

KEYTECH4EV

Development and Demonstration of Key Technologies for Low-cost Electric Vehicle Platforms

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STATE OF THE ART



Hyundai ix35



Toyota Mirai

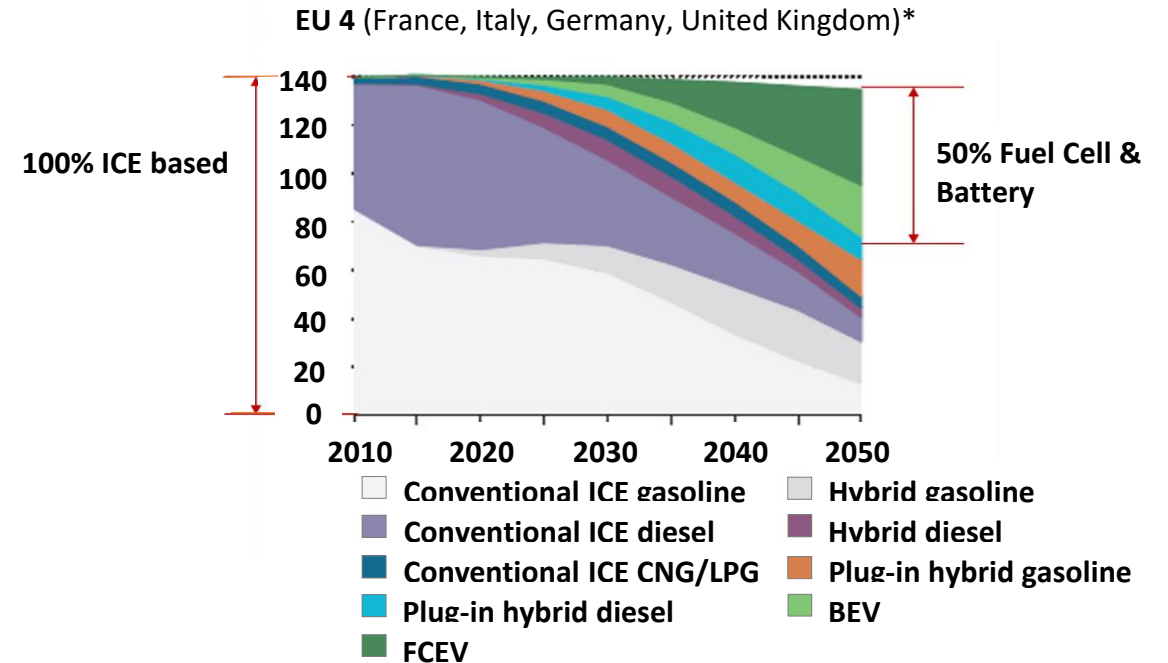


Honda Clarity

2015 was the turning point of automotive history

Asian OEMs have been massively dominant in fuel cell automotive technology

MOTIVATION



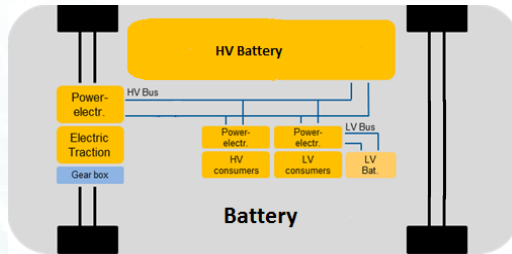
Market Penetration Study for Fuel Cell & Battery in EU 4 shows:

- ✓ Market shares of around 10% in 2030
- ✓ Market shares of around 50% in 2050

It is of particular importance for Europe to catch up with Asia regarding fuel cell automotive technology

Bandwidth EV - FCV

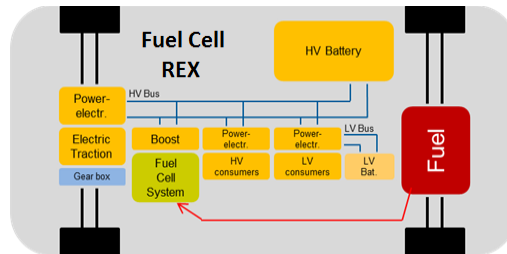
Battery Electric Vehicle



e-Golf

- Very big battery
- Short range
- Long charging time

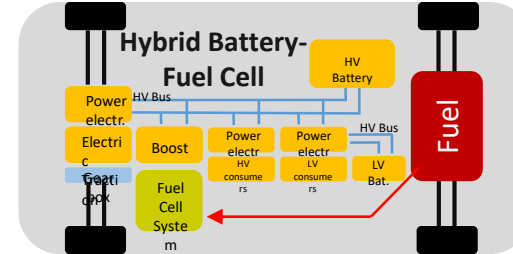
Range Extended Vehicle



FEV concept car

- Big battery (10.5 kWh)
- Small FC (<30 kW)
- Limited drivability

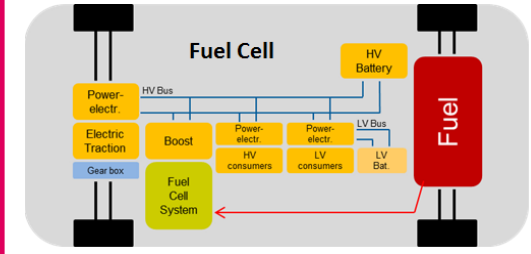
Hybrid Battery-Fuel Cell Vehicle



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- Medium size battery (~8 kWh)
- Medium size FC (~50 kW)
- Long range & High performance
- Short refueling
- Cost reduction compared to BEV & FCV

