Fuel cells and hydrogen

Joint undertaking

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

LOTUS

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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

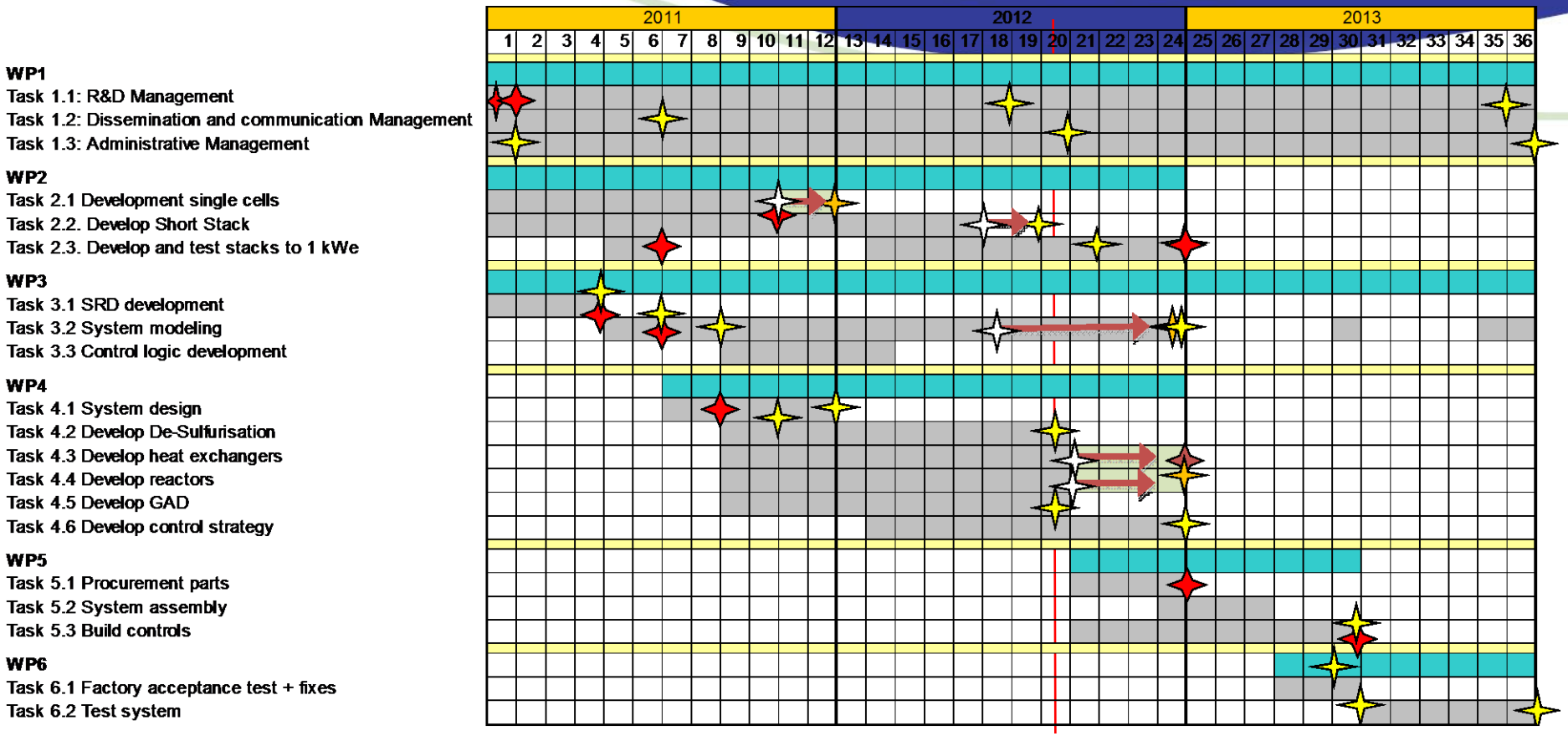
Duration: 3 years (1 january 2011- 31 december 2013)

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



- Development of hardware is making good progress:
- More time taken for developments: no impact on overall schedule or developments from partners.

