Fuel cells and hydrogen

Joint undertaking

Low Temperature Solid Oxide Fuel Cells for micro-CHP Applications (256694)

LOTUS

Ellart de Wit

HyGear Fuel Cell Systems

New Energy World JU

fuel cells & hydrogen for sustainability

http://www.fch-ju.eu/

The LOTUS consortium

LOTUS is:

the development, construction and testing of a μCHP system based on low temperature SOFC stack technology

Duration: 3 years (1 january 2011- 31 december 2013) + extension of 6 months (30-6-2014)

Budget: k€ 2.955 → FCH- Contribution: k€ 1.632

Partner	Main task in Project
• HyGear Fuel Cell systems (NL)	Coordinator, system design and construction
• SOFCPower (I)	SOFC stack development
• Fraunhofer IKTS (D)	System modeling
• Domel (Slo)	Gas- Air system development
• University of Perugia (I)	User profile input, SOFC single cell testing
• European Commission/ JRC (B)	SOFC stack testing, test harmonization

- Associated partner: Vaillant (D)

Planning and Status

WP1
Task 1.1: R&D Management
Task 1.2: Dissemination and communication Management
Task 1.3: Administrative Management

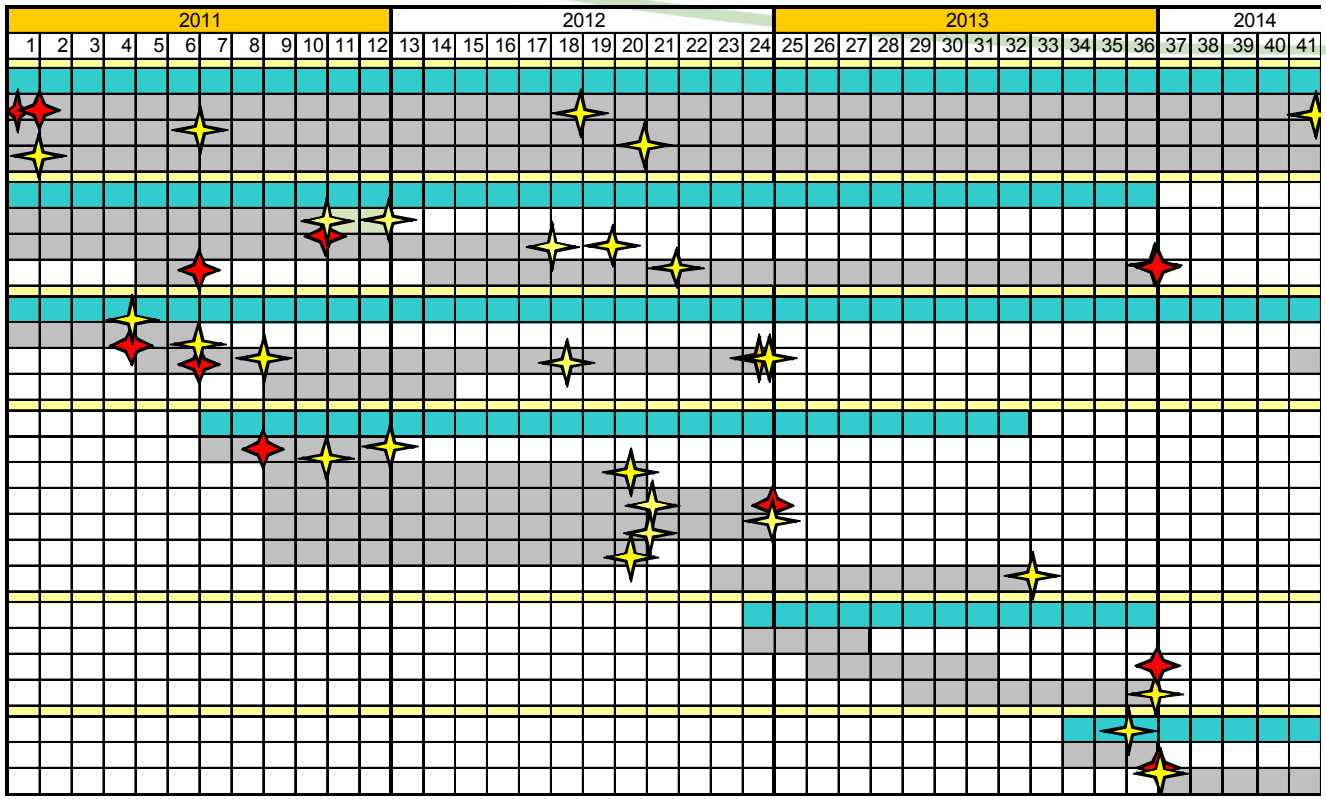
WP2
Task 2.1 Development single cells
Task 2.2. Develop Short Stack
Task 2.3. Develop and test stacks to 1 kWe