Fuel Cell Vehicle



Toyota Mirai

- Very small battery (1.6 kWh)
- Big FC (114 kW)
- Long range
- Short refueling

KEYTECH4EV THE FIRST AUSTRIAN FUEL CELL PASSENGER CAR

PROJECT CONSORTIUM



KEYTECH4EV GOALS



Goals

Increasing the energy efficiency
<100MJ/100km WTW

Vehicle range
Above 500km

Reducing the cost
15% reduction of powertrain cost

Increasing the durability
Reduction of FC degradation

Drivability
Identical to series type vehicles

CO₂ balance
Zero CO₂ g/km

KEYTECH4EV Approach

- Optimize FC powertrain & operating strategy (WP2 & 6)
- Optimize FC stack & **energy management** (WP4 & 6)
- Lowest possible vehicle weight & **maximum amount of H₂** storage (WP5 & 8)
- Optimize FC stack design (WP4)
- **Optimize system control** (WP7)
- Optimize FC powertrain (WP2)
- **Benchmark** against commercially available vehicles (WP9)
- Well-to-wheel **zero emission** (hydrogen produced from renewable energy)

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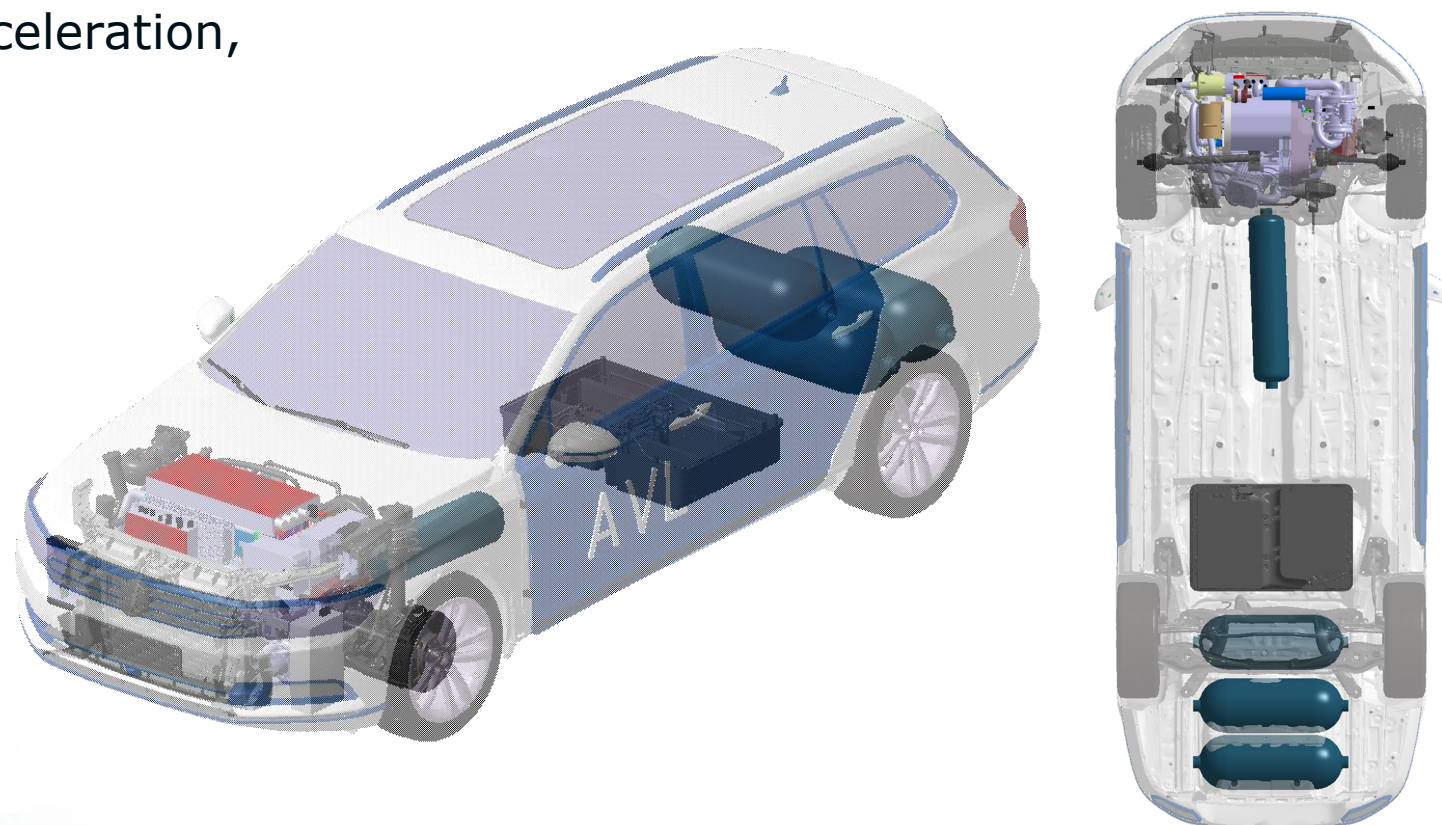
Vehicle specifications



