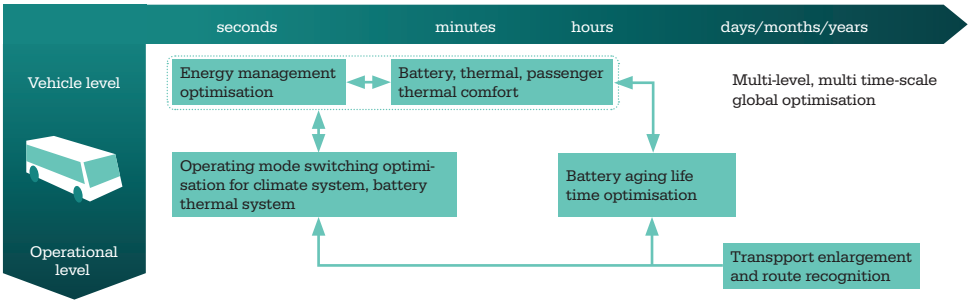
Total Cost Reduction:

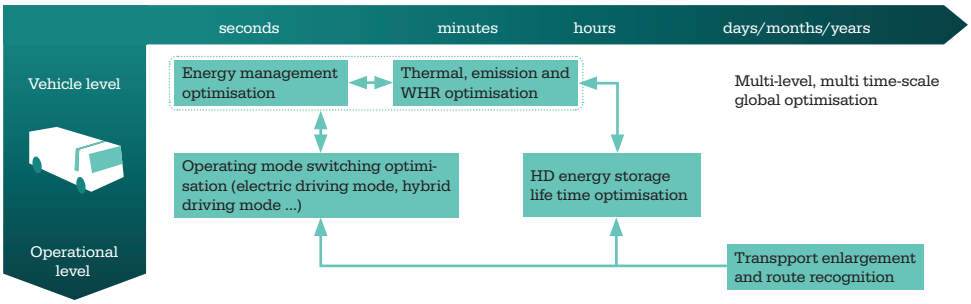


- **To select the most advanced and modular power electronics and electric motor systems** for reducing the cost and to increase the efficiency and performances of the HD vehicles.
- **To simplify the powertrain architecture, to downsize the ICE and to develop an innovative transmission for the hybrid driveline**, which will **lead to reduce the TCO** and the **associated maintenance cost by at least 5%** compared to actual IVECO hybrid bus and VOLVO conventional truck.
- **To demonstrate the key innovations** a hybrid vehicle will be used as an evaluation platform to validate the optimal system co-design solution by altering/emulating the components sizes, and in addition to implement the model predictive optimal control strategy based on the outcome of the system co-design.
- **The validation of ORCA solution will be done by two different demonstrators:**
  - Multimodal Hybrid Bus
  - Distribution Truck

Achieving these key innovations at affordable cost will significantly strengthen the **European** technical and technological **leadership in the value chain of heavy-duty vehicles**, enabling a leading position in this crucial field of hybridised vehicles and increasing the competitiveness of European heavy-duty road vehicle manufacturers and suppliers.

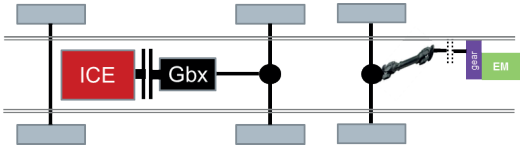
It is foreseen that the technology will be ready for its first market introduction beyond 2021.



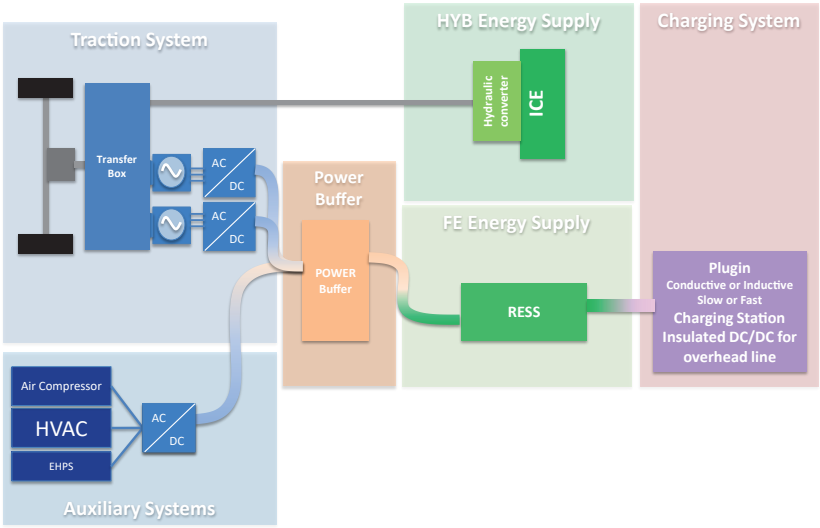


Two principal approaches will be combined to realize the ORCA Project innovation:

The first addresses higher levels of hybridization/electrification through improvements in HD rechargeable energy storage using advanced, modular and scalable technologies, and with ICE range extender optimization/downsizing to simplify the transmission complexity via usage of advanced and standardized subsystems.

