DESTA - Demonstration of 1st European SOFC Truck APU 278899

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AVL List GmbH

Project and Partnership

General Overview

- Demonstration of 1st European SOFC Truck APU
- 36 months
- Total Budget: €9.841.007, FCH JU Contribution: 3.874.272
- Consortium:
  - AVL List GmbH (Coordinator) - AT
  - J. Eberspächer GmbH & Co KG – DE
  - Topsoe Fuel Cell A/S – DK
  - Volvo Technology AB – SE
  - Forschungszentrum Jülich GmbH - DE

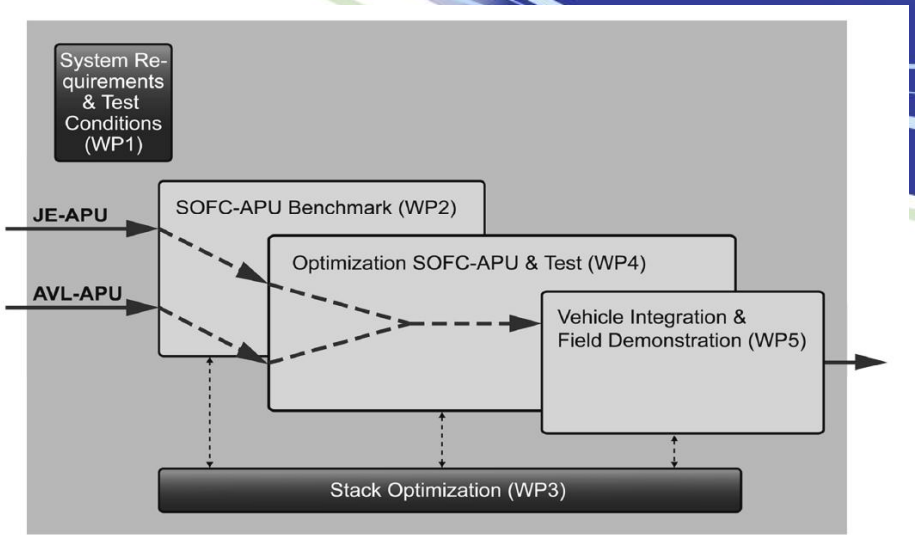
AVL TOPSOE FUEL CELL RETHINKING ENERGY JÜLICH FORSCHUNGSZENTRUM Eberspächer VOLVO DESTA

Project Objectives

Objectives of DESTA:

- **Demonstration of the first European SOFC APU on a Volvo HD truck**
- **1 year testing of 6 APU systems (3 of Eberspächer and 3 of AVL)**
- **Development and assembly of the final DESTA SOFC APU system, merging the most promising approaches of AVL and Eberspächer SOFC APU concepts**
- **Significant improvements of SOFC stacks operated on diesel fuel**

Project Strategy & Setup

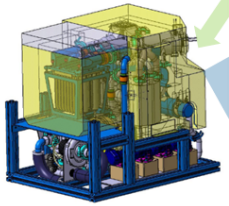


TOPSOE FUEL CELL
RETHINKING ENERGY

AVL

JÜLICH
FORSCHUNGSZENTRUM

VOLVO



Eberspächer

New Energy World JU
fuel cells & hydrogen for sustainability

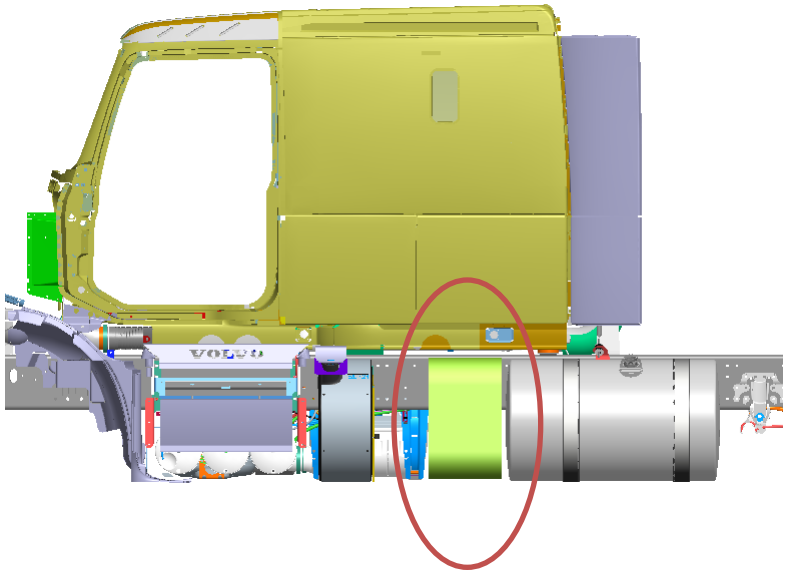
Project Goals

Technical targets:

- **Maximum electrical power ≥3kW**
- **Operation on conventional road diesel fuel**
- **Expected lifetime verified in long-term tests and with statistical methods to reach >20,000h**
- **System electrical net efficiency around 35%**
- **System volume and weight below 150L and 120kg**
- **CO2 reduction of 75 % compared to engine idling of a heavy-duty truck**
- **Start-up time of ~30min**
- **Noise level ~65dB(A)**

Project Achievements
System RQ & Test Conditions WP1

- Milestone 1.1: Type of commercial vehicle defined
  - US Heavy duty truck of tractor type with sleeper cab version
  - 12V electrical system
- Deliverable D1.1 – System requirement report – delivered
  - Requirements have been developed in collaboration with CP partners and experts from truck product development areas.
- Deliverable D1.2 – Test plan
  - Will be developed in collaboration with all partners to cover test plans for the different stages of the development; APU sub-system, APU system, APU on-vehicle.



Project Achievements
System Benchmark WP2

Tasks:

- Build-up of 6 APU Systems (3 from AVL, 3 from Eberspächer) based on existing technology developed in pre-DESTA programs by AVL and Eberspächer
- Benchmark test of these 6 APU Systems
- Independent benchmark report by FZJ based on test results (performance) and system parameters (weight, volume, costs,…)
- Decision on system approach (AVL, Eberspächer or joint configuration) for further optimization to the “DESTA APU System” which will go into the truck demonstration and laboratory tests (salt-spray, vibration, durability)

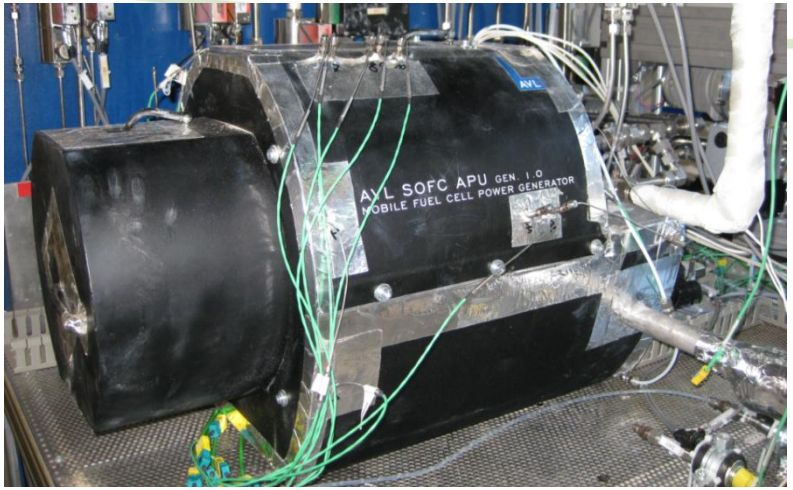
Project Achievements
SOFC – APU Benchmark WP2

Test of AVL APU Prototype systems

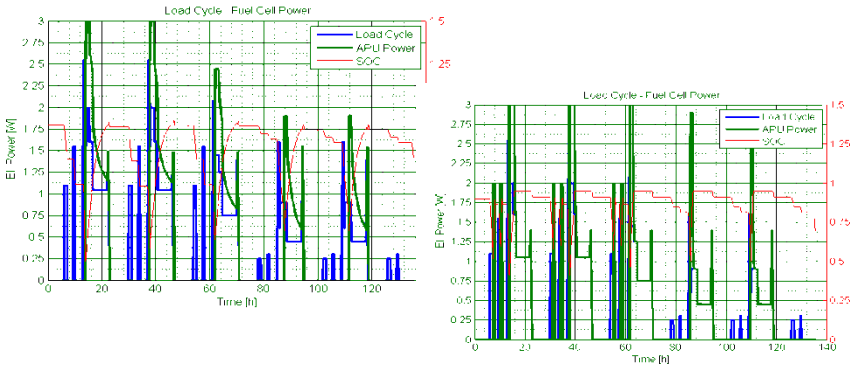
➔ Controller for DESTA Prototyps ready
- map- based control for all actuators
- blowers integrated
- for benchmark relevant sensors