Vehicle Concept

- ~70 kW fuel cell (scaled for top-speed and intended climbing performance)
- ~10 kWh battery (scaled for max. acceleration, boosting and good drivability)
- ~5 kg H₂ for 600 km range

Vehicle platform	VW Passat GTE
Vehicle curb weight	1746 kg
Vehicle gross weight	2182 kg
Battery size	9.9 kWh
Battery power	85 kW
Battery weight	125 kg
Fuel cell system power	~55 kW
e-drive power	100 kW
Hydrogen tank capacity	5.3 kg
Number of tanks	4
Hydrogen refilling time	approx. 3 min
Hydrogen consumption	0.8 kg /100 km
Driving range	>600 km



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55 kW AVL PEM FC System



~70 kW NM5 **fuel cell stack**
(ElringKlinger)

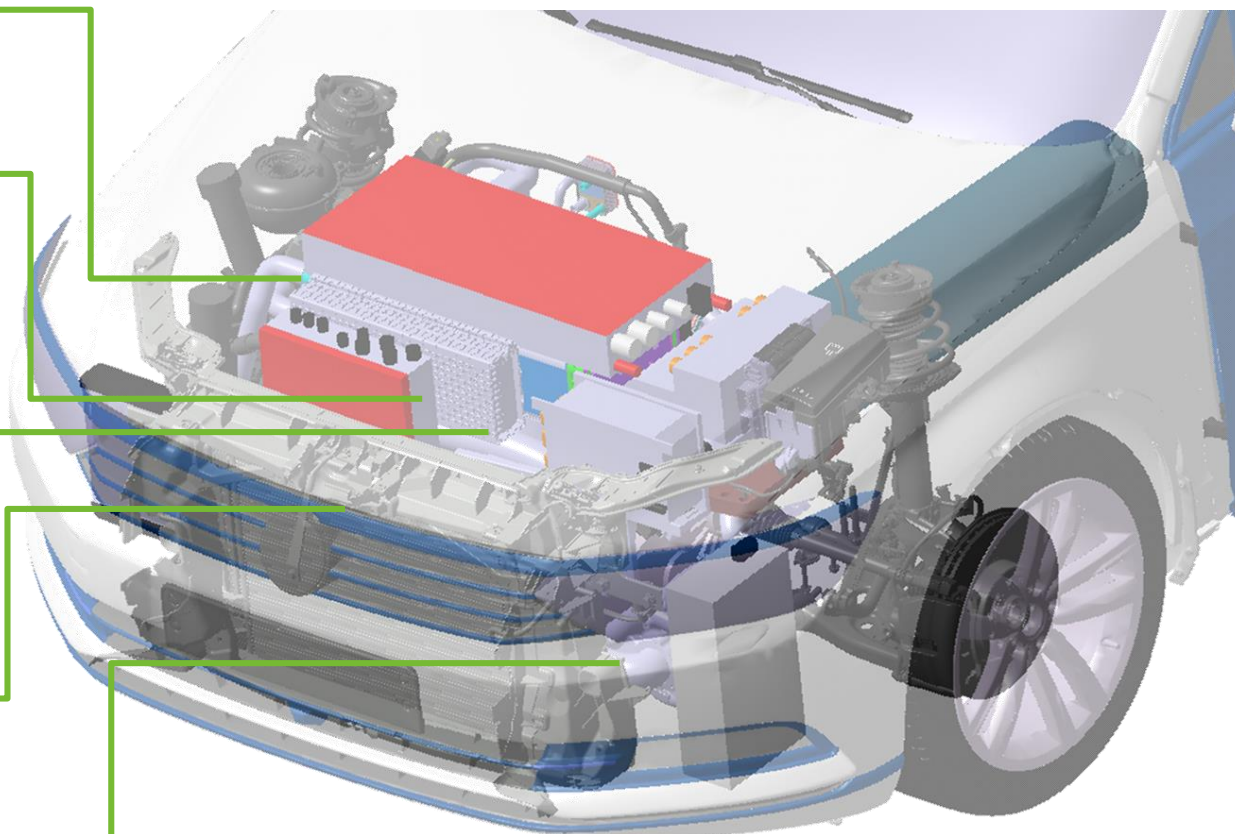
Passive anode recirculation
(Hoerbiger & HyCentA)