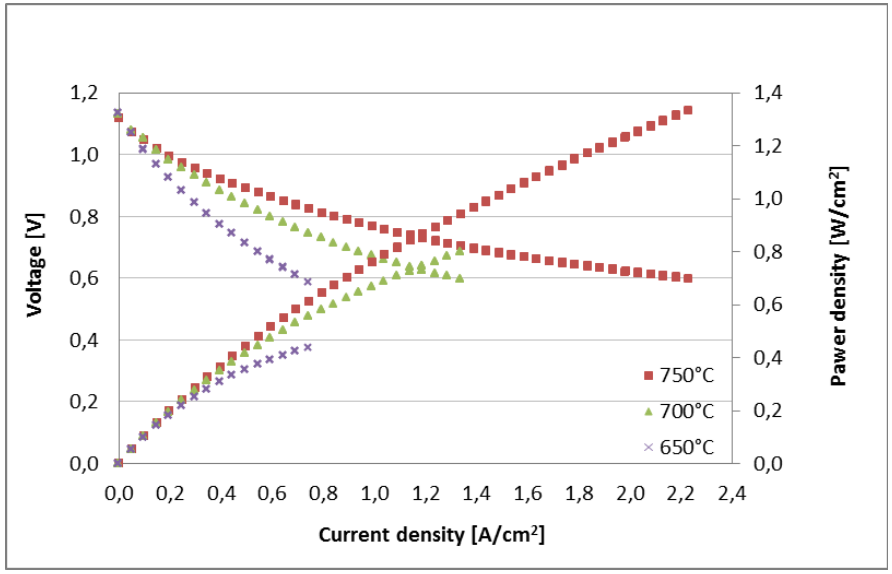
Project achievements(1)

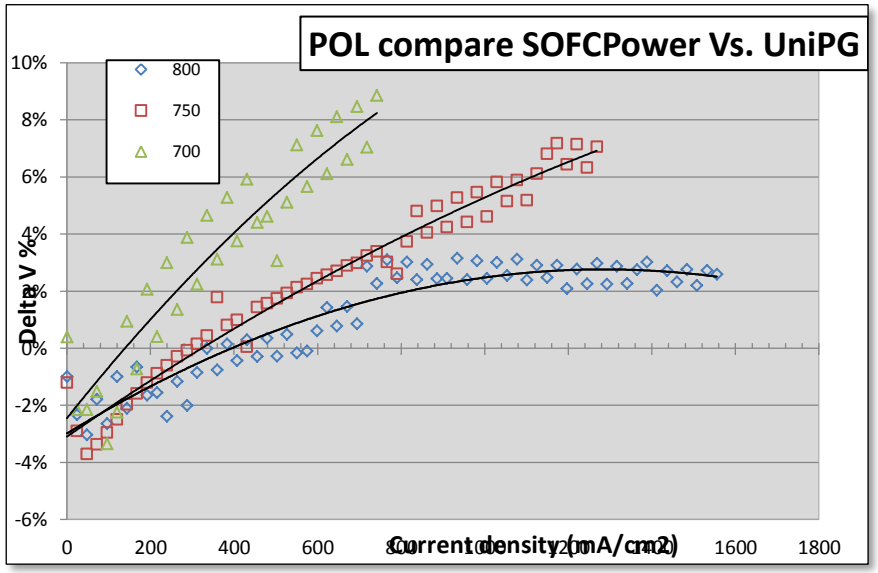
- The LOTUS project is well on track:
  - Mid term review 24 October 2012
  - Stack long term testing 4 month behind (M 17(May 2012) → M 21 (Sep 2012)
  - Dynamic system modeling 6 month behind (M18 (June 2012) → M24 (Dec 2013)
  - These delays cause no issues with in the LOTUS consortium or the overall planning, as tasks are not on critical path. Data are available, reporting to be done.
- Main events to come:
  - Stack delivery to HFCS Jan 2013 (M 24)
  - Working prototype June 2013 (M 30)