WP3
Task 3.1 SRD development
Task 3.2 System modeling
Task 3.3 Control logic development

WP4
Task 4.1 System design
Task 4.2 Develop De-Sulfurisation
Task 4.3 Develop heat exchangers
Task 4.4 Develop reactors
Task 4.5 Develop GAD
Task 4.6 Develop control strategy

WP5
Task 5.1 Procurement parts
Task 5.2 System assembly
Task 5.3 Build controls

WP6
Task 6.1 Factory acceptance test + fixes
Task 6.2 Test system

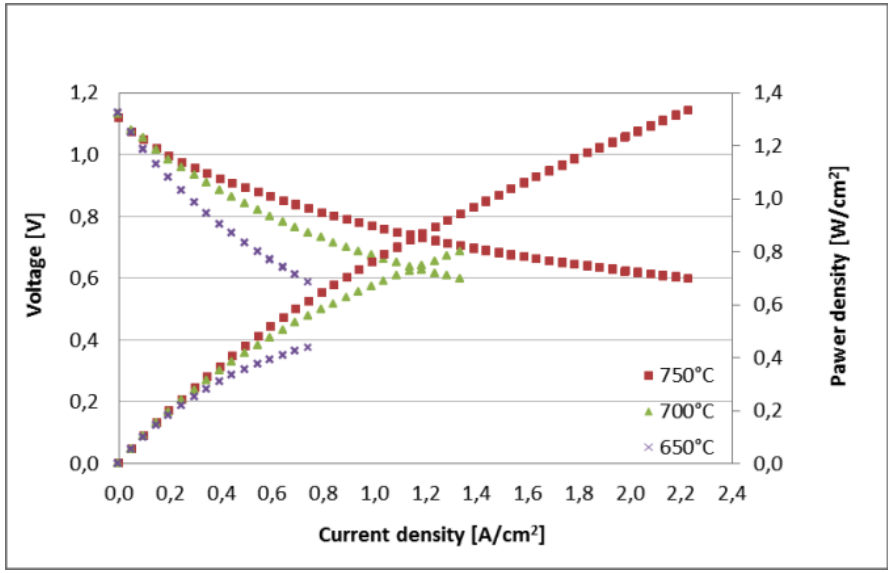


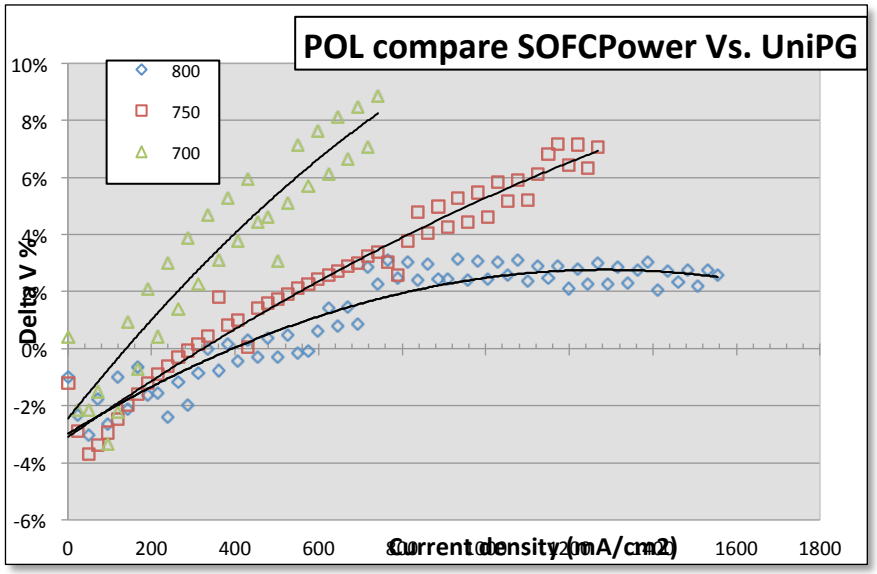