FC control unit & monitoring
(AVL)

- State of health
- AVL THDA methodology
- AVL RPEMS, SW & HW

Optimized heat management to avoid de-rating (AVL & IESTA)

FC air compressor
(Honeywell)



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Hydrogen tank system



Newly developed center tunnel hydrogen storage vessel

(MAGNA Steyr Engineering)

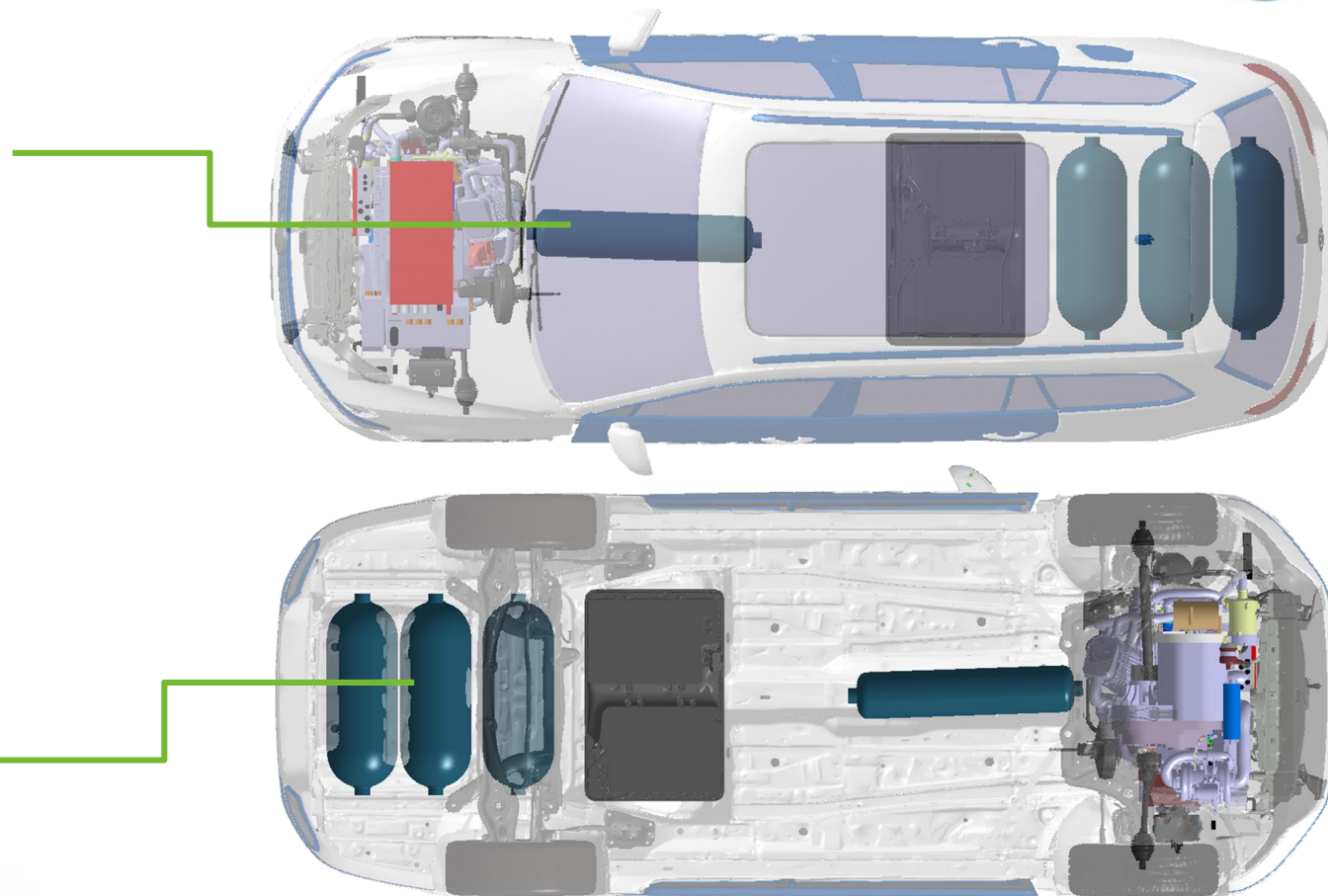
1x 22 NL = 0.9 kg H₂

- Cost effective design of composite vessel
- Reduced complexity of hydrogen storage for faster assembling & manufacturing
- Plastic liner as hydrogen permeation barrier
- Advanced winding process
- Integrated components (tank valve unit)

Commercial hydrogen storage vessels

(MAGNA Steyr Engineering)