Project achievements(2)

WP2: Cell performances

- Activity focused on new material for improved performances at low temperature, developing mainly cathode and barrier layer;
- VI and durability tests performed, with performance improvements of approx. 75% in comparison to SoA cell;
- At testing level, a round robin test between SOFCpower and FClab facilities was carried out, showing good reproducibility (<10% difference, due to temperature differences)





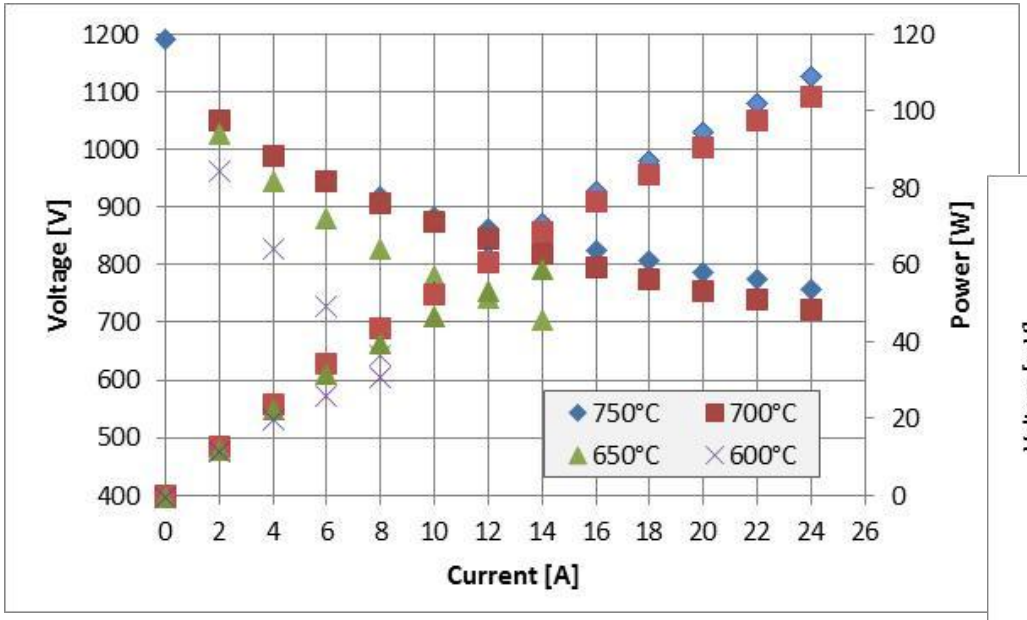
WP2: Short Stack performances

Test conditions:

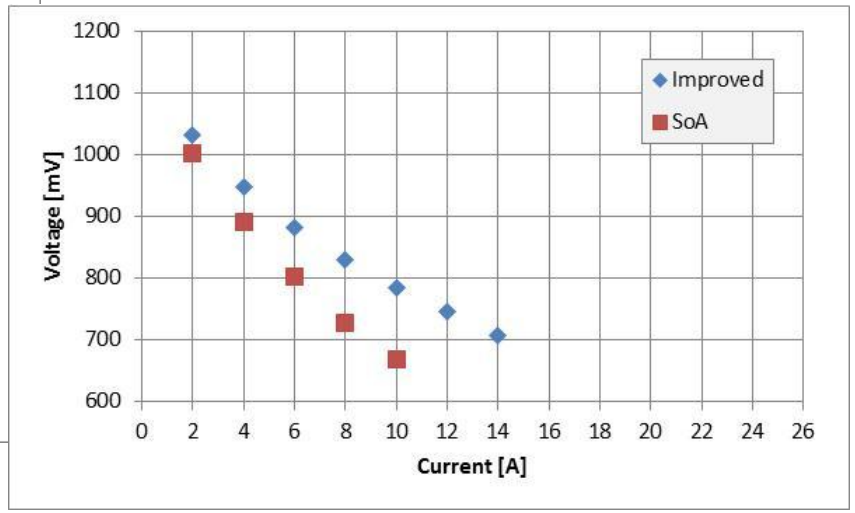
$T_{air\ out}$ = 600 - 750 C

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

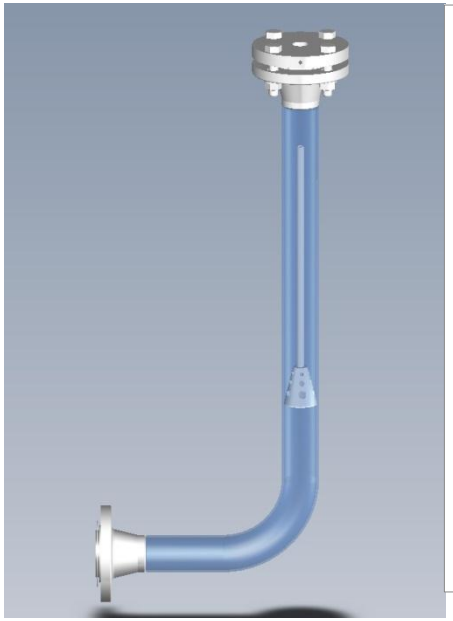


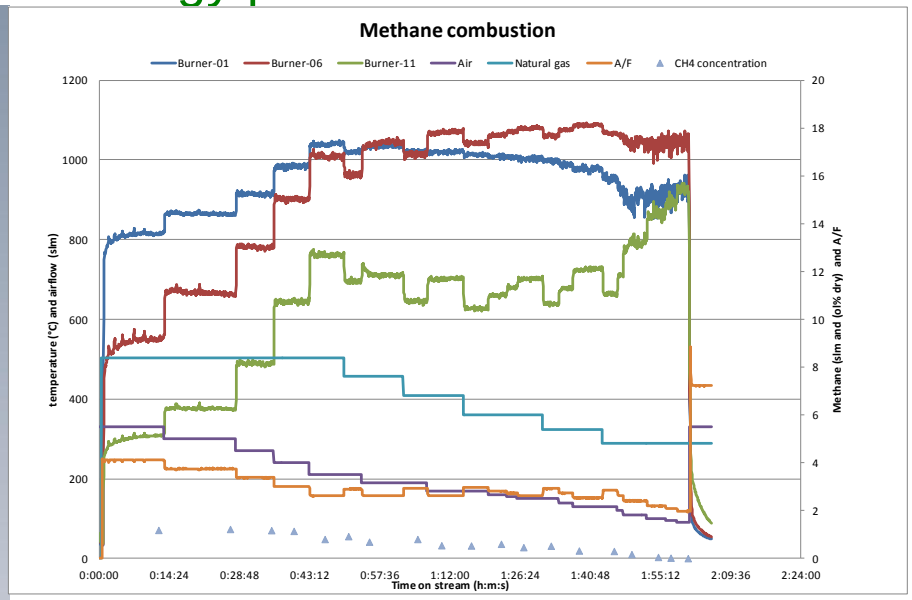
Project achievements(4)