- 6 month delay due to stack production delay (origin by causes outside project)

Project achievements (1)

WP2: Cell improvements

- New material, high performances at low temperature
  - Improvement mainly cathode and barrier layer
- Performance improvements of approx. 75%
  - VI and durability tests performed
- Round robin test between SOFCpower and FClab facilities was carried out
  - Good reproducibility (<10% difference, due to temperature differences)





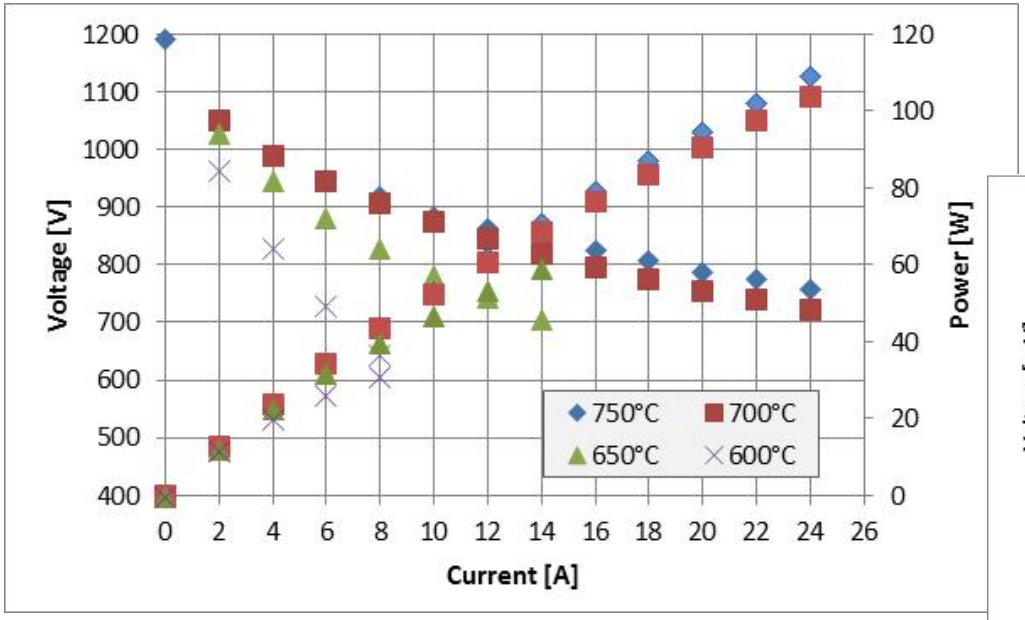
WP2: Short Stack improvements

Test conditions:

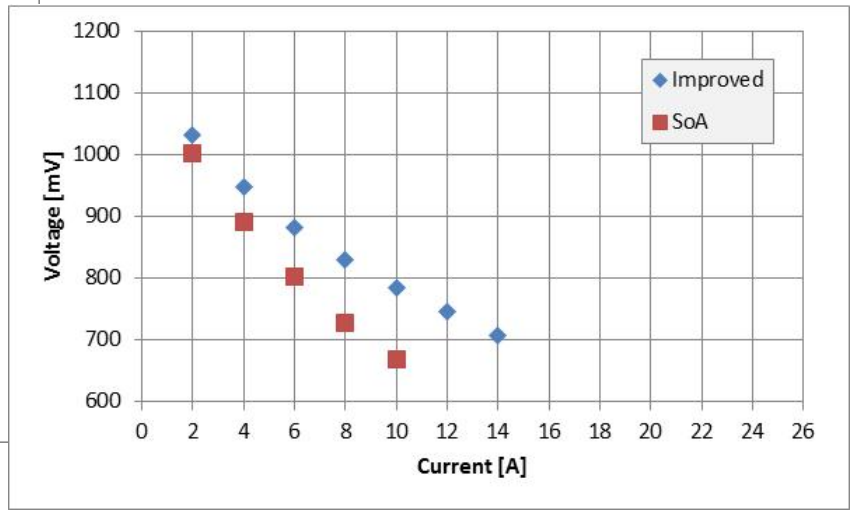
$T_{air\ out}$ = 600 - 750 C

Fuel: H_2/N_2 60/40 (H_2 = 1.44 NL/min)

Air: λ=3



Comparison between SoA (red marks) and improved (blue one) cells

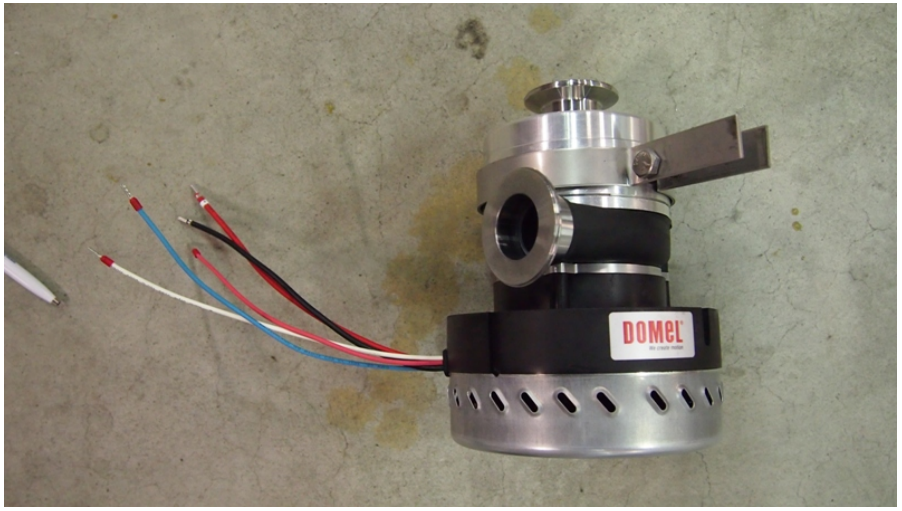


Project achievements(3)

- WP3: System Design & Modeling
  - System Requirements Document (SRD) was compiled at joint workshop
    - *Based on Customer demands*
    - *Basis for system design and process layout*
  - 0-D SOFC stack model was parameterized using ASC measurement data
    → *Basis for system performance estimation*
  - System design and preliminary process layout calculation was
    → *Basis for component design and system engineering*
  - Dynamic process modeling ready
    → *Next step validation of the model using system data*

Project achievements(4)