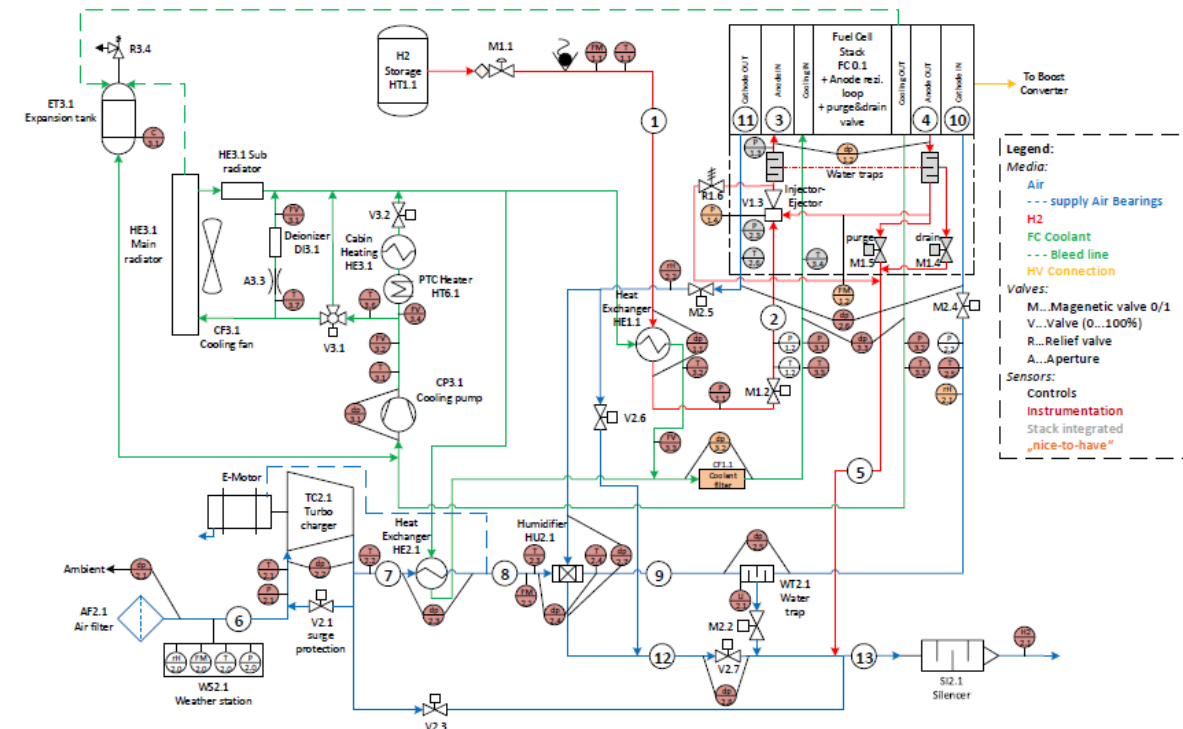
3x 36 NL = 4.4 kg H₂



KEYTECH4EV Fuel cell system



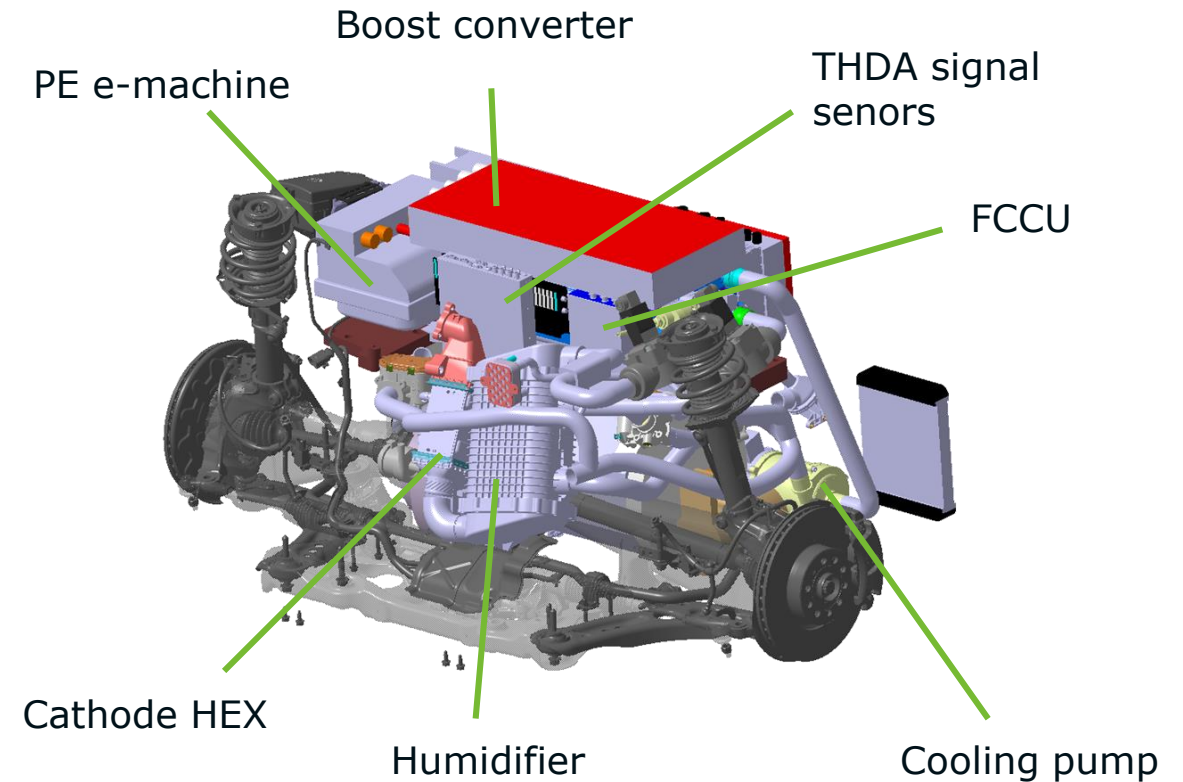
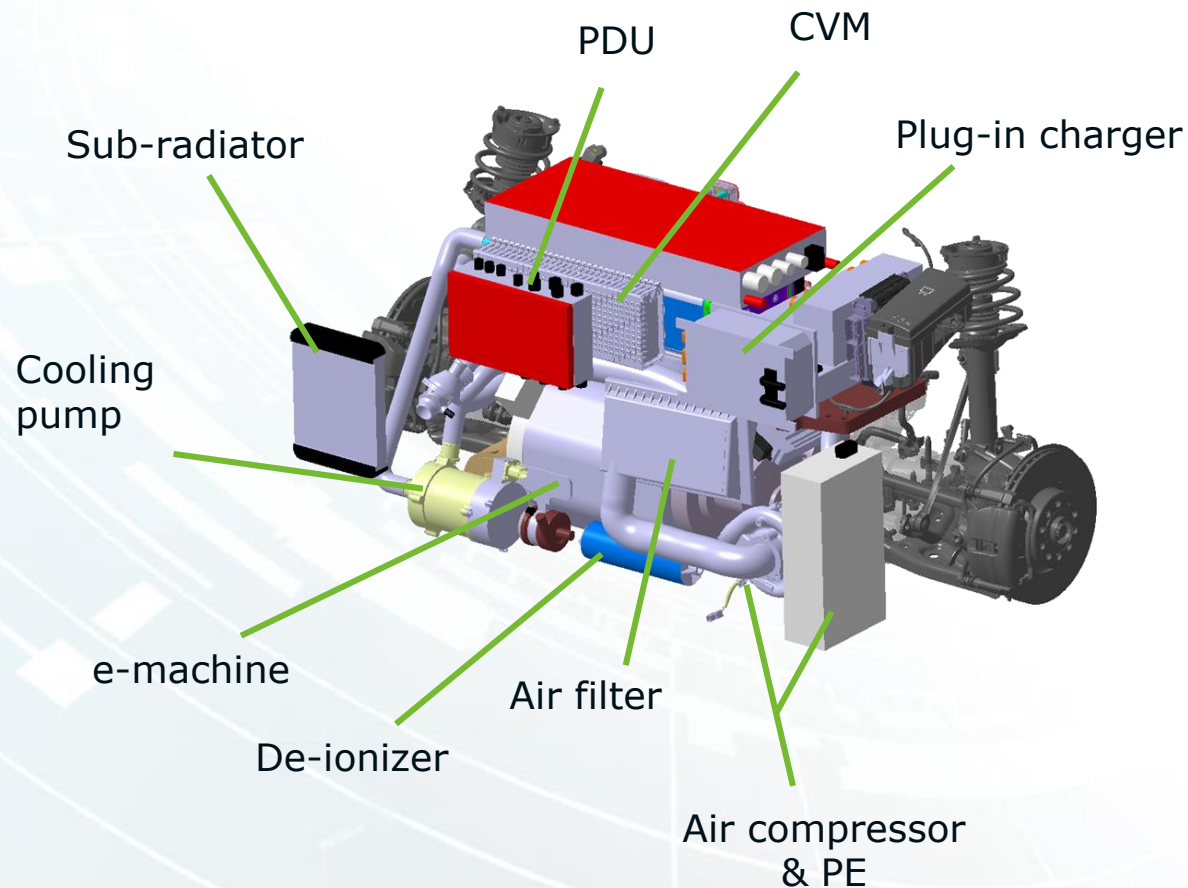
- **System simulations** for component selection were completed
- Continuous **system optimization** with AVL CAMEO
- **Operation management** definition
 - Start-up
 - Shut-down
 - Freeze start-up
 - Freeze shut-down
 - Emergency stop
- **Component selection and supplier identification**
 - RFQ – ongoing
- **Packaging of FC system** for vehicle integration first loop completed



