Fuel Flexible, Air-regulated, Modular, Electrically Integrated SOFC-System

Contract No. 019875 - (SES6)
Co-ordinator: Jürgen Valldorf / VDI/VDE-IT

Project Overview

by
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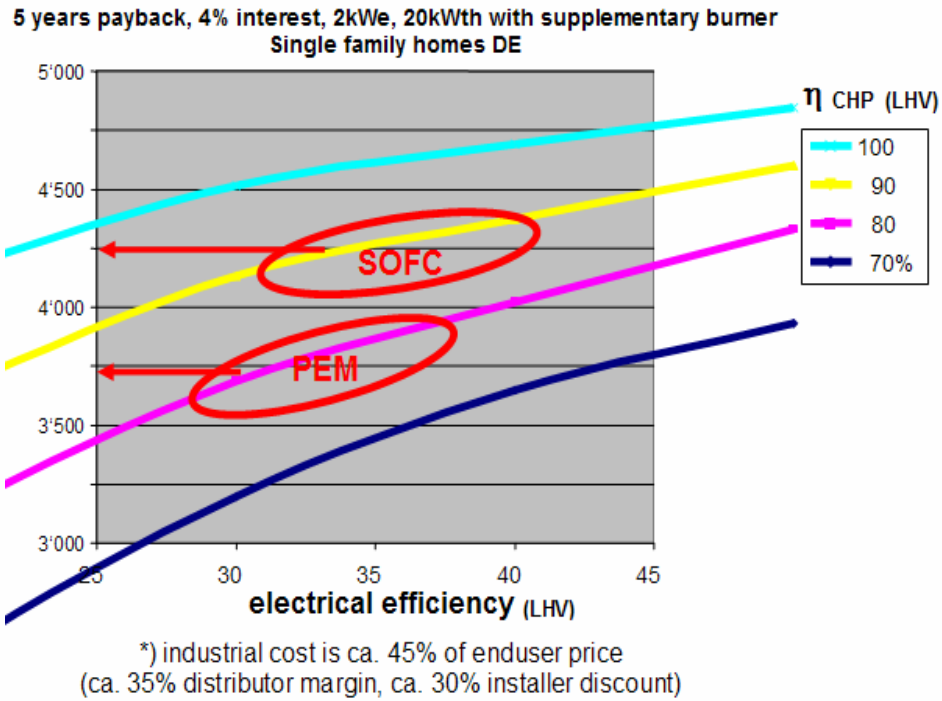
Technical Co-ordinator
on behalf of the FlameSOFC consortium

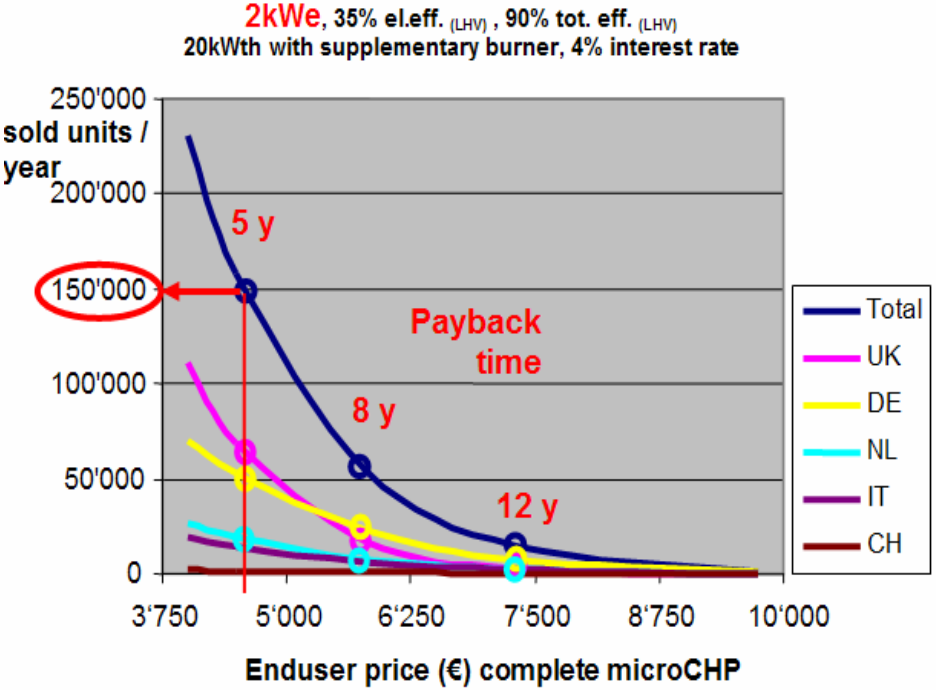
HarmonHy Final Conference, 04/10/2006, Brussels

