

Federico Zenith

The STASHH Fuel-Cell Module Standard

Standard-sized Heavy-duty Hydrogen

SINTEF Digital, Trondheim, Norway

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Clean Hydrogen JU Info Day, Brussels



Outline

Motivation

The STASHH project

The Standard

Project Results & Impact

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Project Results & Impact

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- Shifting focus towards heavy-duty (HD) for hydrogen
- 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
- OEM and FC supplier must agree to long-term relationship
 - E.g. Alstom & Hydrogenics for iLint train

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Project Results & Impact

The STASHH project

- Funded by the EU with 7.5 M€ (CH JU), total budget over 14 M€
- From January 2021 to February 2025
- Defined a standard for size, interfaces, communication
- 8 prototypes built & tested
- Standard submitted to IEC TC 105 (New Work Item Proposal 105-1077 recently approved!)
- Large consortium with strong industry presence

STASHH Partners

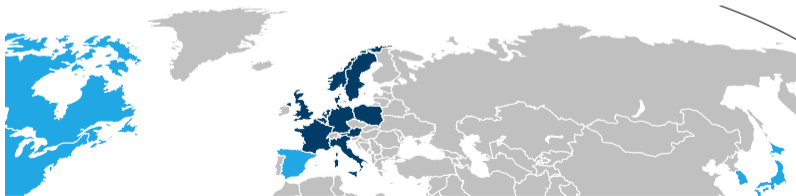
More than 25 involved companies and 14 million € in budget

FCM Suppliers Ballard, OPmobility, FCP[†], Freudenberg, Cummins[†], 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 SINTEF (coordinator), CEA, FEV, TNO, WaterstofNet.

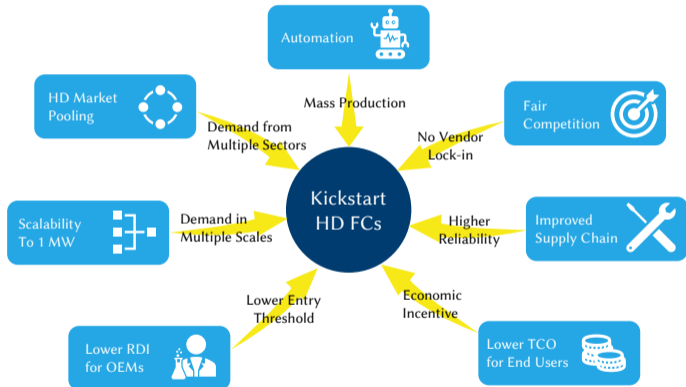
Advisory Board Airbus, Bosch, cellcentric, Colruyt, Engie, Mahle.



STASHH' Core Concept

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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Standard Definitions

Black Box What is *inside* the module is not StasHH' business

- H₂ storage, air filters, coolers not in FCM
- DC/DC may or may not be included

Power rating Not part of the standard (expected above 30 kW)

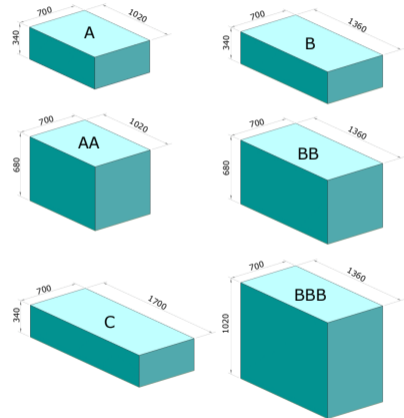
Continuous Power Indefinitely maintainable at nominal operating conditions

Peak Power Can be held for at least 60 s

End of Life When FCM cannot deliver design continuous power without exceeding limit on heat rejection (OEM constraint)

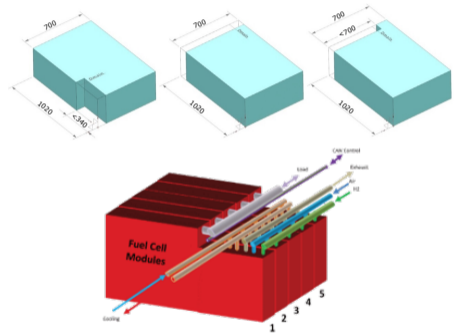
Standard Size Formats

- 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
 - AAA, BBB for truck engine bays
- By default lying, but can be provided standing on side



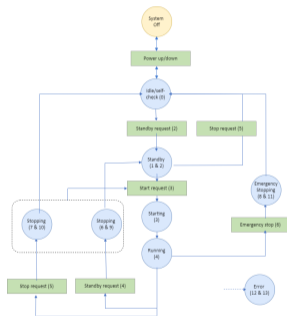
Standard Flow Interfaces

- 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
- Cummins submitted alternative extension to SAE J1939
 - Incorporated into our standard in second iteration
- Multiple FCMs: possibility of FCM hierarchy
- No specific connector, but 18 pins required



Standard delivered to Clean Hydrogen JU

2024 Hydrogen Week



STASHH
Towards a standardised fuel cell module

Freely downloadable from on stashh.eu

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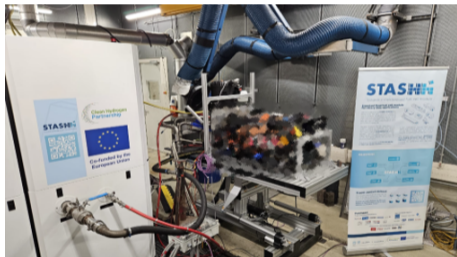
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STASHH Results

Available on stashh.eu

- Standards for size, interface and communications
 - Already available for download
 - Submitted to IEC/TC105 (long process)
- 2 custom-built test rigs (FEV)
- Test protocols (TNO)
- Extensive cross-sector RCS overview (CEA)
- OEM best practices report (Damen)
- X-in-the-loop Modelica library (SINTEF)



STASHH Prototypes and Testing

- 8 standard modules from FC partners
 - Some deviations accepted in first iteration
 - Final designs to be 100 % compliant and public
- Tests at FEV Aachen / TNO Helmond / CEA Grenoble
 - 6 modules tested on rig
 - 1 tested in-house at Intelligent Energy
 - 1 field-tested (Freudenberg)
- Power ratings from 36 kW to 125 kW



STasHH Deployments & Way Forward

- Already 7 retrofit trucks by VDL
 - 2 with OPmobility modules
 - 5 with Toyota modules
- Genset with Freudenberg module, in testing
- Extension to SOFCs planned



(not to scale)

Mid-Term Impact

- FC modules will be available from StasHH suppliers
- Submission to standard bodies (SAE, IEC, ISO...)
- Adoption of standard by both OEMs and FCM suppliers beyond the project
- Easier development of hydrogen vehicles
- Lowered barriers for competition
- Accelerate market growth towards economies of scale

Long-Term Impact

- Heavy duty is more difficult to electrify with batteries
- Hydrogen solves many problems – but needs scale
- StasHH joins HD markets with a common standard
- Zero-emission HD is shown to be possible
- Authorities encouraged to mandate ZE HD vehicles

Conclusions

- Standard for fuel-cell modules prepared with inputs from FCM suppliers and OEMs
- Strong interest from the industry
- Great starting point for your projects!

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Thank you for your attention!



Towards a standardised fuel cell module

Standard-Sized Heavy-duty Hydrogen

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