Clean Hydrogen Construction & Mining Machines

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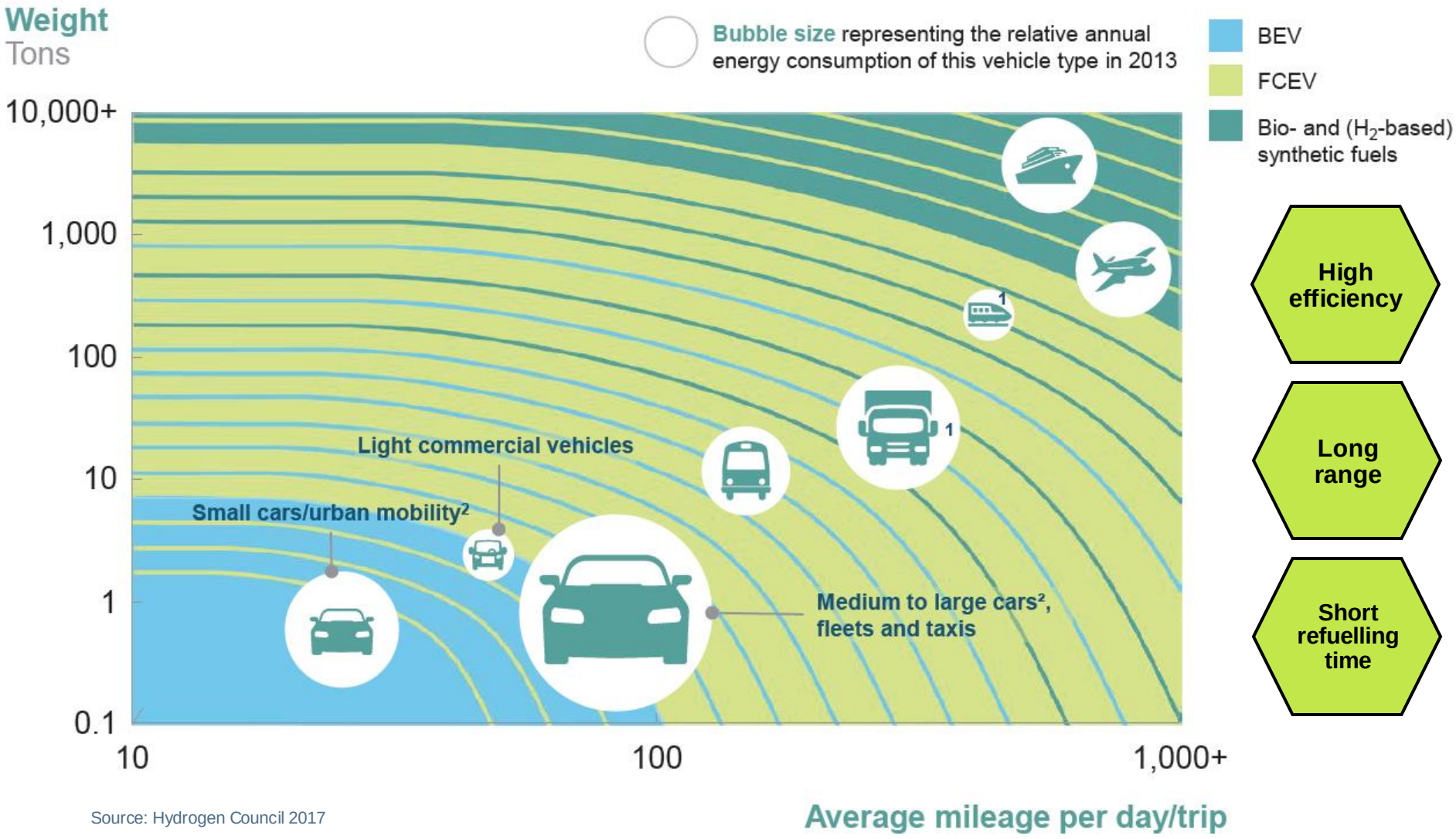
HYDROGEN CENTER AUSTRIA