Main Project Objectives

- **Overall target:** development of a robust stationary NG, LPG, IGO, or FAME fired SOFC based micro-CHP system.
- **Power target:** 2 kW_{el} net output (expected future mainstream high volume mass market for micro-CHPs)
- **Power modulation target:** > 1:4
- **Efficiency targets:** > 35% net electrical, > 90 % total CHP efficiency
- **Durability target:** > 30.000h (no catalytic components; limitations mainly at the SOFC stack level)
- **Cost targets (for series production > 20.000 pieces per year):**
  - < 1950 € for the complete micro-CHP
  - < 400 €/kW_{el} concerning the stack components
  - < 100 €/kW_{el} concerning the inverter power electronics
- **Start-up time:** significantly less than 60 minutes
- **Main target application:** domestic micro-CHP for single or two-family homes with electrical grid connection (further potential as backup power unit, up-scaling)

Market situation / MTS study
2 kW_{el} case; enduser price and market volume

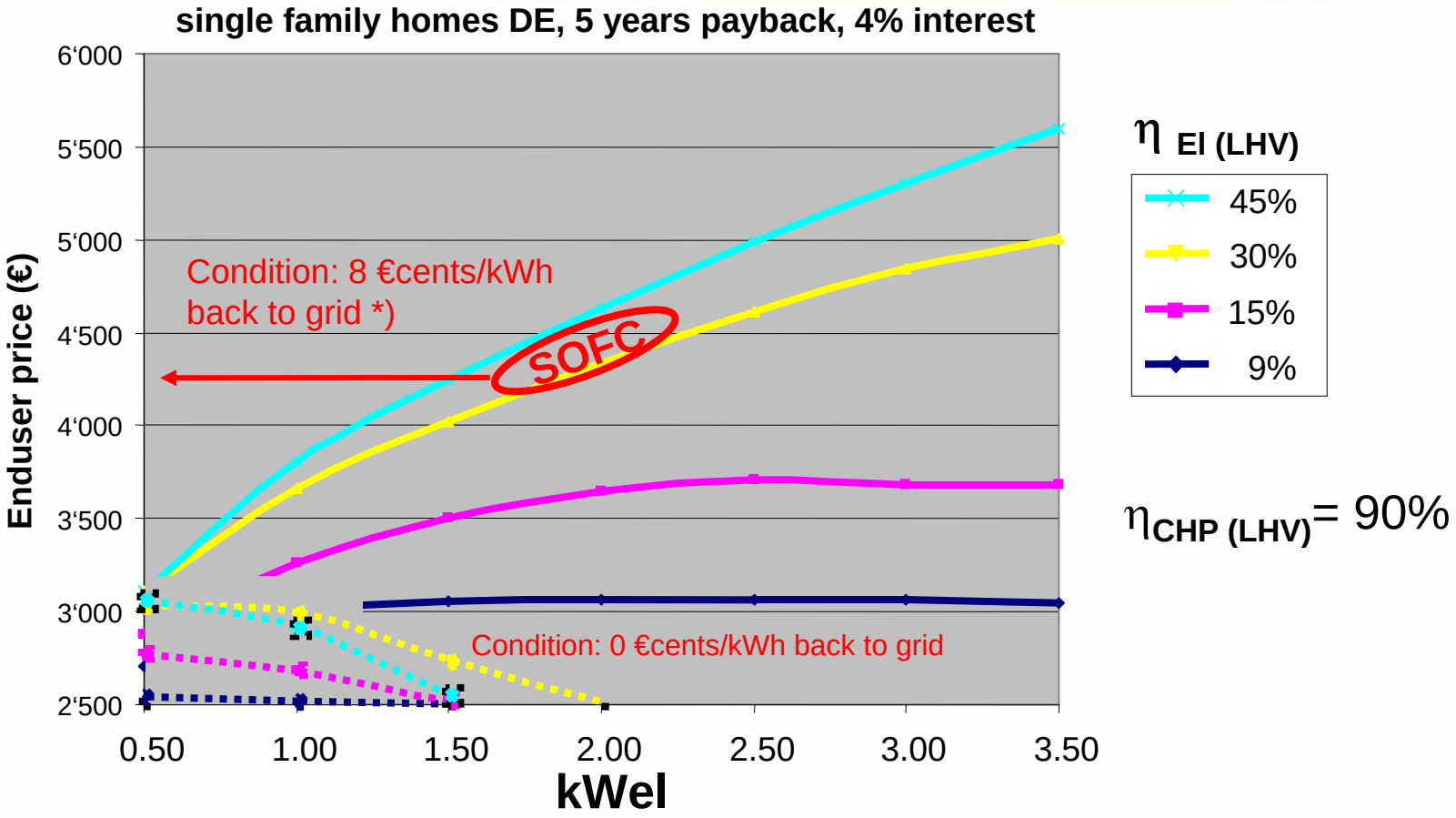




Enduser price target for SOFC and PEM CHP units at 5 years payback

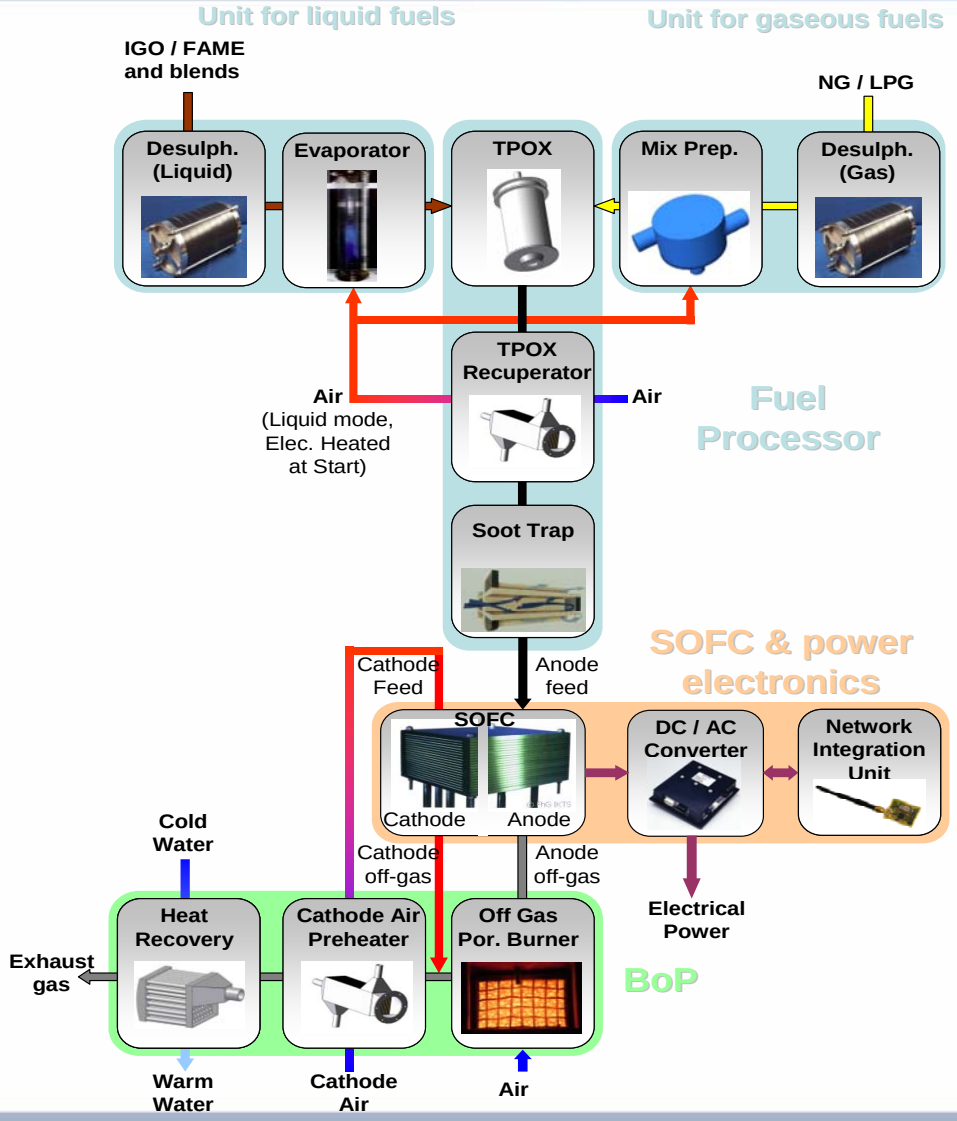
SOFC micro-CHP demand curve for single/two-family homes (natural gas)

