Fuel-cell based power generation FCGEN (277844)

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PROJECT OVERVIEW

- **FCGEN (Fuel Cell Based Power Generation)**
- **Call topic:** SP1-JTI-FCH.2010.1.5 APUs for Transport Applications
- **Application Area:** Transportation & Refuelling Infrastructure
- **Duration:** November 2011 – May 2015
- **Budget:** 9,309,998 € (FCH JU contribution, 4,010,884 €)
- **Consortium overview:**

PowerCell, Volvo, Johnson Matthey, Modelon, "Jožef Stefan" Institute, Jülich Forschungszentrum, Fraunhofer ICT – IMM

- **Short summary:** The main objective of the FCGEN (*Fuel Cell based Power Generation)* project was to **design, develop, and demonstrate a proof-of-concept diesel-powered PEM fuel-cell based 3 kW_e APU** in the laboratory in close to real conditions and this way prove the feasibility of PEM fuel cell technology with logistic fuels.

  The initial goal of demonstrating the first PEM APU on-board the truck has been dropped as the responsible partner left consortium and no alternative was found.

- **Project status:** finished, main goals achieved

PROJECT TARGETS AND ACHIEVEMENTS

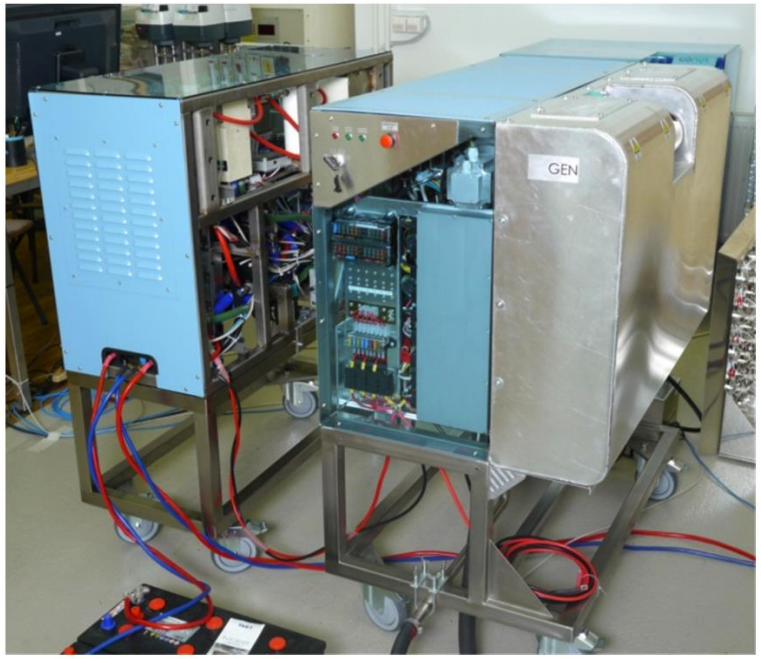
Programme MAIP objective/target	Project objective/target	Project achievements to-date	Expected final achievement
Proof of feasibility for logistic fuels	System operation using SD10	Objective reached	
Demonstration of fuel processing for logistic fuels	Design FP to handle logistic fuels & produce PEFC quality reformate	Objective reached achieved CO < 20ppm, NMHC <2ppm	
Research, development and PoC demo of APU systems for on-board power generation	develop PEMFC-APU and demonstrate in laboratory environment	Objective reached	

