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The STASHH Fuel-Cell Module Standard

Standard-sized Heavy-duty Hydrogen

SINTEF Mathematics & Cybernetics

VDL ETS

3 November 2022, Merced, California

Vehicle Power and Propulsion Conference



Outline

Motivation

The STASHH project

Results

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Heavy vs. Light Duty Fuel Cells

Why we are so interested in heavy duty

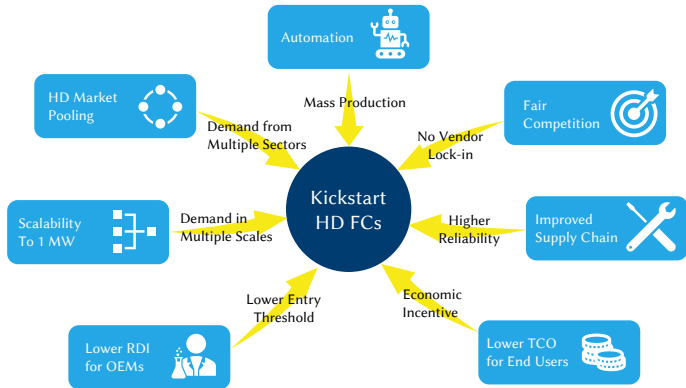
- Increasing interest in hydrogen for HD applications
- There are also batteries, what is the case for hydrogen?
- Batteries have established an advantage in the car sector
- Cars vs. heavy-duty vehicles:
 - 95 % parked vs. maximised operation time
 - Distributed vs. focused/dedicated infrastructure
 - Disposable income vs. cost minimisation
 - Free time vs. salaried time
- All these factors push towards hydrogen

What are the Barriers?

- Experience at VDL: 3 generations of fuel cells, 3 re-engineerings
 - ... (and that was with the same supplier!)
- Re-engineering is expensive and demotivating
- Unique design gives difficult support and maintenance
- Multiple, fragmented heavy-duty markets
- Each segment much smaller in numbers than car sector
- Different power requirements, from 100 kW to multi-MW
- OEM and FC supplier must agree to long-term relationship

How a Standard Helps

- Join multiple markets
- Increase production volumes
- Enable automation
- OEMs can change FC vendor
- Composable modules
- Easier (re)placement



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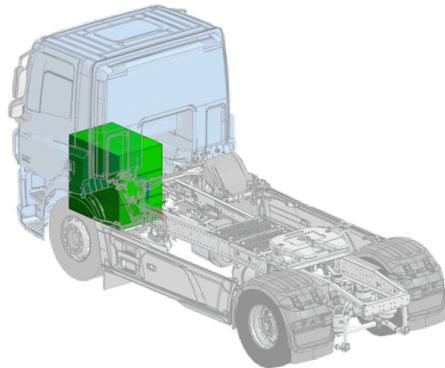
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STASHH' Core Concept

- Standards for size, interface and communications
- Construction of prototypes from multiple suppliers
- Rigorous module testing, respecting IP
- Field demonstration
- Regulations, codes, standards and safety
- Dissemination and standard adoption by industry



STASHH Partners

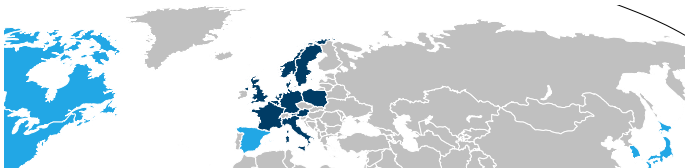
More than 25 involved companies and 14 million € in budget

Coordinator SINTEF

FCM Suppliers Ballard, Plastic Omnium, FCP[†], Freudenberg, Hydrogenics[†], Hyundai*, Intelligent Energy, Nedstack[†], Nuvera, Proton Motor, Symbio[†], Toyota.

OEMs Alstom (trains), AVL (powertrains), CETENA (ships), Damen (ships), Future Proof Shipping (inland ships), Solaris (buses), VDL ETS (trucks, buses etc.), VDL Energy Systems (generators), Volvo (construction equipment).

Institutes CEA, FEV, TNO, WaterstofNet.