Market situation / MTS study
Optimal size analysis



***) German law for microCHP** assures a buy back price for electricity back to the grid of about 8 €cents/kWh (ca. the half of the electricity price); **DIRECTIVE 2004/8/EC on the promotion of cogeneration** (27)
... Especially for small scale and micro-cogeneration units access to the grid system of electricity produced from high-efficiency cogeneration may be facilitated subject to notification to the Commission.

Proposed technological solution



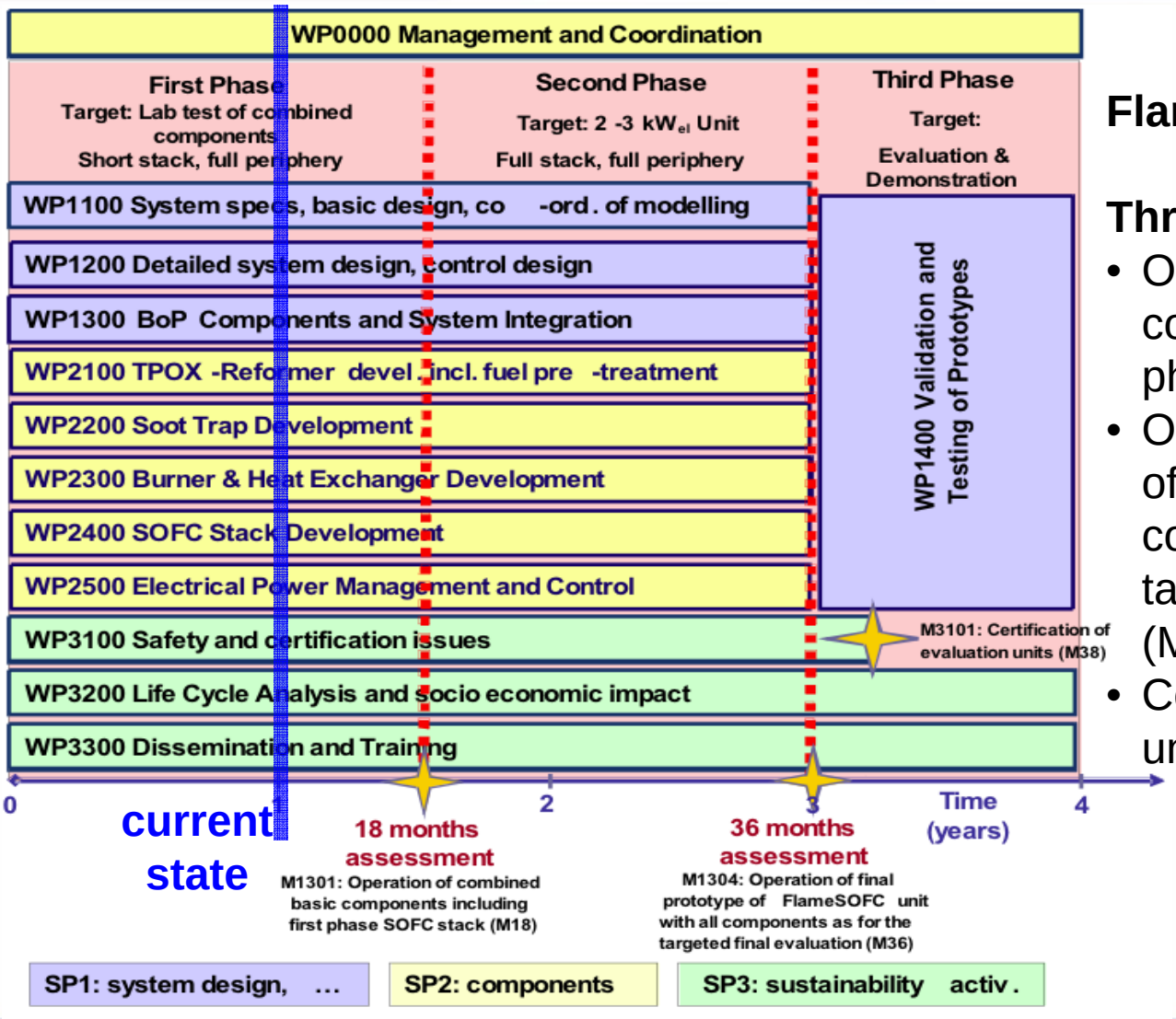
The overall **proposed technological solution is significantly simpler and innovative** in comparison to existing practice:

- No sensitive catalysts are used for the fuel processing, enabling a long durability
- No de-ionized water management is needed
- The large operational windows of the individual components and the additional operational safety given by the soot trap yield a robust non-sensitive design
- Multi-fuel feedstock is enabled
- Up-scalable and potentially low-cost SOFC technology is applied

Partnership

Partner number	Partner short name	Name	Type	County
1	VDI/VDE-IT	VDI/VDE Innovation + Technik GmbH	SME	DE
3	MTS	MTS GROUP (Merloni TermoSanitari SpA)	IND	IT
4	FED	Fagor Electrodomesticos S. Coop	IND	ES
5	EBZ	Entwicklungs- und Vertriebsgesellschaft Brennstoffzelle mbH	SME	DE
6	HTc	HTceramix SA	SME	CH
7	PROMEOS	PMC Porous Media Combustion GmbH	SME	DE
8	STC	Stobbe Tech Ceramics A/S	SME	DK
9	IKERLAN	Ikerlan S. Coop.	RI	ES
10	ECN	Energy research center of the Netherlands	RI	NL
11	OWI	Oel-Wärme-Institut gGmbH	RI	DE
12	UERLN	Friedrich-Alexander-Universität Erlangen-Nürnberg	UNI	DE
13	EPFL	Ecole Polytechnique Fédérale de Lausanne	UNI	CH
14	POLITO	Politecnico di Torino	UNI	IT
15	NTUA	National Technical University of Athens	UNI	GR
16	IST	Instituto Superior Tecnico	UNI	PT
17	IMPERIAL	Imperial college of science technology and medicine	UNI	UK
18	BUTE	Budapest University of Technology and Economics	UNI	HU
19	IEO	EC BREC Instytut Energetyki Odnawialnej	RI	PL
21	TU-BAF	Technische Universität Bergakademie Freiberg	UNI	DE
22	ELCO	ELCO Shared Services GmbH, MTS-Group	IND	DE

Workplan (PERT)