KEYTECH4EV Fuel cell system



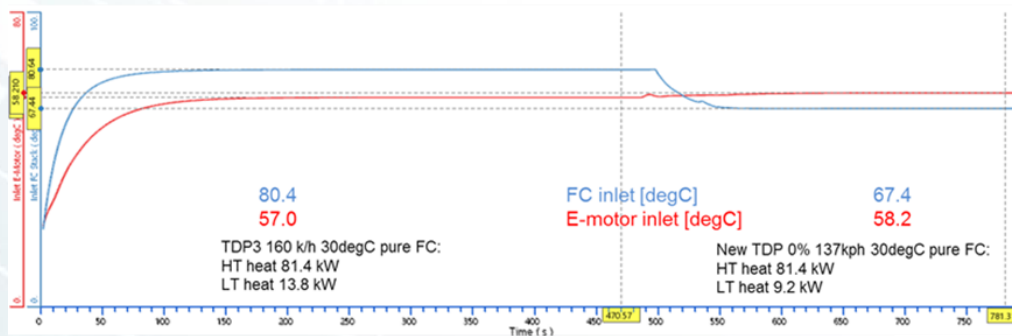
- **Packaging of FC system** for vehicle integration first loop completed
- **Identical layout for testbed** to achieve same behaviour



KEYTECH4EV Thermal management system

- **Optimization of thermal management system** concept in terms of hydraulic and thermal performance is under investigation
- **High temperature cooling circuit**
 - FC Stack
 - Anode HEX
 - Cathode HEX
 - Deionizer

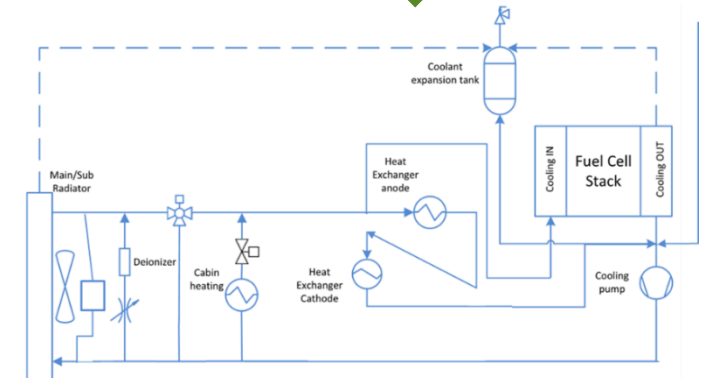
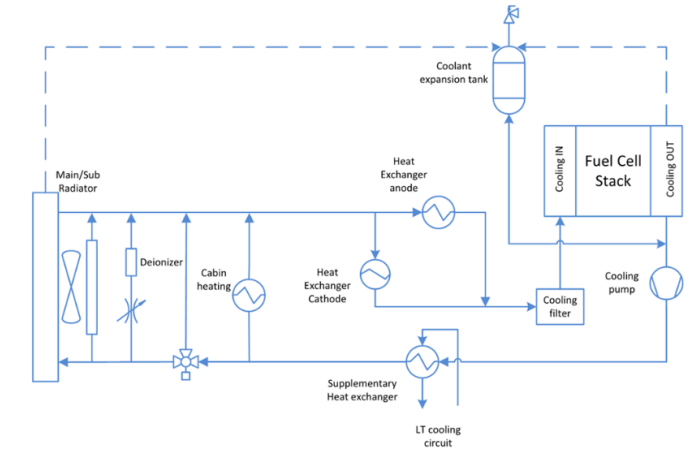
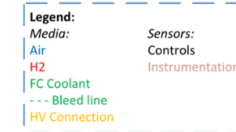
- Simplified (air mass flow through heat exchangers assumed) transient simulation for two Thermal Design Points (TDPs)



- It is clear that the TDP1 is the most critical for the HT circuit due to high heat input and low vehicle velocity resulting in low radiator air massflow