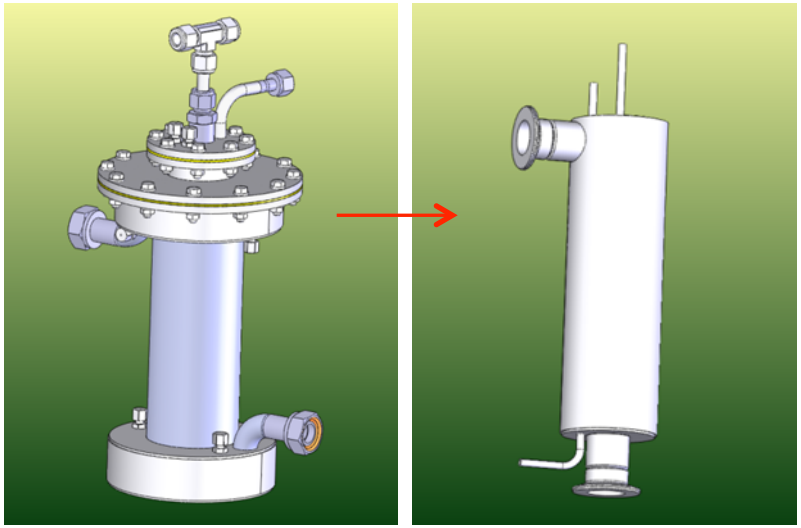
- Double staged impeller blower by Domel developed
  - Improved lifetime
  - Built and tested at Domel, prototype is delivered



- Single blower strategy→ lower number of components to improve reliability and cost

Project achievements(5)

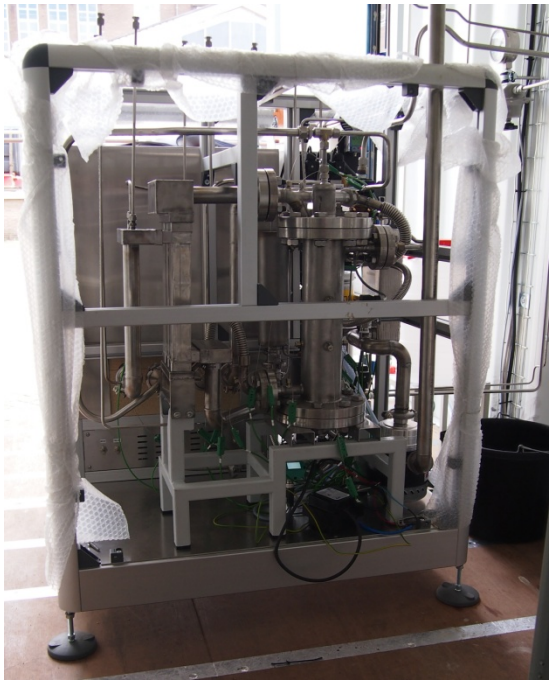
- Simplification of hardware
  - Single blower
  - Single burner
  - Certification ready design
- Modules built, tested and improved
  - E.g. second iteration on evaporator
    - First design was tested
      - providing data for modeling and testing principles.
    - 2nd generation less bulky
    - Easier to insulate
    - Low cost design
    - Same functionality: flue gas cooling, steam generation, gas mixing



Project achievements(6)

- System built together with dummy stack to develop controls without stack damage

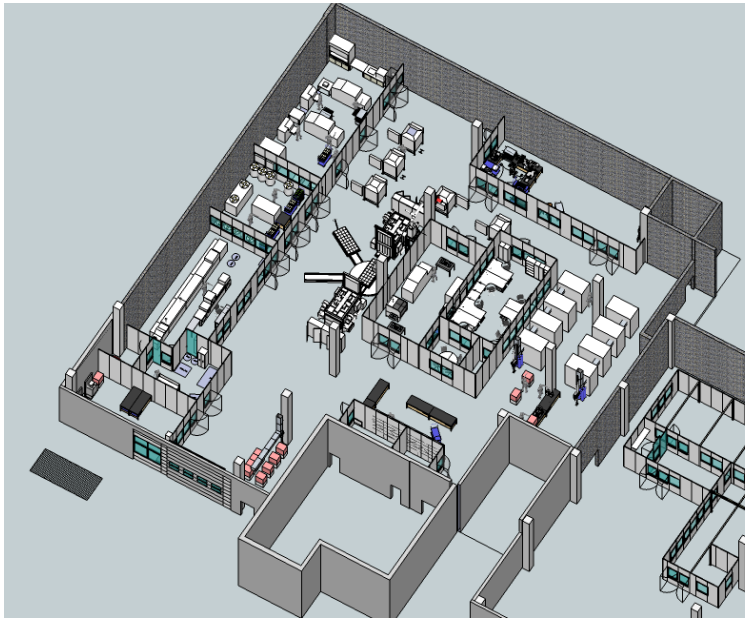
- LOTUS module testing



- The LOTUS system

Project Status

- The LOTUS project is delayed:
  - Further stack improvements on sealing need pilot production equipment – supplier of stack conditioning equipment in delay
  - Shipment damage of dummy-stack