FlameSOFC started Oct.2005

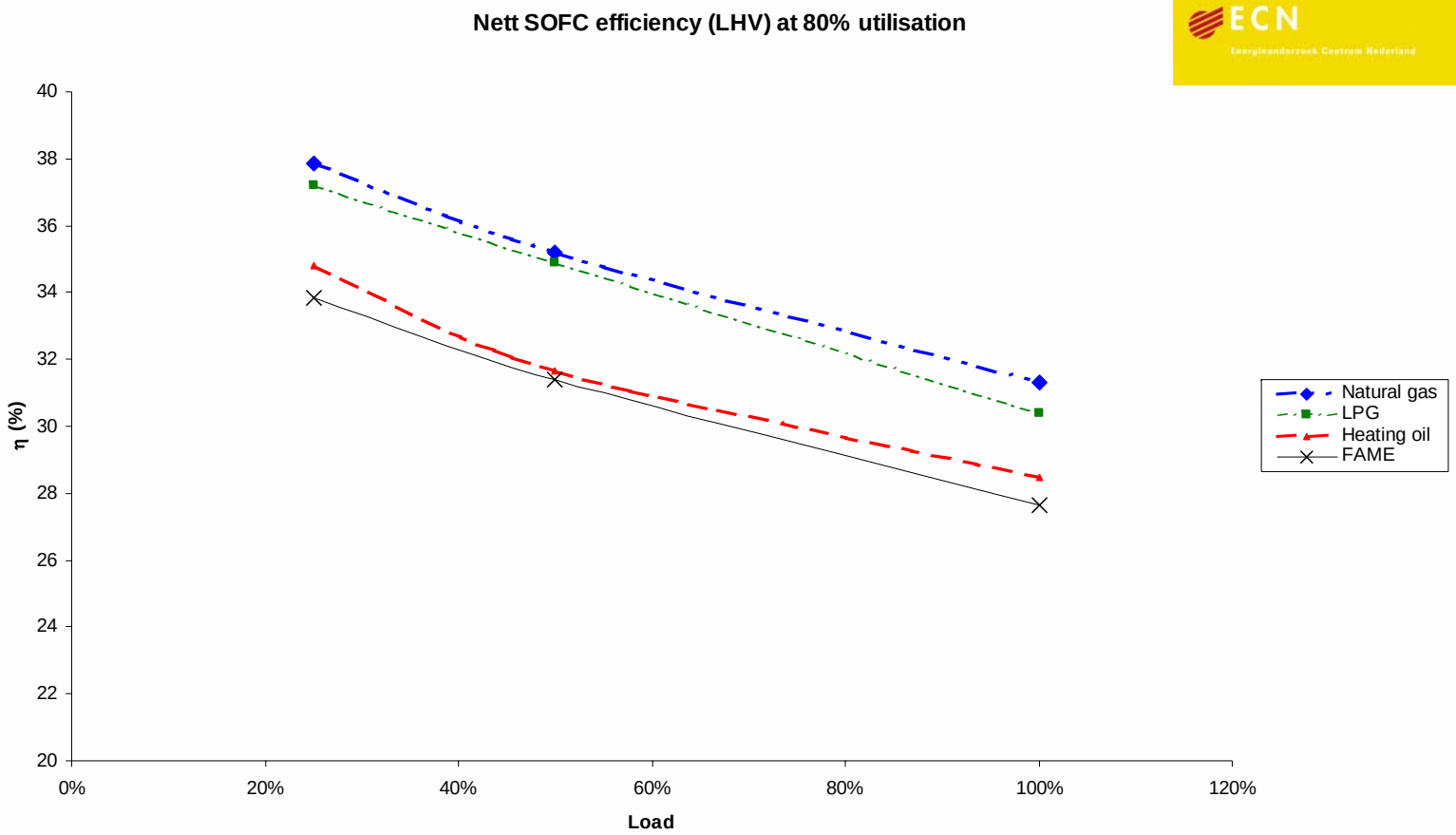
Three major milestones:

- Operation of combined basic components including first phase SOFC stack (M18)
- Operation of final prototype of FlameSOFC unit with all components as for the targeted final evaluation (M36)
- Certification of evaluation units (M38)