Hy.CoMM

H_2 in Mobility



Source: Hydrogen Council 2017

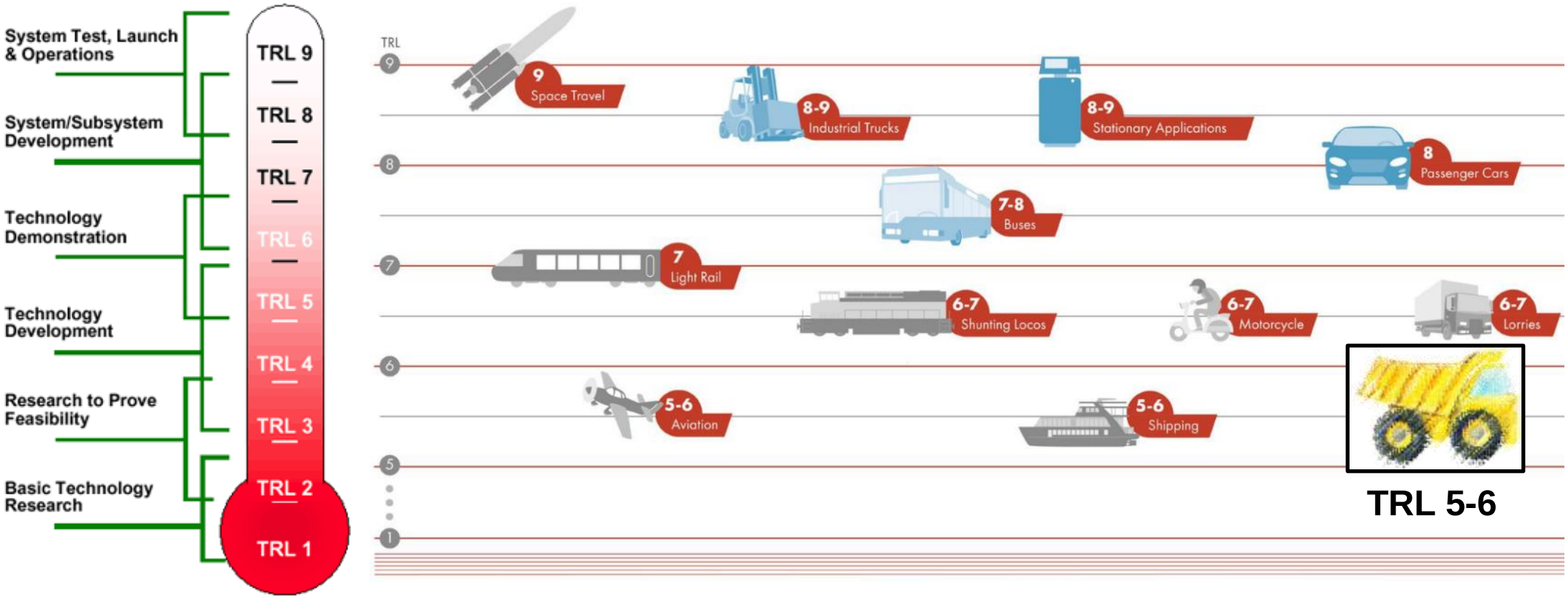
High efficiency

Long range

Short refuelling time

H_2 in Mobility

- Technology Readiness Level



Source: Shell, The Shell Hydrogen Study: Energy of the Future

Overview of FCE Vehicles

Typ	Tractor	Tractor	Tractor	Excavator	Excavator	Excavator	Dump Truck	Dump Truck	Dump Truck	Dump Truck	Dump Truck	Mixer Truck
Company	New Holland	Kubota	Fendt	Terberg Techniek	Komatsu	Hyundai	Weichai	SANY	Anglo American	Volvo	Komatsu	SANY
Maturity Level	Prototype	Prototype	Prototype	Prototype	Concept	Prototype	Prototype	Prototype	Prototype	Prototype	Prototype	Prototype
Presented	2011/2020	2023	2023	2023	2023	2022	2019/2021	2020	2022	2022	n/A	2020
FCS Power	100 kW	74 kW	n/A	50 kW	n/A	n/A	800 kW	n/A	800 kW	100 kW	800 kW	n/A
Battery Capacity	12 kWh	n/A	n/A	n/A	n/A	n/A	n/A	360 kWh	1200 kWh	n/A	1100 kWh	360 kWh
Battery Power	50 kW	n/A	n/A	n/A	n/A	n/A	n/A	n/A	2000 kW	n/A	n/A	n/A
E-Motor Power	200 kW	n/A	n/A	n/A	n/A	100 kW	n/A	n/A	n/A	n/A	n/A	n/A
FCS Supplier	Nuvera	n/A	n/A	Zepp. solutions	Toyota	n/A	Ballard	REFIRE	Ballard	Powercell	Ballard	REFIRE

Hy.CoMM Project



Duration: 11/2023 – 11/2026

Funding Program: CETP

Overall Budget: 6.5 M€

Clean H_2 Construction and Mining Machines

- **Design** of a **fuel cell hybrid construction machine** for **mining applications**
- **Test operation** and knowledge gain for research and industry in a **real application scenario**
- **Build-up** of a **hydrogen refuelling infrastructure**

Motivation / Challenges / Goals

Functional FC-based demonstrator for mining and construction

Energy-efficient and degradation-minimised **operation strategy**

Supporting **pre-series development**

Providing **knowledge gain** for research and industry

Developing an innovative filter technology for **air purification**

Solving challenges of **thermal and water management**

Ensuring **reliable refueling** for daily use

Hydrogen infrastructure powered by **renewable energy sources**

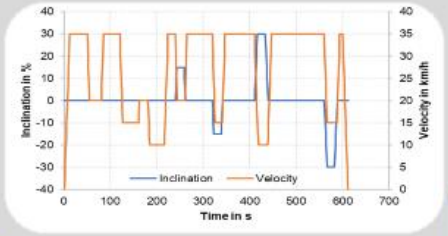
Methodology / Content

System Requirements | **Concept Definition** | **EMS Development**

Customer Requirements

- Legal Conditions
- Lifetime
- Power
- Agility
- Operating Conditions
- Ambient Conditions