Project Status

- Main events to come:
  - System testing (w/o stack) on-going
  - Stack delivery to HFCS dec 2013 (M 36)
  - Working prototype Jan 2014 (M 37)
  - System testing and model validation Jan – Jun 2014

2. Alignment to MAIP/AIP

- LOTUS is part of Application area AA3: micro-CHP residential, natural gas based
  - Electrical efficiency > 45%
    - LOTUS Modeling data: ±43%. Measurement data available 2014.
  - CHP efficiency > 80%
    - LOTUS Modeling data: ±80% : design for very low heat loss
  - System cost: €5000 / 1kWe in 2020

2. Alignment to MAIP/AIP

- LOTUS cost prediction: meeting the MAIP

Module/component	Cost estimate (>10,000 pcs)	Source
Stack	€ 520	Supplier info
Air Preheater	€ 650	Supplier info
Burner/Reformer assy	€ 910	Engineering calc.
Blower	€130	Supplier info
Controls	€195	Engineering calc.
CHP Hex	€130	Engineering calc.
Steam generator	€ 260	Engineering calc.
Inverter	€ 975	PV info
BoP	€ 650	Engineering calc.
Enclosure	€ 325	Engineering calc.
Total	€ 4.745	

2. Alignment to MAIP/AIP

- Cost of € 5,000/kW
  - Reduction of SOFC temperature to 650°C
    - Rational: Use of less expensive materials; Longer life-time
    - Status: single cell and short stack tests are onging with good results so far
  - Simplify system design
    - Rational: Less components lowers costs and increases reliability; Combining functions within same hardware
    - Status: New system design model made combining functions: e.g. 1 blower, 1 burner for start-up and peak burning, combine steam generator with gas mixing
  - Use commercial available components
    - Rational: Use of less expensive materials: proven reliability and long life-time
    - Status: several components sourced and in house

2. Alignment to MAIP/AIP

- Develop system for real market conditions
  - LOTUS will deliver a prototype unit
  - BUT, is based on Voice-of-customer demands and requirements
    - System Requirement Document finished
  - Input from Vaillant GmbH
  - Input from market analysis HyGear, SOFCPower
  - Using user profiles North and South Europe
    - Vaillant GmbH
    - University of Perugia

- Training and Education within LOTUS
  - ➢ University of Perugia makes students familiar with fuel cells and their applications
- Safety, Regulations, Codes and Standards
  - ➢ System will be designed to meet CE criteria, which includes creation of a HAZOP document and a FMEA
  - ➢ Harmonization of testplans for single cells, stacks and systems
- Dissemination and public awareness
  - ➢ LOTUS website
  - ➢ Partners are taking part in many other international projects
  - ➢ Partners are members of many (inter)national organizations (IPHE, IEA HIA, EHA, etc)

4. Enhancing cooperation and future perspectives

- Technology transfer/collaborations
  - Vaillant GmbH. as associated partner provides input on the customer specifications
  - National collaborations in all partner countries on Fuel Cell Technology
  - Specific national collaboration on SOFC CHP:
    - Italy: Efeso
  - Interactions with other EU SOFC projects: (ADEL), DESIGN…
  - Technology improvement in HyGear, DOMEL, SOFCpower products
  - Component reliability improvements

4. Enhancing cooperation and future perspectives

- Collaboration with other European funded SOFC projects: ADEL, SUAV, Design
- Partner discussions on further collaboration on-going
  - Market approach plan
  - Size range
  - Market uptake
  - JDA