➔ Pretests with APU Gen. 1.0
- results used for DESTA demonstrator
- development
- verification tests with new DESTA
- controller

➔ System simulation for test plan preparation
- Simulation of one week load profile on US Truck
- including driver aspects, difference between winter and summer conditions…



AVL APU Gen. 1.0 on test bed



Results of system simulation

Project Achievements
SOFC – APU Benchmark WP2

Test of AVL APU Prototype systems

➔ Optimization of DESTA prototype

- DESTA prototype based on AVL APU Gen 1.0
- design improvements to get closer on requirement specification

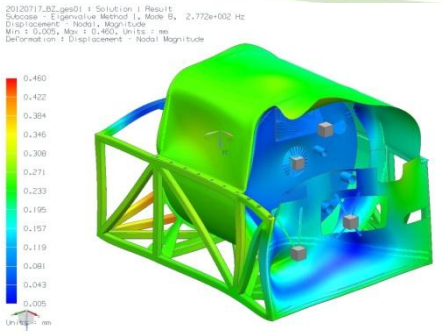
→ **AVL APU fits into Volvo's truck volume and weight requirements!**

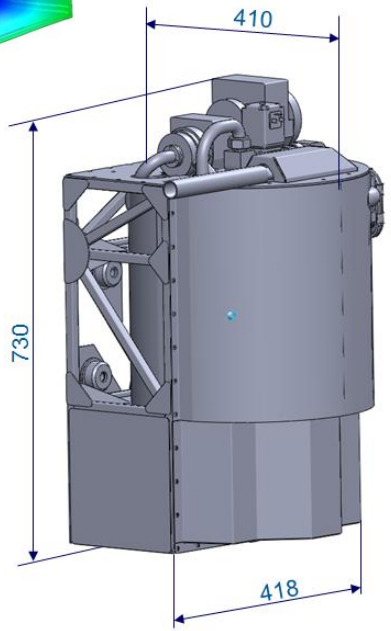
- vehicle integration concept realized
  - FE Simulation
  - Response Analysis

➔ Test bench for benchmark tests designed

- parallel testing of 3 APUs

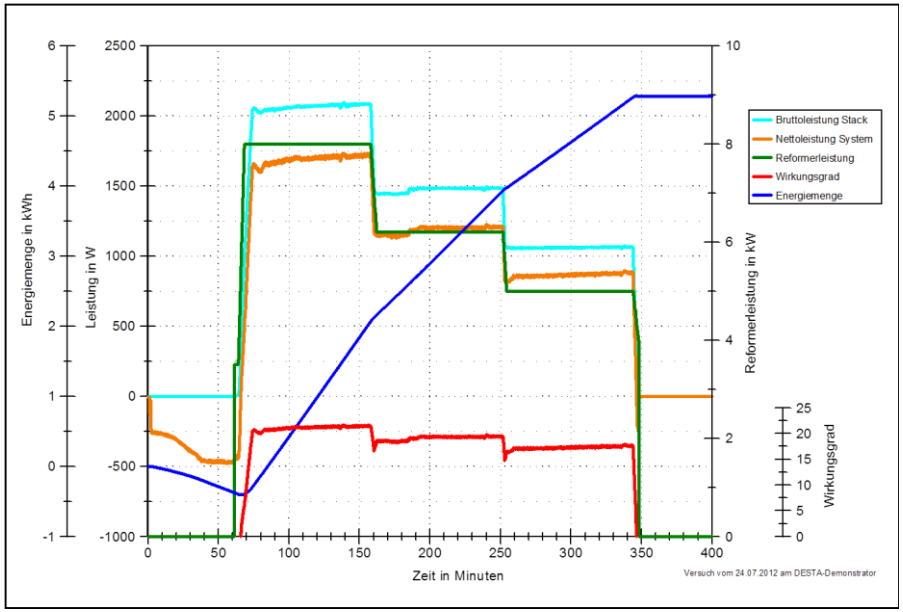
➔ Test of 2 AVL APU systems will start in 4/2012, 3rd system will start in Q1/2013