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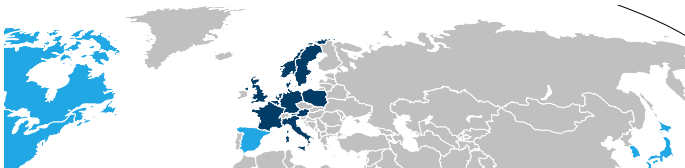
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Additional entities:

- Advisory Board
- Exploitation Group

STASHH' Timeline

2021 Development of the STASHH standard

- Detailed RCS overview
- Update at project end
- Submission to standard bodies

2022 Construction of prototypes and test rigs

2023 Testing and analysis

- Recommendations for assessment

STASHH' Timeline

... with some modifications

2021 Development of the STASHH standard

- Detailed RCS overview
- Update at project end
- Submission to standard bodies
- OEM “Best Practices” manual (2023)

2022 Construction of prototypes and test rigs

2023 Testing and analysis

- Recommendations for assessment
- Heavy-duty demonstration (in port of Rotterdam?)

2024 6-month extension

Outline

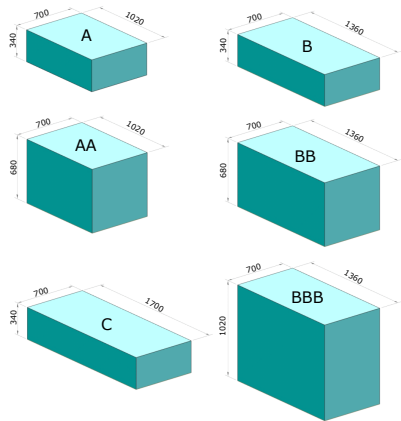
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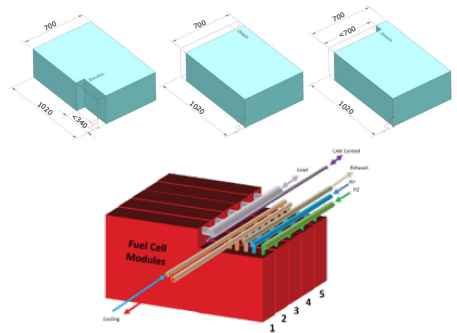
Standard Size Formats

- Three base sizes based on unit length of 340 mm:
 - 1 Height
 - 2+ Width
 - 3,4,5 Lengths A, B and C
- Numbers most influenced by measures of EU trucks
- Stackable formats by doubling the letters. Most popular:
 - AA, BB for truck side tanks
 - BBB for truck engine bays
- By default lying, but can be provided standing on side



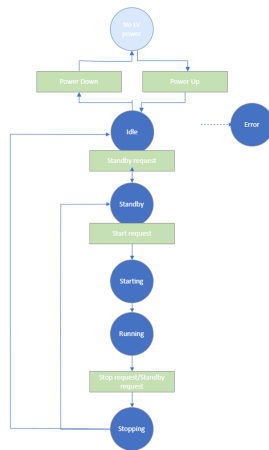
Standard Flow Interfaces

- Connections located on either or both sides of box
- If both, some connections must be redundant
- Connections must not interfere with straight manifolds
- Size of fittings/nozzles depends on power rating
 - Metric interval (includes common US sizes)
- Exceptions: drain, HV and LV power



Standard Digital Interface

- Defined on top of CAN bus
 - Ethernet implementation possible (ships)
- Signals defined according to SAE J1939
- FCM State machine
- Multiple FCMs: possibility of FCM hierarchy
- No specific connector, but 18 pins required



Prototypes

- Early deployments at VDL with Plastic Omnium units
 - A-size in truck
 - Vertical A-size in genset racks



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- Plan to test on Autonomous Guided Vehicle for container transport in Port of Rotterdam



Conclusions

- Standard for fuel-cell modules prepared with inputs from FCM suppliers and OEMs
- Strong interest from the industry
- Future work until June 2024:
 - Construction of 9 FCM by consortium
 - Testing and data analysis
 - Update and dissemination of the standard
- If interested, join the exploitation group!

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Thank you for your attention!



Towards a standardised fuel cell module

Standard-Sized Heavy-duty Hydrogen

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