Drive Cycle



- Torque
- Resistances
- Vehicle Mass
- Inclination

Topology Variation

- Efficiency
- Costs
- Mass
- Consumption

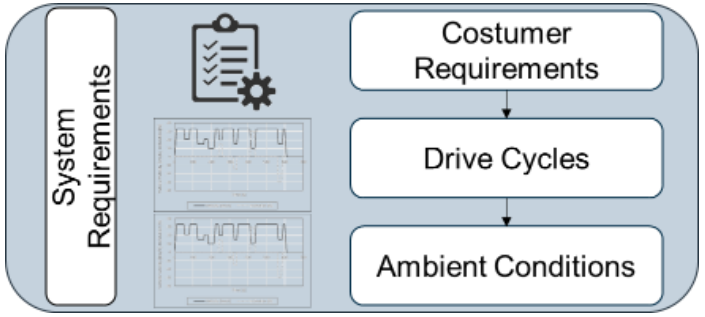
Operation Strategy

- Fuel Consumption
- Efficiency
- SoC – Level
- Current Limits

Optimization Operation Strategy

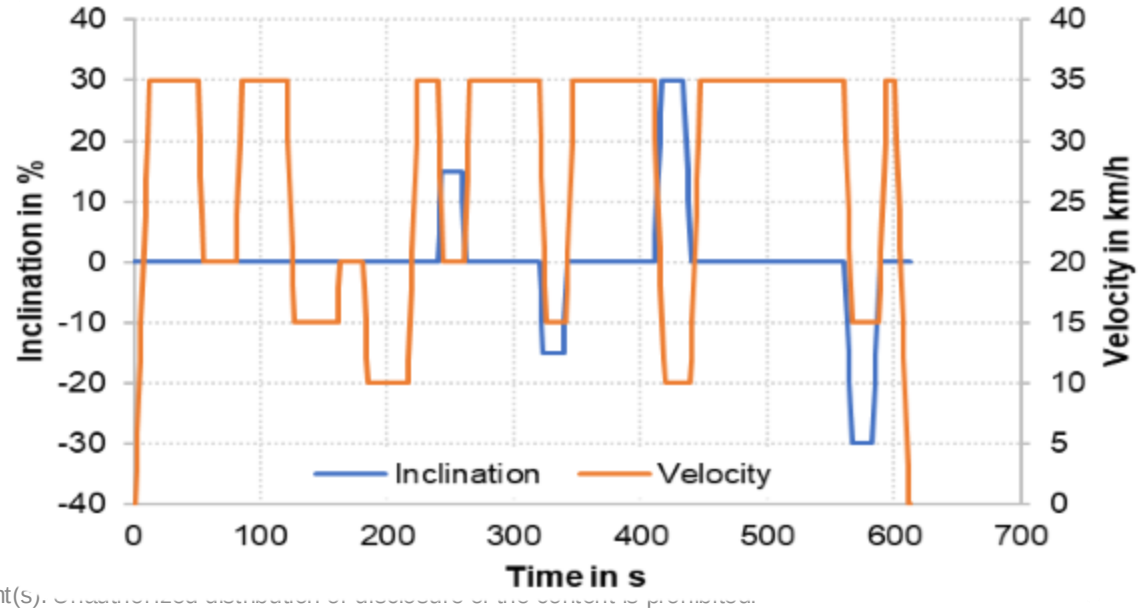
- Energy Management
- Minimum Fuel Consumption
- Maximum Lifetime

Hy.CoMM System Requirements

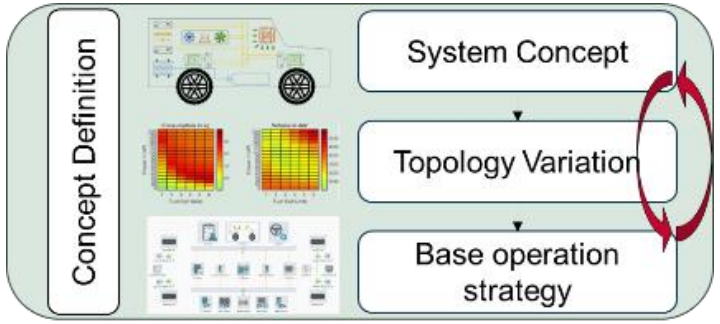


Ambient Temperature	-20 °C to 40 °C
Operating Time / Shift	4 h
Driving Range	100 km
Max. Velocity	35 km/h
Max. Inclination	30 %
Velocity @ Inclination	10 km/h @ 30 %
Curb weight	6500 kg
Payload	1500 kg
Durability	~20 000 h