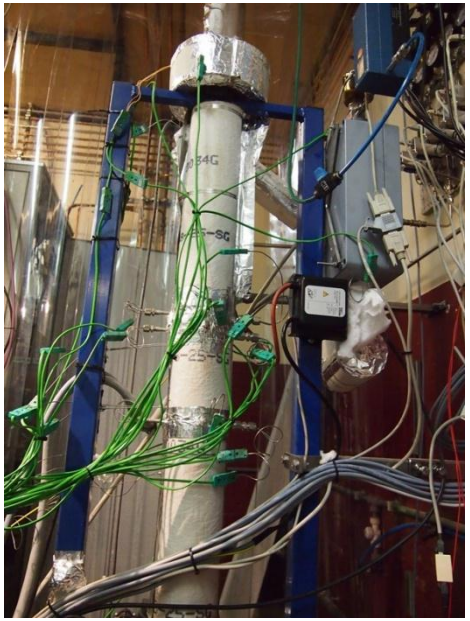
- WP3: System Design & Modeling (IKTS)
  - System Requirements Document (SRD) was compiled at joint workshop in 06/2011 (D3.1, M3)
    → *Basis for system design and process layout*
  - 0-D SOFC stack model was parameterized using ASC measurement data and development goals from WP2
    → *Basis for system performance estimation*
  - System design and preliminary process layout calculation was finalized in 09/2011 (D3.2, D3.3, M4)
    → *Basis for component design and system engineering*
  - Ongoing work for dynamic process modeling and control logic development:
    - Available Modelica-libraries evaluated for LOTUS process modeling → *"ThermoPower"-Library was chosen as development basis for dynamic process model*
    - Available Modelica-simulators evaluated for LOTUS model implementation → *"Dymola" was qualified*
    - Base classes for dynamic process model compiled and tested → *First model versions of all required system components are available*
    - Preliminary investigations of Software State Machines in Dymola → *Principle approach to model-based control logic development was prepared*

Project achievements(5)

- Dual fuel burner for anode tail gas and natural gas
  - Two step design approach: dismountable system for easy hardware changes and testing. Low cost design for production.
  - First design iteration tested and working on both H_2 and CH_4
  - One burner strategy possible: Cost reduction



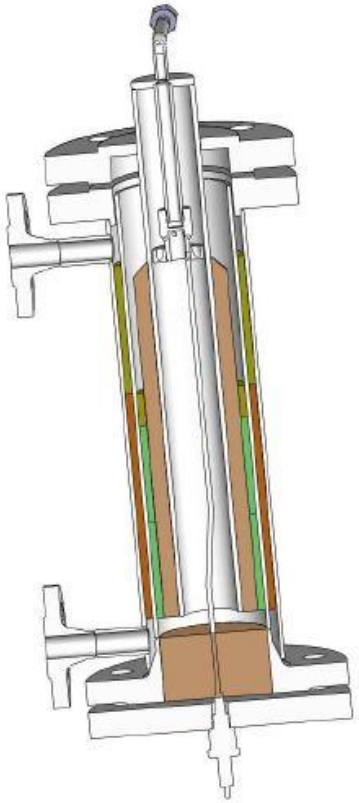




Project achievements(6)

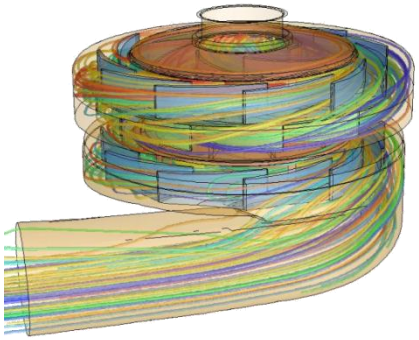
- Integrated burner and steam reformer
  - Commercial precious metal catalyst
  - Sizing limited by heat transfer, not activity of catalyst
  - Detailed design of first iteration ready (height = 40 cm)

- Steam generator/ steam gas mixer design ready
  - Component is built
  - Testing in November 2012 (M 23)
  - Time available for Second iteration, if required



Project achievements(7)

- Double staged impeller blower by Domel, to improve lifetime
  - Built and tested at Domel, prototype is ready for delivery



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

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%. Data available Y3.
  - 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 pieces)	Source
Stack	€ 520	Supplier info(SP)
Air preheater	€ 650	Supplier info
Burner/reformer assy (incl catalyst)	€ 910	Assumption
Blower	€ 130	Supplier info
Controls	€ 195	Assumption
CHP Hex	€ 130	Assumption
Steam generator	€ 260	Assumption
Inverter	€ 975	PV information
BOP	€ 650	Assumption
Enclosure	€ 325	Assumption
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 (Blower, heat exchanger) 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
  - 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
- LOTUS partners are interested in follow up demonstration project for field trials.
  - Add more end-user partners