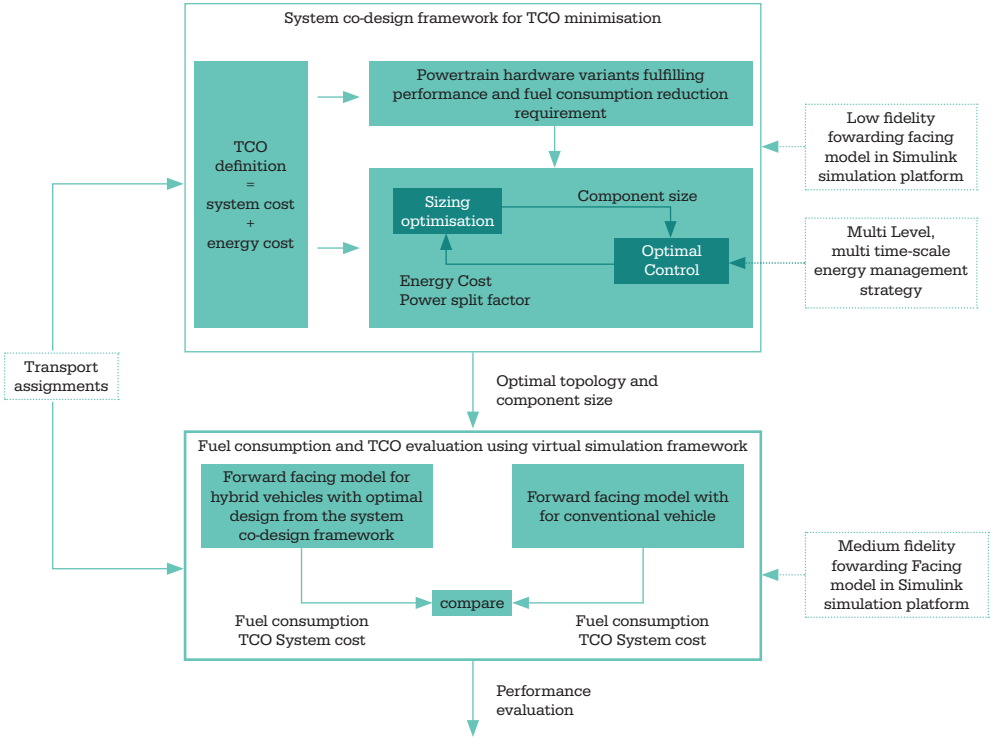


Volvo distribution truck topology



Multi-Modal Bus Architecture

The second focuses on the development of a modular, scalable and systematic optimization strategy (considering operational conditions of the vehicle, the hybrid powertrain design and control strategies as well as the operational lifetime of the HD rechargeable energy storage) in order to generate more synergetic functions and functionalities on the entire vehicle level, in particularly where TCO reduction is possible across vehicle applications in real world operation.



Energy management

Development of innovative energy-management control strategies that are capable of optimizing the power/energy flow between synergy energy buffers (thermal, RES ageing, emissions) in the hybrid HD powertrains.

These strategies will take into account: key parameter variations of RES technologies (SoC, SoH, Temperature, etc.), emissions, thermal dynamics of the ICE, WHR and thermal comfort of the passengers (for bus applications).

Within the research activities, the developed energy management strategies will go beyond the state-of-the-art by also incorporating the transport assignment and route recognition to achieve a minimum TCO for a certain HD missions.
The strategy will be realized using Multi-horizon Predictive Integrated-Energy Management (MP-IEM) that helps us to deal with a wide range of operating conditions and with different time-scales of the component dynamics behaviour.
These control strategies will allow us to cope with the nonlinearity of the dedicated powertrains and to find both off-line and online global optimal solutions at different load conditions and system state constraints.

Advanced simulation framework

To enhance the performance of the hybrid heavy-duty (HD) vehicles, the powertrain and its components need to be optimized for both design and control.

A virtual simulation framework has therefore been developed to enable simulation of the hybrid HD powertrain(s) with various configurations and component sizes. This is done to offer the capability of analyzing the potentially maximum fuel and the TCO reduction performance of the corresponding hybrid HD powertrains. Moreover, using the developed virtual simulation framework, an integrated optimal design approach is formulated to minimize the relevant HD powertrain TCO via optimizing the powertrain components size and control. The developed simulation framework includes a library of relevant components for (hybrid) HD vehicles. The powertrain components models are scalable regarding power and/or energy capacity level. Moreover, thanks to the interface standardization, the powertrain components can be easily integrated.

The developed simulation framework plays a significant role for the development of the modular multi-level and multi time-scale energy management strategy, the TCO analysis and the Life Cycle Assessment (LCA) optimization framework. Furthermore, it will be used to verify the potential fuel reduction and TCO reduction of the hybrid multimodal bus and distribution truck.

Coordinator:
Ir. Rene Corbeij
TNO
rene.corbeij@tno.nl
+31 (0)88 866 57 90

Back office:
Eva Flora Varga
Vrije Universiteit Brussel
info@h2020-orca.eu
+32 (0)473 670 167

coordination: TNO

our partners: VUB Vrije Universiteit Brussel, Volvo, Iveco, CRF Centro Ricerche Fiat, Bosch, Fraunhofer LBF, Altra, JSR Micro, Valeo