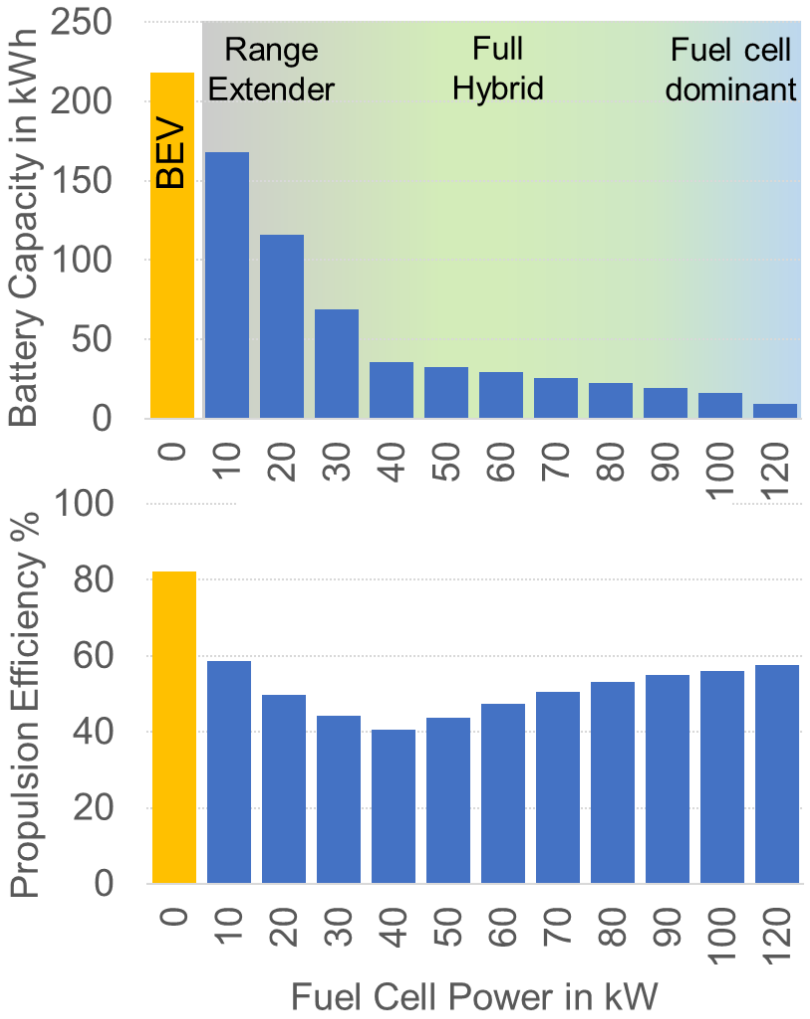
Test vehicle design:
5-seater Pick-up for passenger and material transport

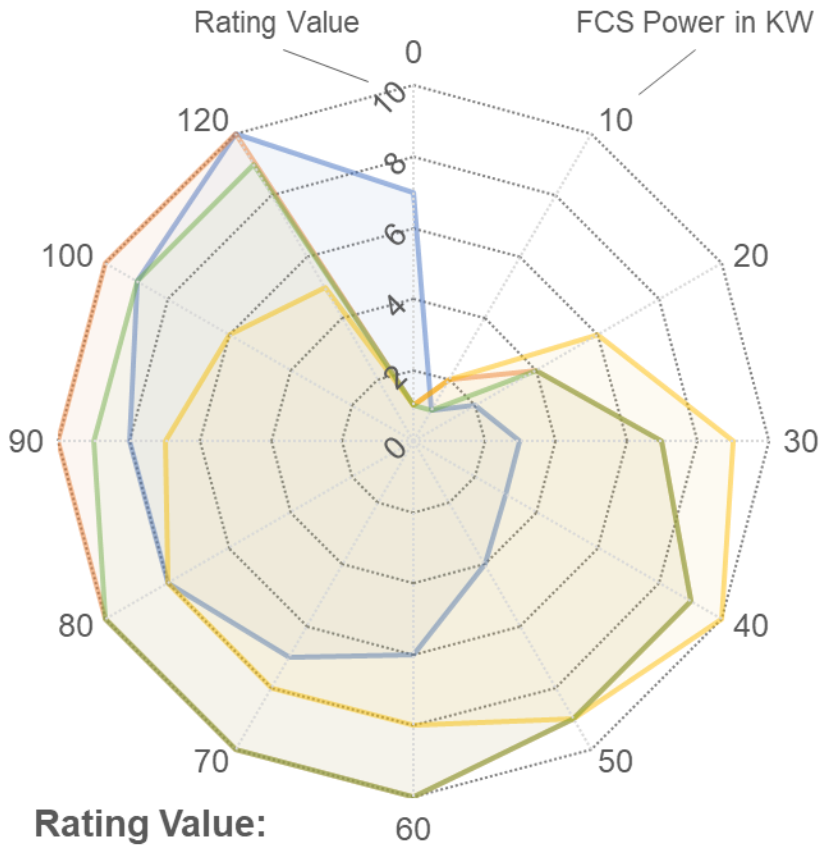


Hy.CoMM Concept Definition



- Simplified static vehicle simulation
- Base operation strategy
- Topology Variation
- Techno-economic assessment
  - Efficiency
  - Weight
  - Packaging
  - Costs

