



Demonstration of 1st European SOFC Truck APU

Jonas Hagerskans, Volvo



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Agenda

- Project DESTA
- Motivation
- Main Requirements
- SOFC Fuel cell APU
- Volvo Vehicle system
- Vehicle Integration
- Test and results

Description of Work



- EU project Fuel Cell and Hydrogen Joint undertaking (FCH JU) 3,5 years
- Objective: Demonstrate the 1st European SOFC Truck APU
- AVL (Coordinator)
 - Development of AVL SOFC APU
- Eberspächer
 - Development of Eberspächer SOFC APU
 - Test of SOFC APU (lab)
- TOFC
 - Stack improvements
- Jülich
 - Evaluate the benchmarktest
- Volvo
 - Requirements
 - Test plan
 - Power Electronics
 - Vehicle integration
 - In-Vehicle tests





Motivation





Motivation

- Estim 2 Billion litres diesel yearly from over-night idling
- Anti idling regulations
- Fuel cost savings
- Low emissions
- Low noise





*regional differences from strict idling bans (0 min, idling) to idling permission of up to 15 min per hour of standstill

SOFC Fuel cell APU



- Advantages of a SOFC APU:
 - Efficiency
 - > 30% vs. Truck idling < 10%</p>
 - Fuel consumption:
 - 1/5 compared to truck idling \rightarrow cost reduction
 - Low noise emissions:
 - No cyclical combustion, no low-frequency vibrations
 - Low pollutant emissions
 - Run on Conventional diesel



Main Requirements

- Width: 40 cm
- Mass: 150kg
- Output: 3kW Net

~35%

12V nom

<60dB(A)

- Efficiency
- System Voltage:
- Conventional US Diesel
 - Up to 15 ppm S
- Environmental requirements
 - Vibrations /Shock
 - Temperature
 - Sealing etc
- Noise:
- Lifetime
 - 20 000 h -> 5000h operation





DESTA SOFC APU: Basic principle







2 * Stack with 75 anode supported cells, 12x12 cm footprint. TOFC

source: www.eberspaecher.com

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Volvo Vehicle System





APU Installation

- APU on chassis
- Exhaust
- Diesel from tank
- Air intake w filter

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In-Vehicle Test

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Noise measurements

dB(A)	Outside 3m	Bunk
APU, Start-up	68,5	41
APU, Operational	58	<40
Idle Engine	72,4	54,8

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55.0

24h Test profile

Typical US mission profile

- APU during night
 - 11h Operation
- Driving during day

E45

- Cool-down
- Heat-up
- ~800 km

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CO2/Diesel reduction

	APU		Engine Ideling		
	Fuel	CO2	Fuel	CO2	CO2 saving
	Litres	kg*	Litres	Kg*	%
Warmstart and Night	9,12	23,86	33,5	90,115	73,5

*US diesel and assumed complete combustion

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Driving

- Total Distance: >2500 km
- Realistic vibrations
 - Highway, City, Country roads
- Salt spray, water splash, gravel etc
- APU still working!

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Technical TARGETS AND ACHIEVEMENTS

The 1st European SOFC Truck APU was successfully demonstrated (06/2015)

Technical objectives	Unit	Planed	Achieved	Status	
Max. start-up time	min	30	< 70		
Max. Electric power (net)	kW	3.0	2.9	•	
System electrical net efficiency (approx.)	%	35	29	0	
Diesel consumption (3 kW, net)	l/h	0.86	0.95	•	
Volume	I	186	178	•	
Weight	kg	150	160	0	
Noise level	dB(A)	65	58	•	
CO ₂ reduction compared to engine idling of a heavy-duty truck	%	75	73.5	0	
Operation on conventional road diesel fuel (US Diesel)					

Future Challenges

- Lifetime
 - Lifetime of 2000h shown but need to increase.
- Cost
 - The cost needs to be in par with the other market alternatives (for HD truck applications)
- Total cost of ownership...
- Start-up time
 - 65 minutes (from cold) shown, but need to decrease.

Project Summary

1st SOFC Fuel Cell APU demonstrated on vehicle

- Excellent Cooperation
- Most project goals achieved

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EEL 721

More material

Project homepage

http://desta-project.eu/desta-project/

Press Release

 <u>http://www.desta-</u> project.eu/fileadmin/downloads/DEST
<u>A website press release Volvo Eber</u> <u>spaecher final.pdf</u>

Film Clip – In-Vehicle testing

<u>https://www.youtube.com/watch?v=B</u> <u>AN5AiJ983M</u>

Public Report

Soon...

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Press Release, June 2015

$\underline{D} emonstration of 1^{st} \underline{E} uropean \underline{S} olid Oxide Fuel Cell \underline{T} ruck \underline{A} PU on a Vehicle$

Recently the goal of the DESTA project (to demonstrate the first Solid Oxide Fuel Cell Auxiliary Power Unit on a heavy duty truck in Europe) has been achieved. The results are a major breakthrough for fuel cell based APU systems for trucks.

DESTA truck with SOFC APU (without fairing) CDESTA

The APU system developed and supplied by Eberspächer, was integrated and tested by Volvo on a long haul truck for the North American market. Until today, several weeks of smooth operation were demonstrated on conventional US diesel fuel (< 15 ppm sulfur). With the DESTA system, 3 kW of electrical net power can be supplied with an efficiency of 30%, very low NOx emissions, no diesel particles and a noise level of about 58 dB (A) outside the vehicle and less than 40 dB (A) inside the vehicle. Compared to engine idling of a heavy-duty truck the CO₂ emissions could be reduced by 71 %. The diesel consumption is 0.95 l/h at an electrical net power of 3 kW.

SOFC Fuel cell principle

Stack with 75 anode supported cells, 12x12 cm footprint

Batteries

- 3 Alternatives
 - All can fulfill energy need for startup (0.8kWh)
 - Alternative 3 with super-capacitor chosen to secure cranking ability

Vehicle Integration

In-vehicle testing activities April- June

- Volvo and Eberspächer joint in-vehicle testing for 5 weeks
- Tests according to test plan
 - ✓ Basic Functionality
 - ✓ Static tests
 - ✓ Vehicle Scenarios
 - ✓ Driving Profiles

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Real loads

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Micro, Coffee maker, Water boiler etc