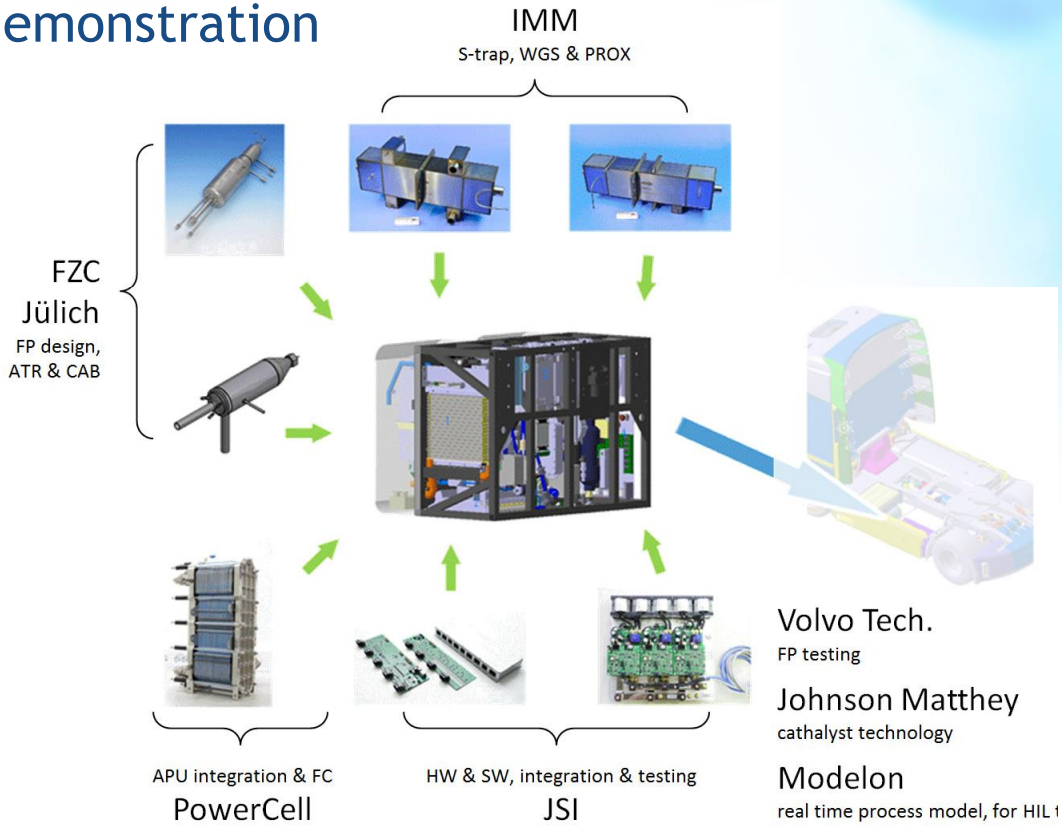
PROJECT TARGETS AND ACHIEVEMENTS

Programme AIP objective/target	Project objective/target	Project achievements to-date	Expected final achievement
Demonstration of increased efficiency and reduced CO_2 emissions and local pollutions	Net electric system efficiency of ~ 30%	~ 25% flat over operating range	means to reach >35% identified
	Emissions below MAIP	**Objective reached** NO_x NMHC CO << 1 ppm	✓
Cost 1000 € / kW, Later increased in MAWP 2011	1000 € / kW	Cost analysis: 1700€/kW in high volume with current design	*current design difficult to achieve* further reduction via simplification
Weight & size	300 kg, 500 l	current design packageable within slightly higher values	means to reduce identified

PROJECT TARGETS AND ACHIEVEMENTS

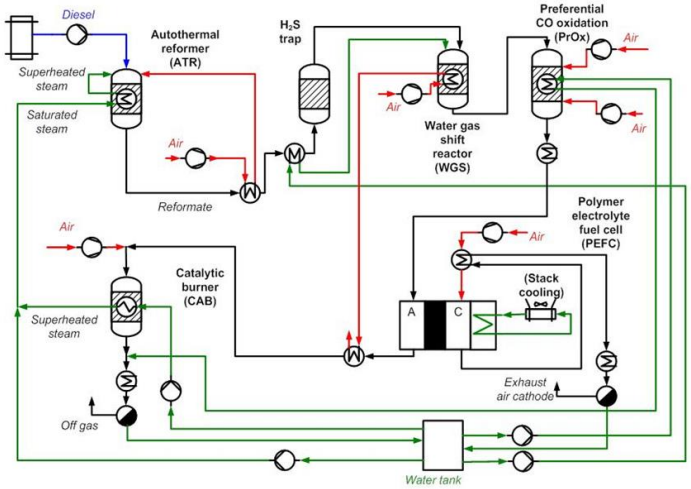
- Started with tested reactor technology, no existing assembly
- 4 project partners developed new components that had to successfully operate together – one shot, no 2nd gen prototype
- On-line collaboration on joint testing sessions – great experience
- Working prototype, APU demonstration



