

Federico Zenith

The STASHH Fuel-Cell Module Standard

Standard-sized Heavy-duty Hydrogen

SINTEF Digital, Trondheim, Norway

27th August, 2025

Europe-Korea Science & Technology
Conference, Vienna



Outline

Motivation

The STASHH project

The Standard

Project Results

Outline

Motivation

The STASHH project

The Standard

Project Results

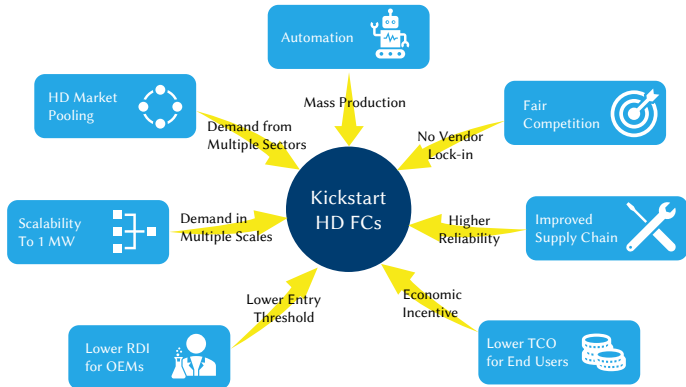
Motivation

- Shifting focus towards heavy-duty (HD) for hydrogen
- Experience at VDL: 3 generations of fuel cells, 3 re-engineerings
 - ... with the same supplier!
- Expensive and demotivating
- Unique design: difficult support and maintenance
- Many heavy-duty markets
- Long-term commitment between OEM and FC supplier
 - E.g. Alstom & Hydrogenics for iLint train

How a Standard for HD Fuel Cells Could Help

STasHH' Core Concept

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



Outline

Motivation

The STASHH project

The Standard

Project Results

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
- Large consortium with strong industry presence

STasHH Partners

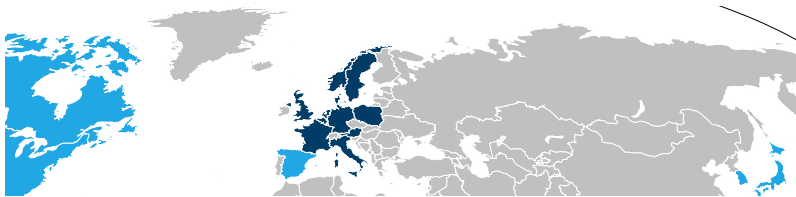
More than 25 involved companies and 14 million € in budget

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.



Outline

Motivation

The STASHH project

The Standard

Project Results

Standard Definitions & Key Concepts

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

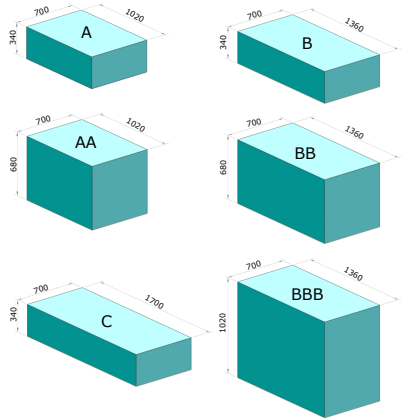
3,4,5 Lengths A, B and C

- Numbers most influenced by measures of EU trucks
- Stackable formats by repeating the letters. Most popular:

AA, BB for truck side tanks

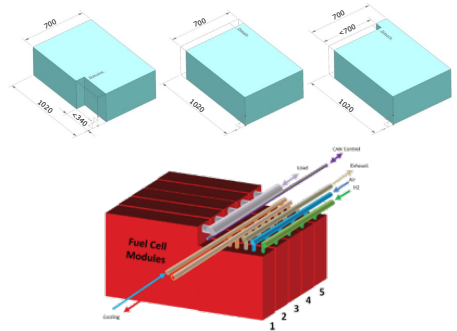
AAA, BBB for truck engine bays

- By default lying, but can be provided standing on side



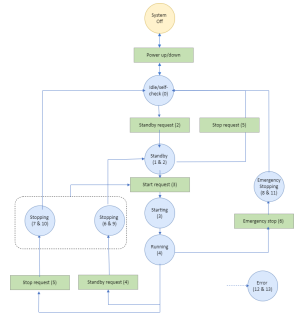
Standard Flow Interfaces

- 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



Freely downloadable from on stashh.eu

Outline

Motivation

The STASHH project

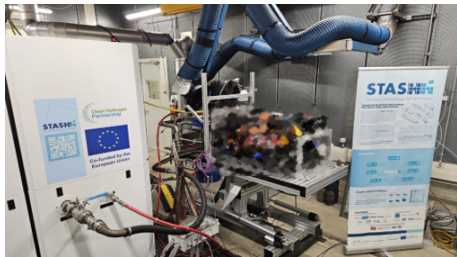
The Standard

Project Results

STASHH Results

Available on stashh.eu

- Standards for size, interface and communications
 - Already available for download
 - Submitted to IEC/TC105, established WG110
- 2 custom-built test rigs
- Test protocols
- X-in-the-loop Modelica library
- Cross-sector RCS overview (598 pages!)
- Best practices for maritime deployment
- Projected market >8M FC modules in 2050
- Estimated 10–13 % TCO reduction

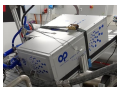


STasHH Prototypes and Testing

- 8 standard modules from 7 FC partners
- Tests at FEV Aachen, TNO Helmond, CEA Grenoble, IE, VDL
 - 6 on rig, 1 in-house, 1 on field
- Power ratings from 36 kW to 125 kW
- Publication on test results in progress by TNO/CEA/FEV



Ballard



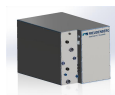
OP mobility



IE



Nuvera



Freudenberg



Proton Motor



Toyota

Way Forward

- Already 7 retrofit trucks by VDL
 - 2 with OPmobility modules
 - 5 with Toyota modules
- Genset with Freudenberg module
- Extension to SOFCs planned
- Standard submitted to IEC TC105
 - New item proposal approved 11 vs. 3
 - Working group 110 established



(not to scale)

Conclusions

- Standard for fuel-cell modules prepared with inputs from FCM suppliers and OEMs
- Prototypes built and thoroughly tested, compliant designs published
- Lowered barriers to develop hydrogen vehicles
- Opened for competition

Conclusions

- Standard for fuel-cell modules prepared with inputs from FCM suppliers and OEMs
- Prototypes built and thoroughly tested, compliant designs published
- Lowered barriers to develop hydrogen vehicles
- Opened for competition

Thank you for your attention!



Towards a standardised fuel cell module

Standard-Sized Heavy-duty Hydrogen

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement № 101005934. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Any contents herein reflect solely the authors' view.

The FCH 2 JU and the European Commission are not responsible for any use that may be made of the information herein contained.



Co-funded by
the European Union