Current project state
Overview

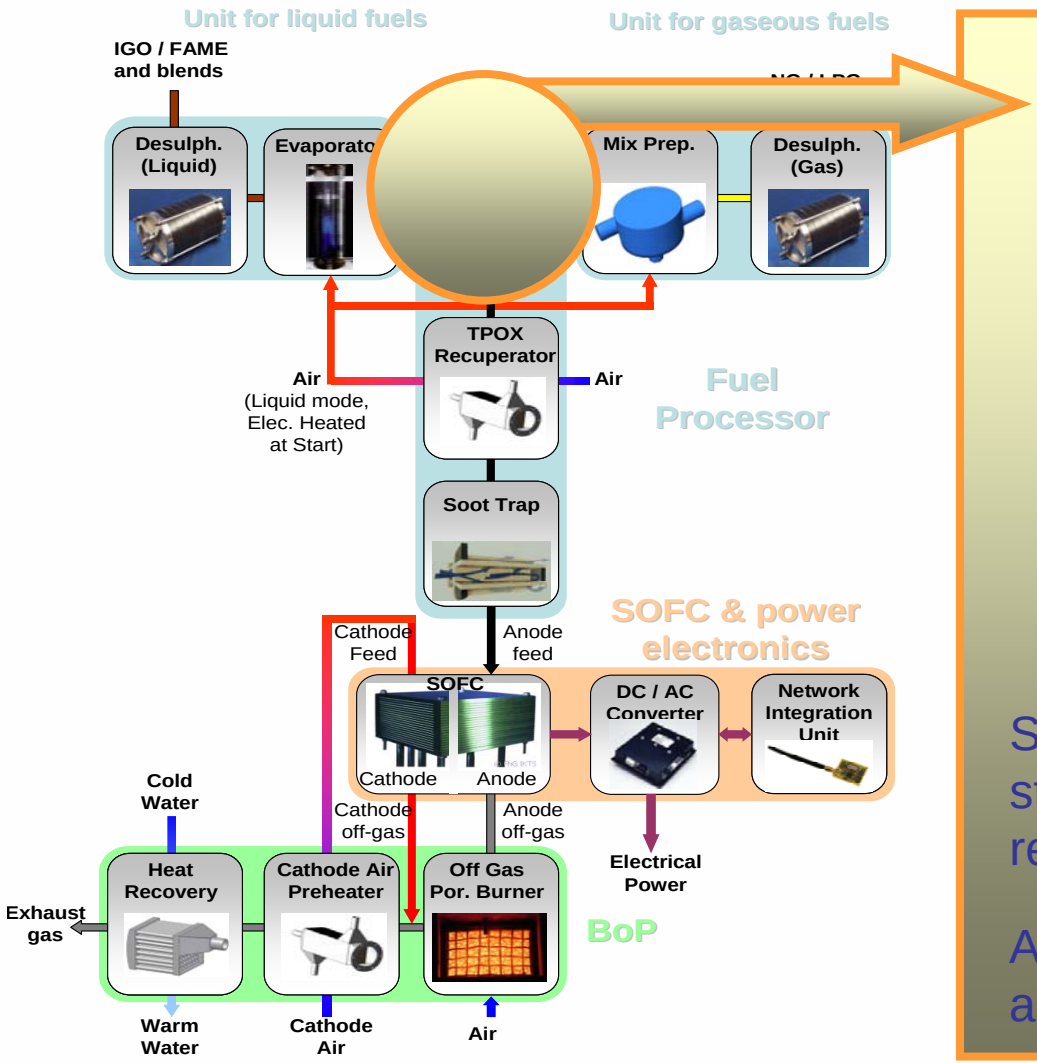
- The project started since 12 months
- First versions of all basic components are already available
- The detailed simulation tools for the component development and optimization are available or in the validation phase
- Process flow scheme, P&IDs etc. frozen for 1st phase unit (lab unit; short stack with full scale periphery)
- Integration of first phase unit starts in January 2007
- System control, selection of BoP components etc. as well as the sustainability activities (LCA, market studies etc.) are proceeding well

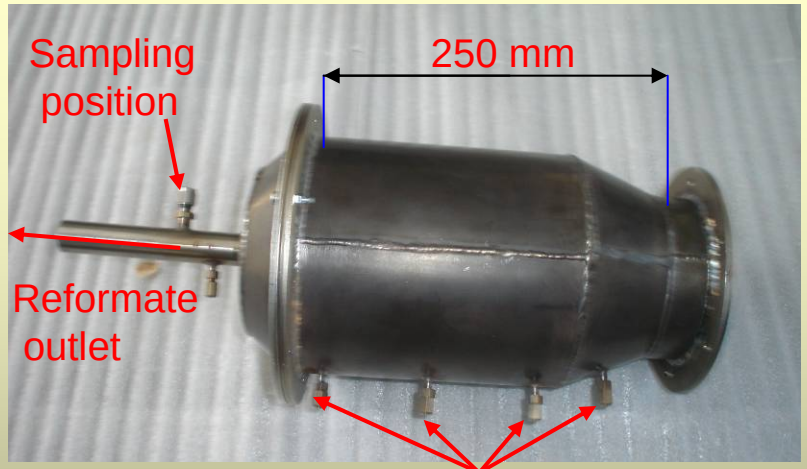
Current project state
Expected net efficiency