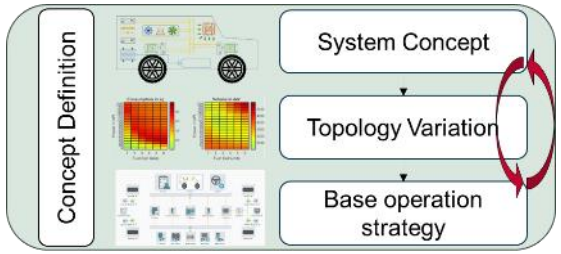


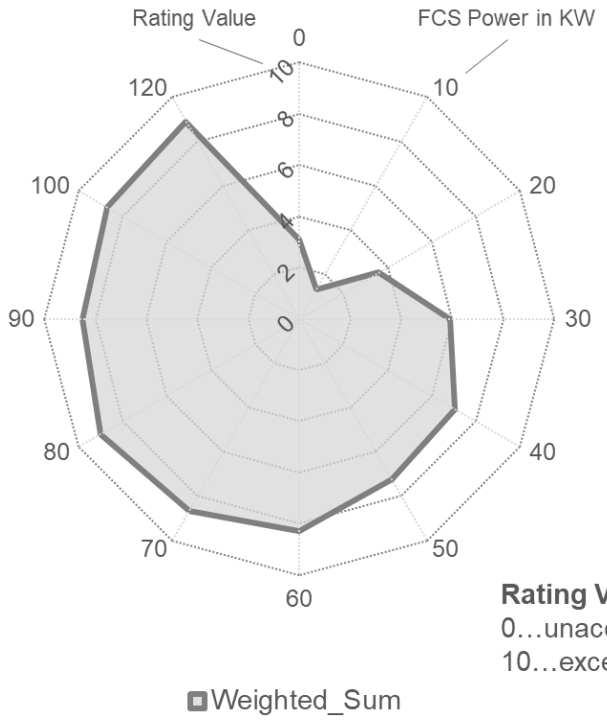


Rating Value:
0…unacceptable
10…excellent

Energy Consumption
Powertrain Mass
Powertrain Volume
Powertrain Costs

Hy.CoMM Concept Definition





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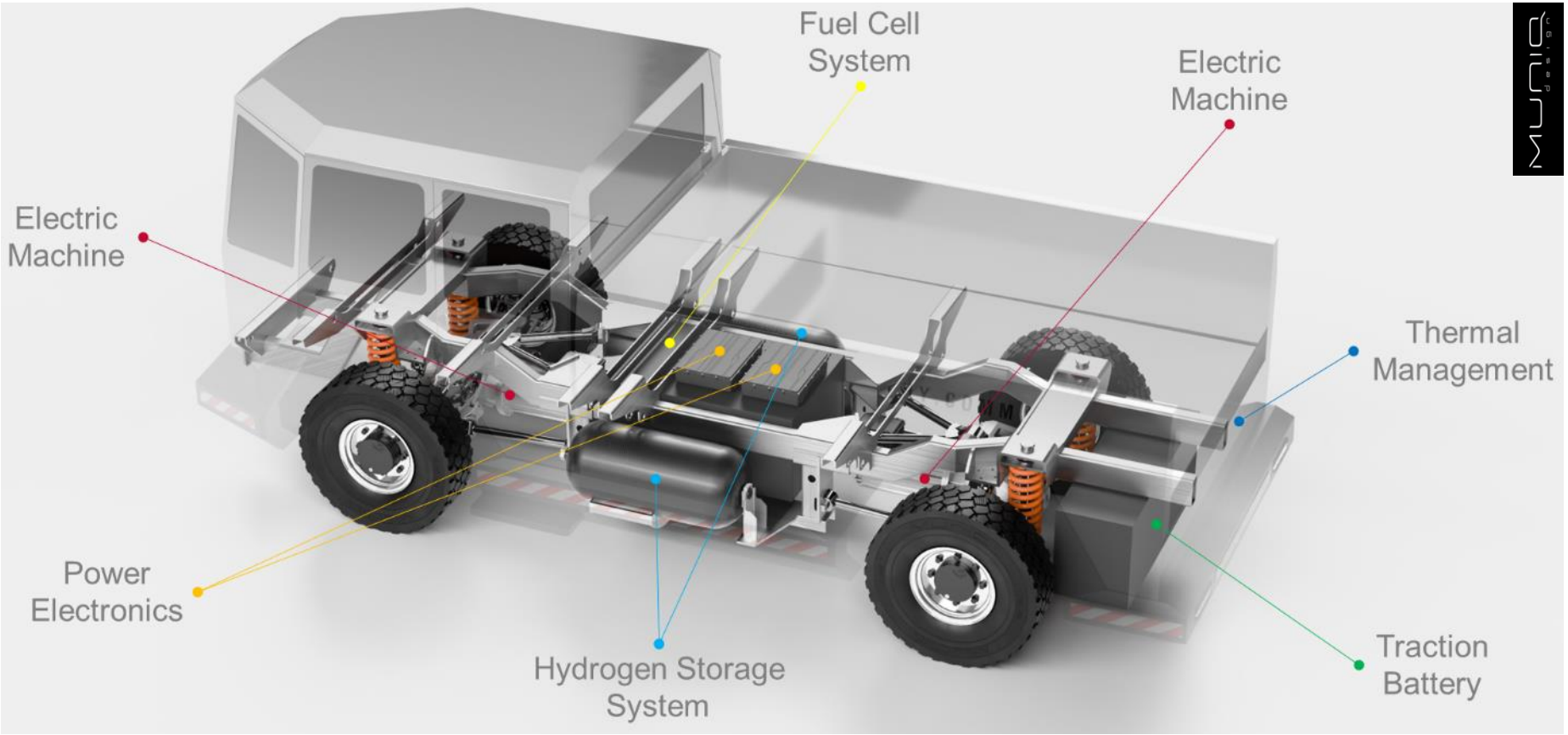
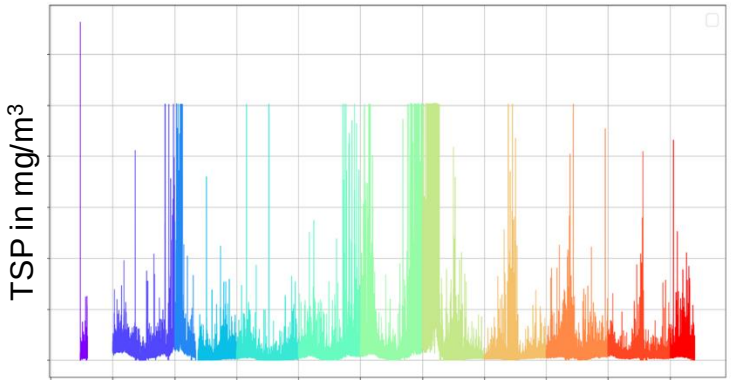