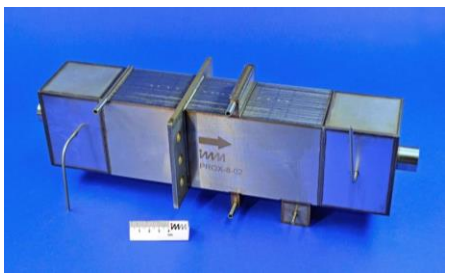


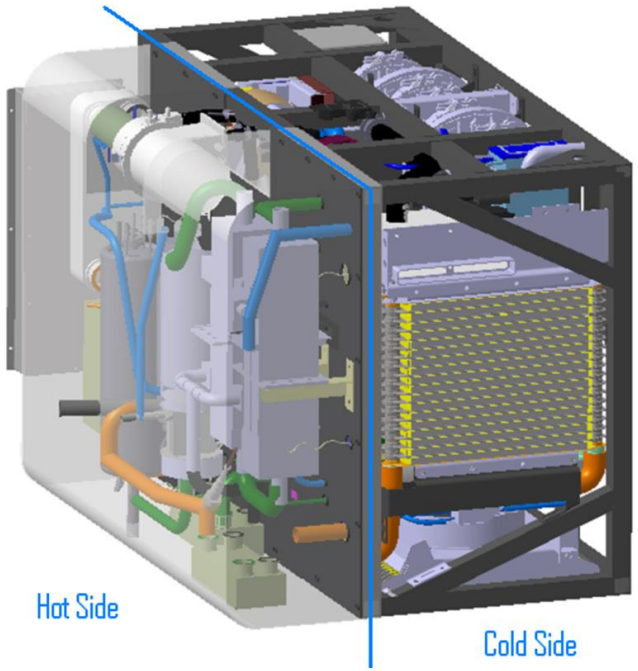
PROJECT TARGETS AND ACHIEVEMENTS

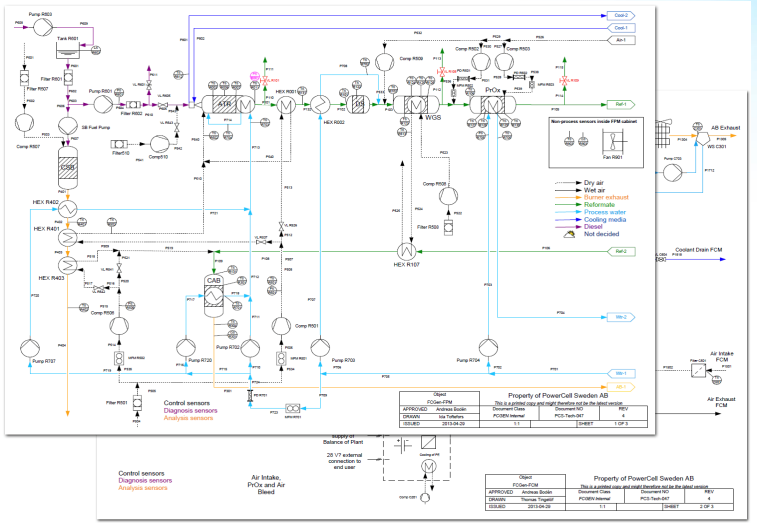
- Fuel processor design (M1)
- APU design (M2)
- BoP components selection (M3)
- FP reactors development and testing (ATR, CAB, DS, WGS, PrOx)