Project Achievements
SOFC – APU Benchmark WP2

SOFC-APU from Eberspächer and first results



- electrical Power (Gross): 2,1 kW @ 8 kW Dieselinput
- electrical Power (Net): 1,7 kW @ 8 kW Dieselinput

→ **Efficiency: 22% with sulphur-free, synthetic Diesel**

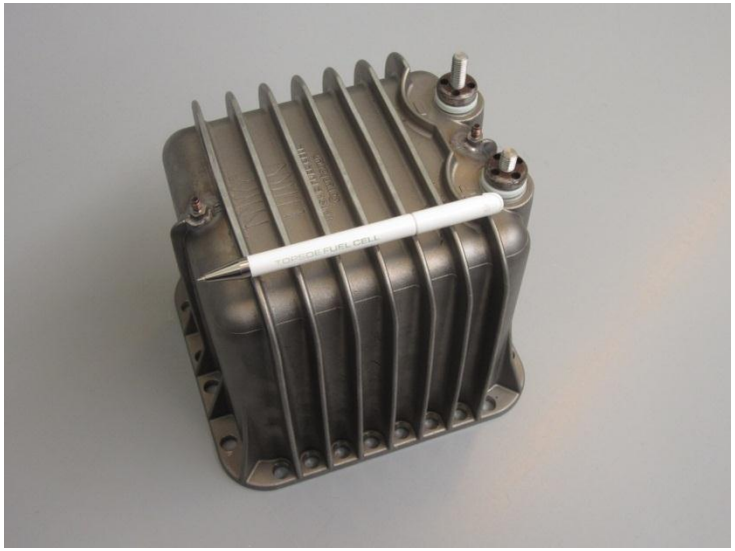
Project Achievements
Stack Optimization WP3

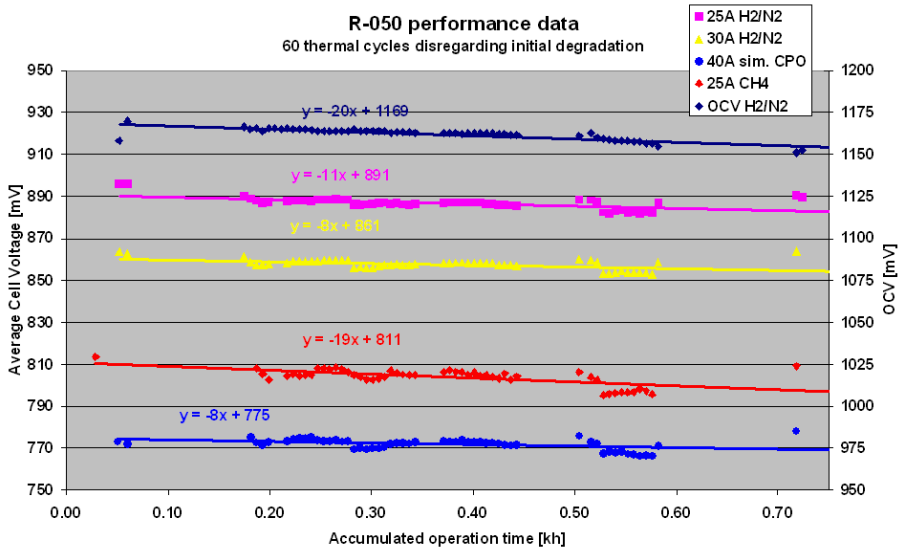
Deliveries

- SOFC Stacks are supplied to the WP2 initial systems.
- SOFC Stacks are under manufacturing for the next systems.

Thermal cycling test on 84 cell stack:

- 100 full thermal cycles passed, 1h start-up, no protection gas.
- => Stack core unharmed, no cell cracks.
- => Bottom gasket failed
- => A better gasket is found.





Project Achievements
Stack Optimization WP3

Project milestones:

- 1000 thermal cycles
- 5000 hour test on diesel reformate

Operation on ULSD diesel reformate:

- New, more sulphur resistent cells are introduced.
- Testing at TOFC is so far only made on simulated CPO reformate.
- Test on real ULSD reformate will take place at Eberspächer and AVL who have received a set of upgraded stacks.
- ULSD WP2 testing is expected to take place in Q4 2012.
- TOFC continues testing new anode formulations for further understanding and cell improvement.
- New anodes will be introduced when improved formulations are identified.