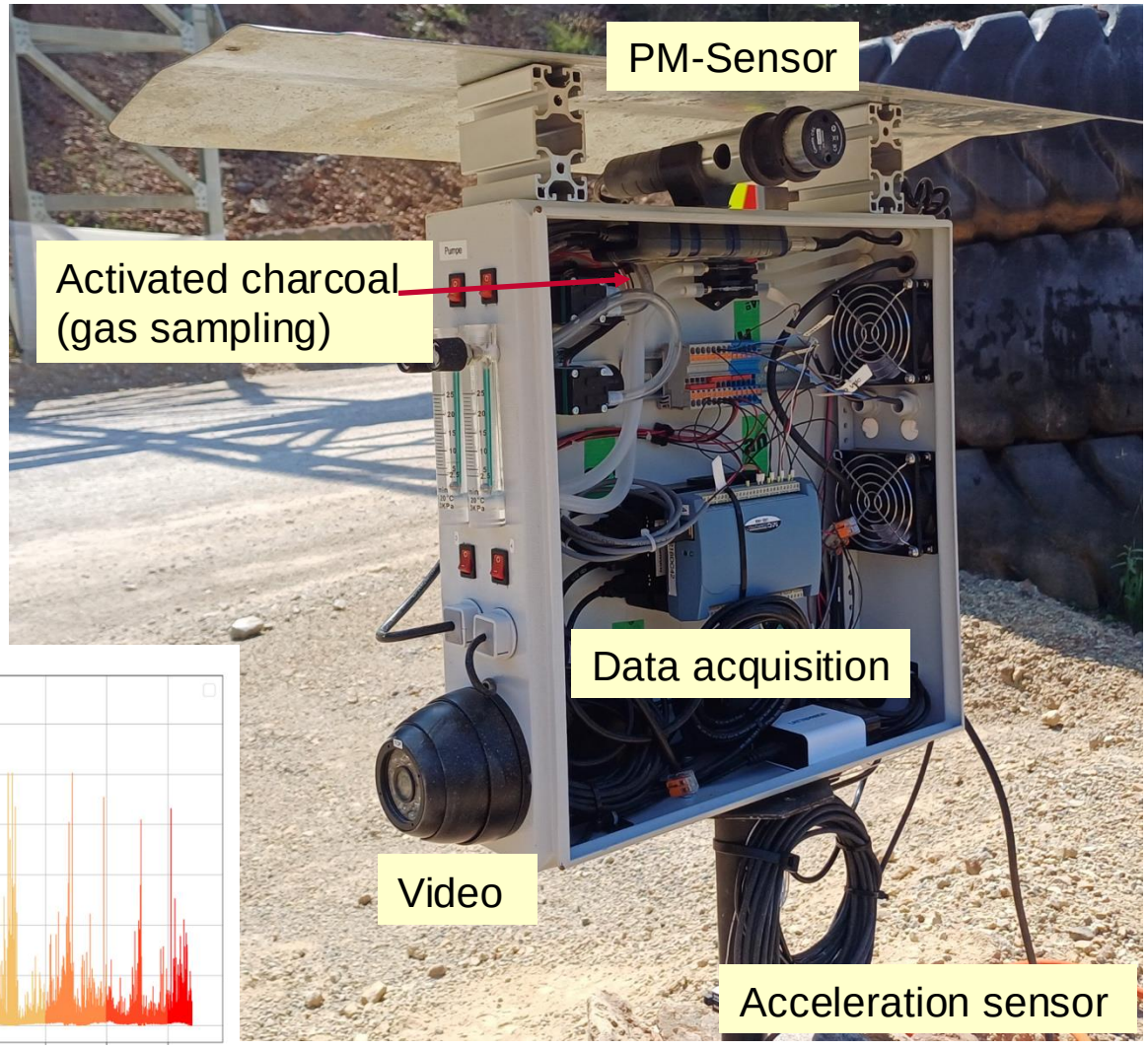


Traction Battery	30 kWh
Fuel Cell System	60 kW

Hy.CoMM Dust measurement @ Erzberg

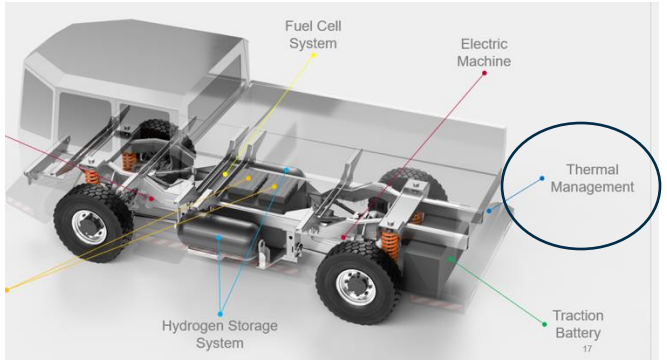
- Installation equipment of the dust measurement system at a mine area “Erzberg”
- Measurement data acquisition directly on the tramline of the dump trucks
- 1st series of measurements mid-August to end of September