- maximize heat recovery
- minimize pressure drop
- ensure controlability

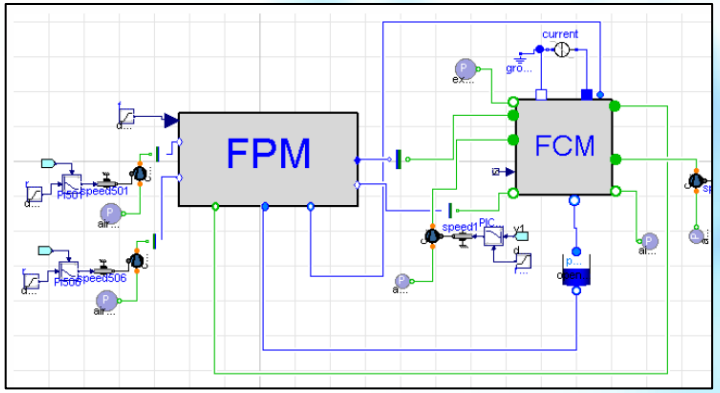


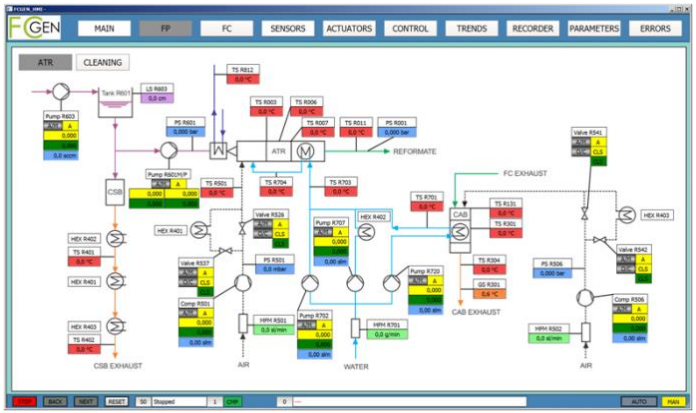


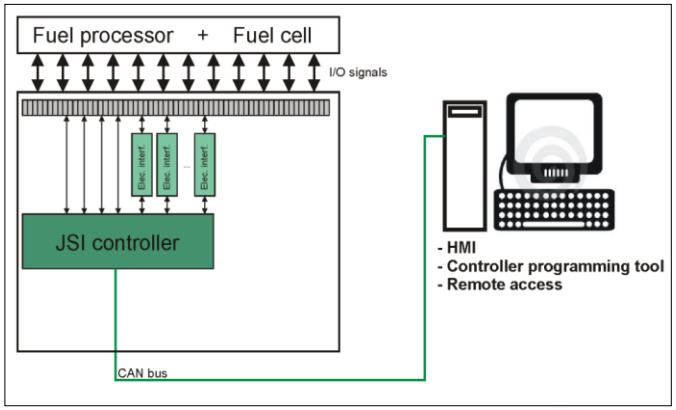


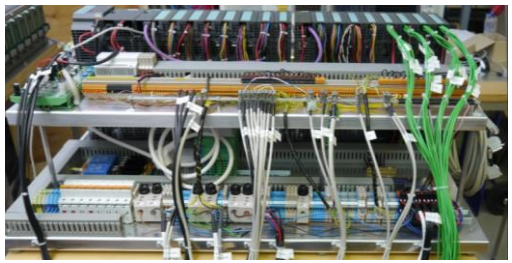
PROJECT TARGETS AND ACHIEVEMENTS

- APU model development for HIL tests
- Power conditioning development (M4)
- Control system HW & SW development (M6)