Outlook WP 4 / WP5

- **Optimization SOFC APU & Test WP4:**
  - Development of optimized DESTA SOFC APU by joining AVL and Eberspächer APU systems
  - Laboratory tests of four DESTA APUs (salt spray, vibration, reliability)
  - Systematic durability and reliability optimization
- **Vehicle Integration & Field Demonstration WP5:**
  - Vehicle mechanical and electrical interface is to be defined
  - Electrical system layout is to be defined
  - DC/DC hardware and software is to be developed
  - Overall system control strategies is to be defined and implemented in control unit.
  - SOFC-APU installation and integration on vehicle
  - Test and demonstration of operational SOFC-APU on truck

Alignment to MAIP

MAIP

… Heavy duty road transport applications will also be addressed in this application area.
… Proof-of-concept demonstrations are also foreseen for APUs in aeronautic and maritime applications and also for trucks. The common goal of all these demonstrations is to increase efficiency of onboard power generation and reduce CO2 emissions and local pollution
…

DESTA targets

- Operation on conventional road diesel fuel
- System electrical net efficiency around 35%
- CO2 reduction of 75 % compared to engine idling of a heavy-duty truck

Application Area	Market application		Volume & cost 2010 baseline	2015 mid-term	2020 long-term
AA1 - Transportation & Refuelling	*Cars: Vehicle*		>100 / 0.5M€	>5,000 / <50k€	500,000 /<30k€
	PEM-FC System		>1,000€/kW	100€/kW	50€/kW
	Busses: Vehicle		>10 / 2M€	500 / <1M€	1,000 / <500k€
	PEM-FC System		>3,500€/kW	<3,500€/kW	<400€/kW
	Hydrogen refuelling stations		<75 / 1 - 3 M€ (depending on size of filling station)	<300 / 0.6 - 2.5 M€ (depending on size of filling station)	>2000 / 0.6 - 1.6M€ (depending on size of filling station)
	APU's	*for truck applications (5kW)*	3,000€	1,000€	500€
		for aircraft applications (20-120kW)	Lab test units only	flight validation supply	early operation (hundreds) / 500 €/kW
		for maritime applications (50-500 kW)	single demonstrations	some tens / 3000-4000 €/kW	hundreds / <2000 €/kW

Alignment to AIP

Expected AIP Outcome	DESTA contribution
Proof of feasibility of using logistic fuels	DESTA systems will be operated on conventional diesel fuel
Demonstration of fuel processing technology for logistic fuels	DESTA systems will be operated on conventional diesel fuel
Definition of RQ for fully integrated systems in the specific application	Deliverable 1.1 System Requirements Report
Cost below € 1,000/kW for automobile application	Will be adressed in WP4

Alignment to AIP

Expected AIP Outcome	DESTA contribution
Electric system efficiency (LHV) in the range of ~35% for automotive applications with logistic fuel	22% demonstrated, goal: 35%
Anticipated lifetime according to application requirements (≥ 20,000h for automotive)	Will be adressed in WP4
Anticipated reliability figures (MTBF, availability) according to application requirements	Will be adressed in WP4
Emission reduction to less than current rules and regulations under development	DESTA APU will reduce truck idling emission by 75%

- Gaps/bottlenecks in RTD&D proposed by MAIP/AIP documents
  - SOFC APU Technology was no continuous topic in the AIPs (2011, 2012)

Cross-cutting Issues

Safety, Regulations, Codes & Standards

- collaboration with JRC to contribute to standardized test methods for SOFC stacks

Dissemination & Public Awareness

- Project identity for consistent communication of project material
- Project website: www.desta-project.eu
- Presence at major conferences and events
- Final DESTA event
- Public international workshop proceedings
- Exhibition of AVL SOFC APU at the Fuel Cell Seminar in CT, USA in November 2012

Project Interaction

Collaboration with national and EU funding programmes / projects

- METSAPP (EU)
- ENSA III (DE)
- ASYS1 (AT)
- RELIVE CAT (AT)
- EUDP (DK)

DESTA contact

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www.desta-project.eu