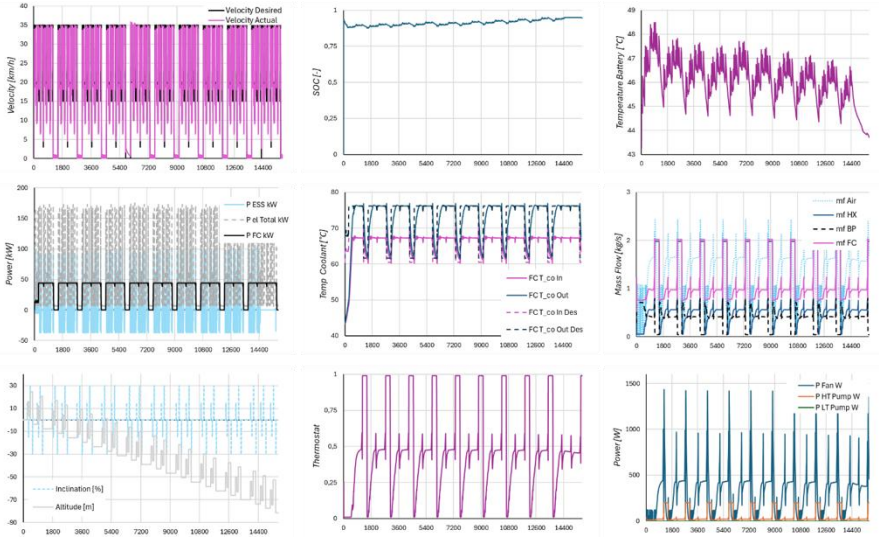




Hy.CoMM Thermalmanagement

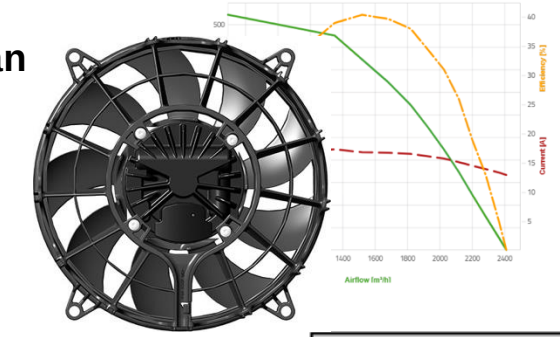
- Design of 2 coolant loops
- Thermal Management Package in the rear of vehicle (~130x35cm)





Simulation of Sequence Underground Cycle

Fan



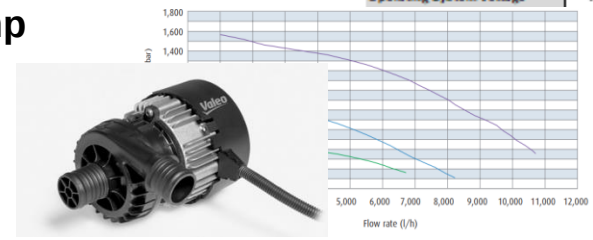
Motor

EM		
Temperature	°C	65
Temperature	°C	37
Coolant Mass Flow	l/min	20
Diameter	mm	14
Coolant	-	Water Glycol

Fuel Cell

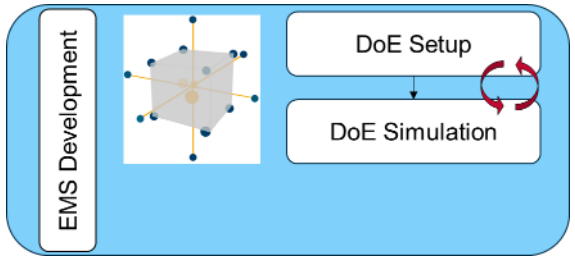
Fuel Cell		
Technology	-	PEM FC
Name	-	BALLARD
Rated Power	kW	100
Efficiency @ P	%	
Peak System Efficiency	%	57
Mass	kg	298,0
Power @ EOL	kW	90,0
FC	-	1,0
Heat Rejection @ EOL Conditions	kW	
Mass Flow	l/min	
Max Pressure Loss	kPa	
Temperature Operation Limit	°C	30... + 50
Operation System Current	A	21-360
Operating System Voltage	V	280-560