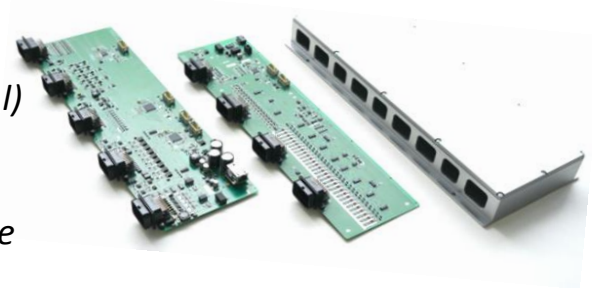
Industrial PLC

100 x 20 x 16 cm (32 l)
6 kg, no power supply
very expensive
industry standard

→

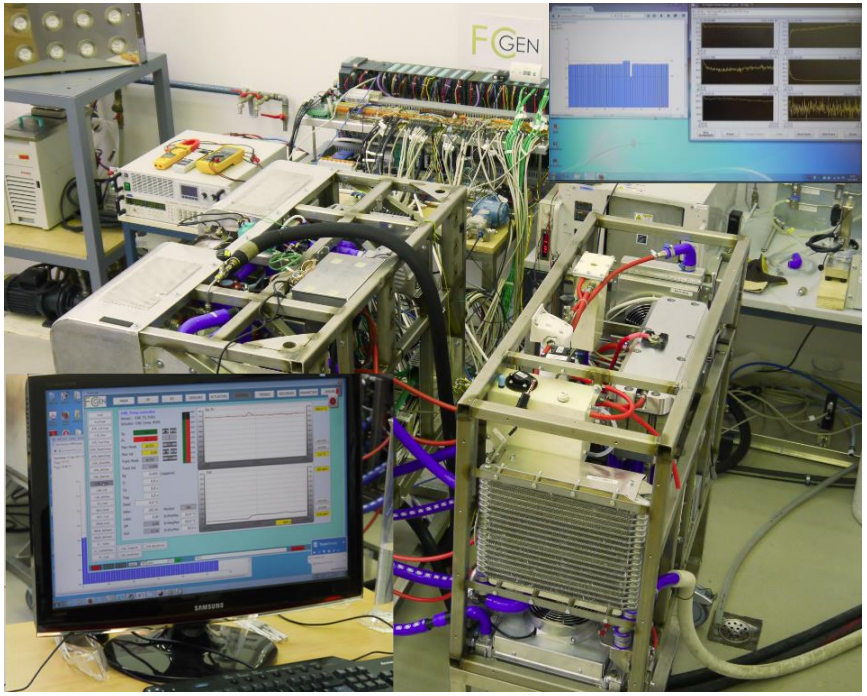
FCGEN ECU

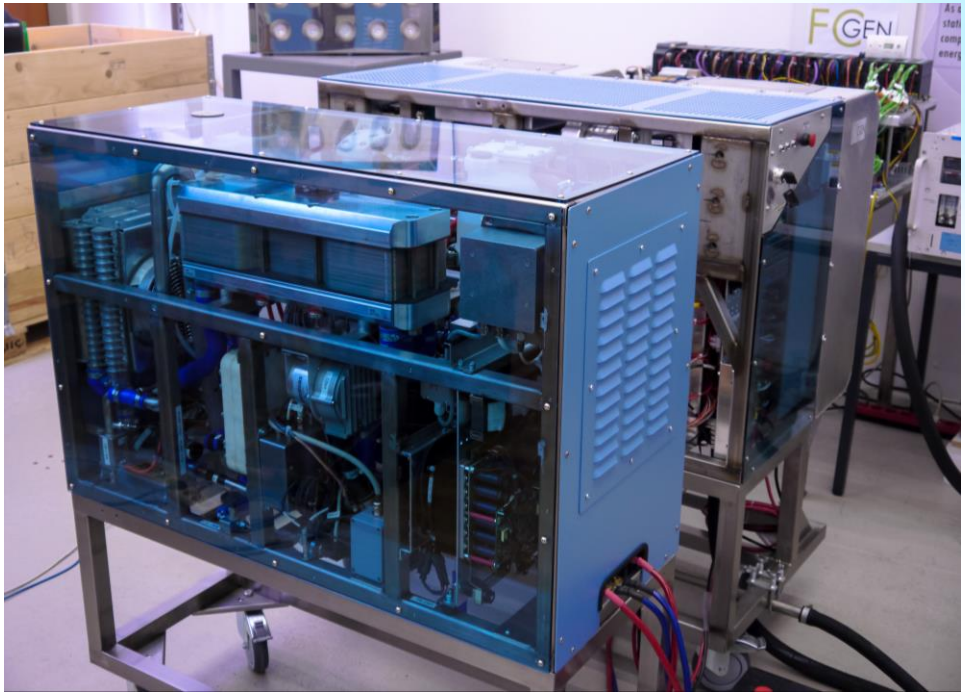
45 x 16 x 4 cm (< 3 l)
0.7 kg
affordable
close to auto-grade