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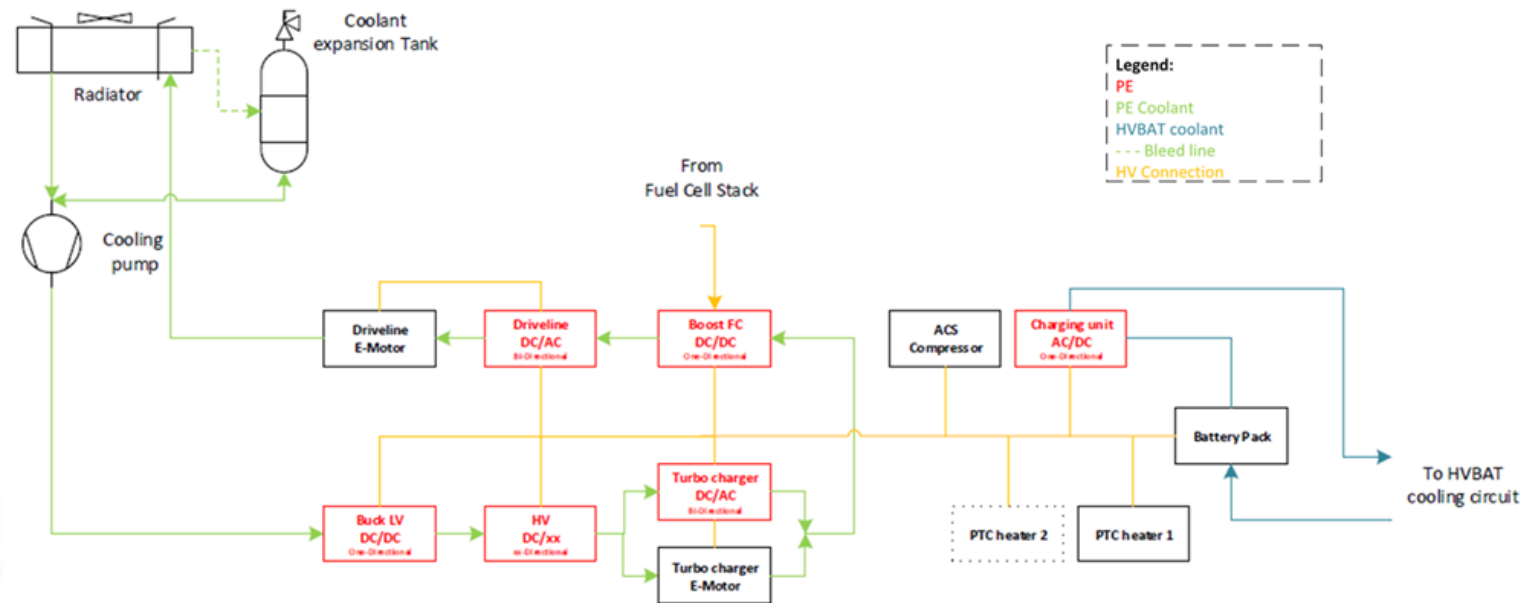


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Thermal management system



- **Optimization of thermal management system** concept in terms of hydraulic and thermal performance is under investigation
- **Low temperature cooling circuit**
 - E-Motor
 - Traction inverter
 - Boost converter
 - Compressor e-motor
 - Compressor inverter

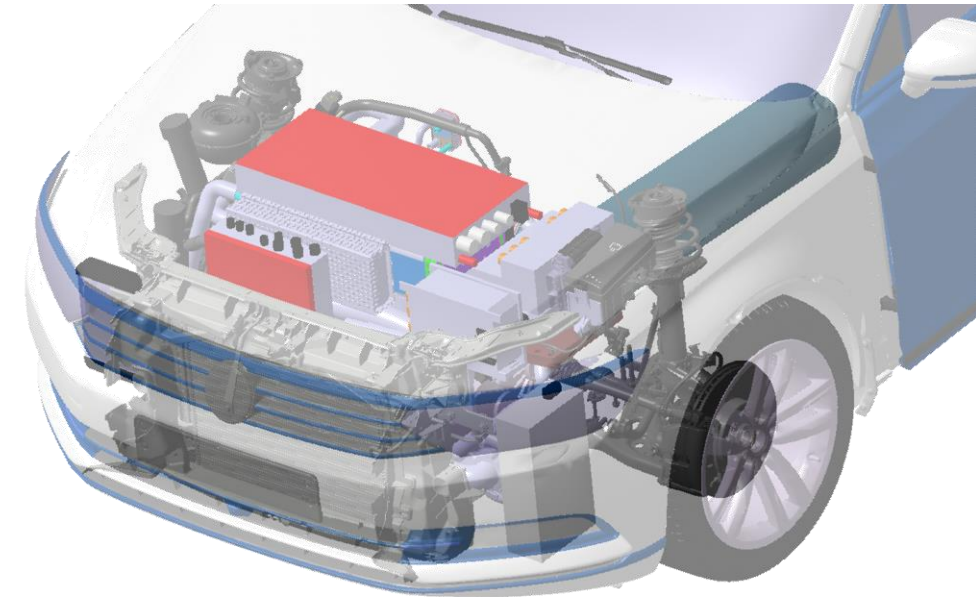


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Next steps



- **Final FC system packaging for vehicle** (AUG-2018)
- **Built-up of testbed FC system**
(full size FC system, start JUN-2018)
 - Calibration
 - Extensive testing of sub-systems and components
 - Optimization of operating strategy for increased lifetime and high efficiency
- **Vehicle integration** (start OCT-2018)
 - Installation of FC system in OCT 2018
 - first vehicle tests until end of 2018
- **Optimisation** (2019)
 - Calibration
 - Extensive testing
 - Optimization of operating strategy



KEYTECH4EV Summary



- **KEYTECH4EV** is a project to build the first Austrian hybrid battery - fuel cell passenger car
Consortium: AVL, Hörbiger, Magna, Elring Klinger, TU-Wien, TU-Graz, HyCentA, IESTA
- **Completed Works (1st year)**
 - System simulations for component selection
 - Packaging of FS-system for vehicle integration
 - Design of testbed layout
- **Plan for 2nd year**
 - test of FC system on testbed
 - installation of FC-system into vehicle
 - first vehicle tests until end of 2018
- **Optimisation in 3rd year (2019)**
 - Calibration
 - Extensive testing
 - Optimization of operating strategy





Thank You



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