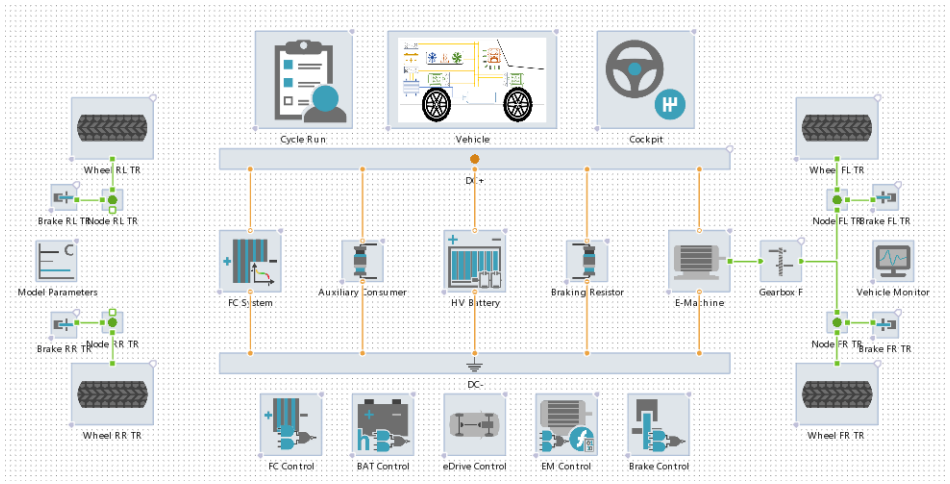
Pump



+ Others (Battery….)

Hy.CoMM EMS Development

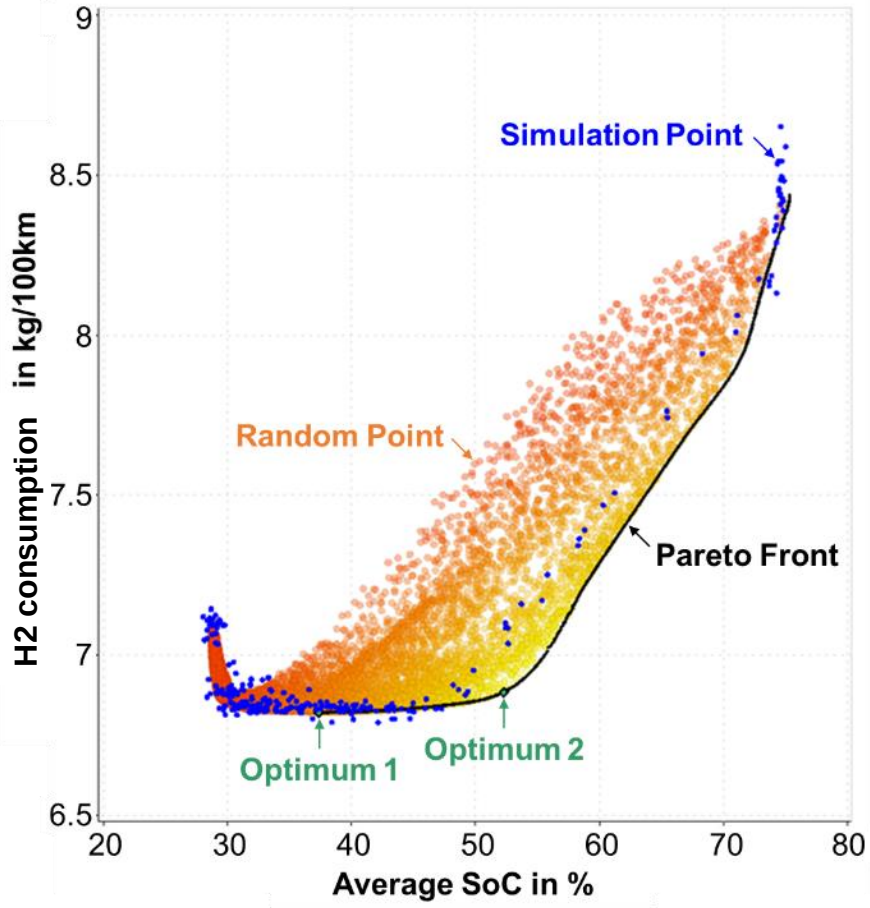




DoE Simulation

- Optimization for consumption and life time of fuel cell and battery
- Rule based operation strategy

"Off"	$LoFC = 0\ \%$	$\{SoC > 80\ \%\}$
"Stop"	$LoFC = 20 \dots 30\ \%$	$\{v = 0\frac{km}{h} \mid SoC = 20 \dots 80\ \%\}$
"Low Load"	$LoFC = 20 \dots 40\ \%$	$\{v > 0\frac{km}{h} \mid SoC = 20 \dots 80\ \% \mid \alpha < 5 \dots 30\ \%\}$
"Medium Load"	$LoFC = 30 \dots 75\ \%$	$\{v > 0\frac{km}{h} \mid SoC = 20 \dots 80\ \% \mid \alpha < 25 \dots 80\ \%\}$
"High Load"	$LoFC = 70 \dots 100\ \%$	$\{v > 0\frac{km}{h} \mid SoC = 20 \dots 80\ \%\}$
"Full Load"	$LoFC = 100\ \%$	$\{SoC < 20\ \%\}$



Base operation strategy: 8.9 kg/100km

~ -23%

Opt. 1: 6.8 kg/100km; SOC: 37%
Opt. 2: 6.9 kg/100km; SOC: 54%

Hy.CoMM Outlook

- Procurement of components and systems
- Experimental testing on stack and system level
- Build-up of a demonstrator vehicle
- Real world testing of test vehicle under mining conditions

Hy.CoMM

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie
Bundesministerium Arbeit und Wirtschaft
FFG Forschung wirkt.
Das Land Steiermark
SFG
ober österreich
UAR INNOVATION NETWORK
Stadt Wien
wirtschaftsagentur wien
LAND TIROL

HY.COMM

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