PROJECT TARGETS AND ACHIEVEMENTS

- Fuel processing demonstration (M5)
  - PEFC quality reformate, load change, start/stop procedures
- APU integration and complete system testing (M7)
  - autonomous operation, flat efficiency (~25%), battery charging
  - exhaust gasses less NOx, CO, NMHC, odorless
  - remote control and operation monitoring (remote HMI & VM)





RISKS AND MITIGATION

- Risk analysis
- Technical
  - *Issues with prototypes ordered from suppliers* (start-burner, high-pressure pump)
  - *ATR damage* during testing
  - *Nozzle clogging*
  - *More heat transfer required* FP experiments revealed
- Other
  - **Truck-demonstrating partner (CRF) decides to leave FC projects**

RISKS AND MITIGATION

- Unreliable operation of high-pressure diesel pump
  - Further testing performed
  - Substitute component searched ordered and tested
- Issues with real-time APU model for HIL tests
  - Decision to re-allocate resources from full to real-time model
- Unreliable start-burner operation when installed to APU
  - Further development & testing undertaken
  - Decision to use *electric heater* for FP demonstration to prevent excessive delays and to install the orignial when ready
- ATR damaged during tests
  - Decision to pursue original test plan with damaged ATR, and replace it before final integration
  - Decision to build fuel cell module in parallel to save time (size increase)

RISKS AND MITIGATION

- Truck demonstration partner leaving project
  - Various options investigated, with signifficant effort
  - ***Project goal modified to laboratory demonstration***
- Project coordinator leaving for other position
  - ***JSI takes the coordinator role and puts additional resources*** for ATR replacement + verification FP testing
- Remaining issues
  - Resulting increased APU size & weight
  - Long-term testing of complete system (for APU level not planned, 500 hrs ATR test performed)
  - Suboptimal efficiency (simplifications in the design to achieve good controllability and reliable operation)

→ *applied for funds to address issues, increase TRL, perform 2 long-time demos*

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- FCGEN builds on HYTRAN and PROFUEL experience
- Interaction with current international-level projects
  - Cooperation on DESTA-FCGEN-SSH2S Joint Workshop: **FC based Auxiliary Power Units**
  - Interaction with **DESTA** project regarding power conditioning challenges
  - Sharing public data with **H2TRUST** project

HORIZONTAL ACTIVITIES

Safety, regulations, codes, standards, general awareness

- 2 workshops organized on ***H2 Hazard & Safety*** to identify possible risks when
  - running the APU in urban environment
  - installing APU on-board the truck
- Safety specification deliverable produced as a result

DISSEMINATION ACTIVITIES

- 18 Conference & workshop contributions (+further planned) to disseminate results, among other at:
  - EFCF 2015
  - WHEC 2014
  - WREC 2014
  - AIChE Annual Meetings (2012, 2013)
- 1 workshop co-organized (Fuel Cell based APUs, 2014)
- 5 SCI articles published (+ 3 in preparation, 2 planned) in highly rated journals,
  - Journal of Power Sources
  - Applied Energy
  - Hydrogen Energy
  - Fuel Cells
  - Energy and Fuels
- 2 German patents applied (few more under consideration)
- FCGEN web page www.fcgen.com
- Press releases
  - IMM, IJS, IEEE Spectrum, national TV

EXPLOITATION PLAN/EXPECTED IMPACT

- APU level
  - high-efficiency, high-quality fuel processing of logistic fuels
  - hazard and safety analysis pointed out critical issues/challenges for further development
  - means & redesigns identified for overall TRL increase:
    - for improvement of serviceability and durability
    - for improvement of efficiency
    - for cost reduction
    - for size and weight reduction
- Component level
  - DC/DC converter designed for FC systems (JSI)
  - ECU with versatile I/O capability with control SW and HMI (JSI)
  - cheaper fabrication technique of the clean-up reactors (IMM)
  - reduction in the platinum content with big impact on catalyst cost (JM)
  - new models integrated into FCL (Fuel-Cell Library) product (Modelon)
  - anti-clogging diesel-line design and control procedure (JSI, FZJ)

EXPLOITATION PLAN/EXPECTED IMPACT

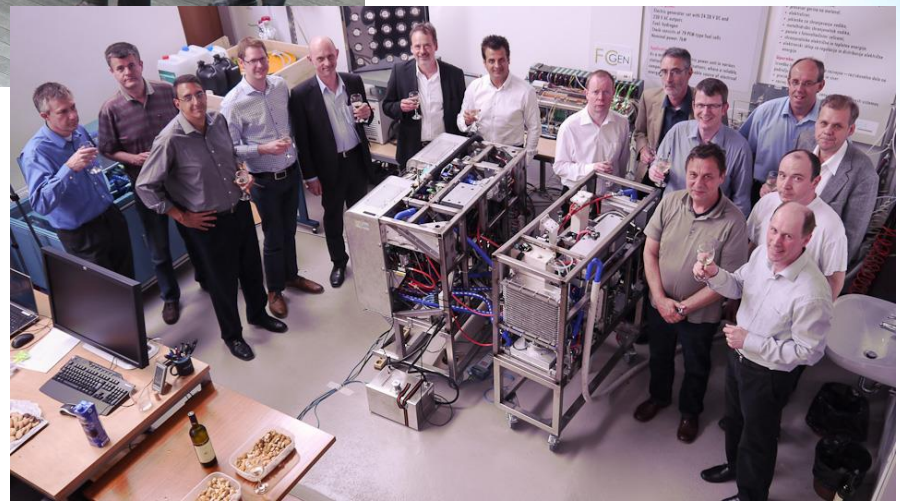
- Know-how
  - **PowerCell** will use gained ***knowhow, methodologies, and subsystems*** in future development work. The derived ***APU component models*** will be further developed and used for design and ***optimization of the future PowerCell's own APU systems***
  - **Volvo** will use the gained ***fuel reforming know-how*** for applications such as direct propulsion / range extension, and considers the gained ***knowledge on the dynamic control of complex systems*** (such as APU) essential for future applications
  - **JSI** will use FCGEN-gained experience to ***promote new technologies*** and ***support partners with cutting-edge knowhow*** to market new products and place within the establishing RES production chains
  - **FZ Jülich's** advances in ***autothermal reforming and catalytic off-gas combustion technology*** will bring benefits at designing, constructing as well as installing FC systems

MANY THANKS TO THE FCGEN TEAM & FCH JU!

Project coordinators:

- Jazaer Dawoody
VOLVO (M1-M35)

- Boštjan Pregelj
JSI (M35-M43)



"Jožef Stefan" Institute

POWERCELL

JÜLICH FORSCHUNGSZENTRUM

VOLVO

Fraunhofer ICT – IMM

Johnson Matthey

Modelon