The process simulation (AspenOne Ver.12), considering all peripheral components and the currently available characteristics, indicates that the FlameSOFC unit will reach a net el. efficiency of ca. 30% at full load (up to 37 % at min power and NG fuel)

Current project state
Development state of selected components

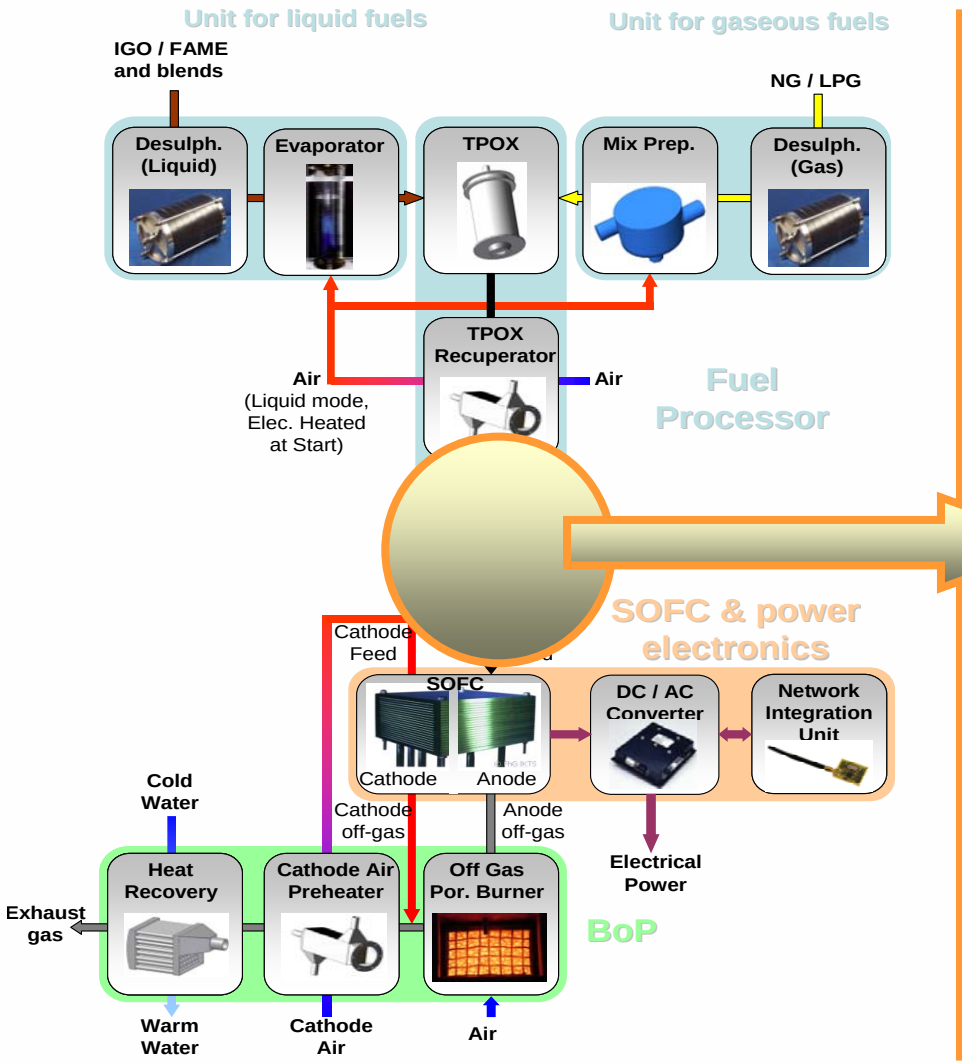




Selected porous structure for T-POX reactor: SiC foam

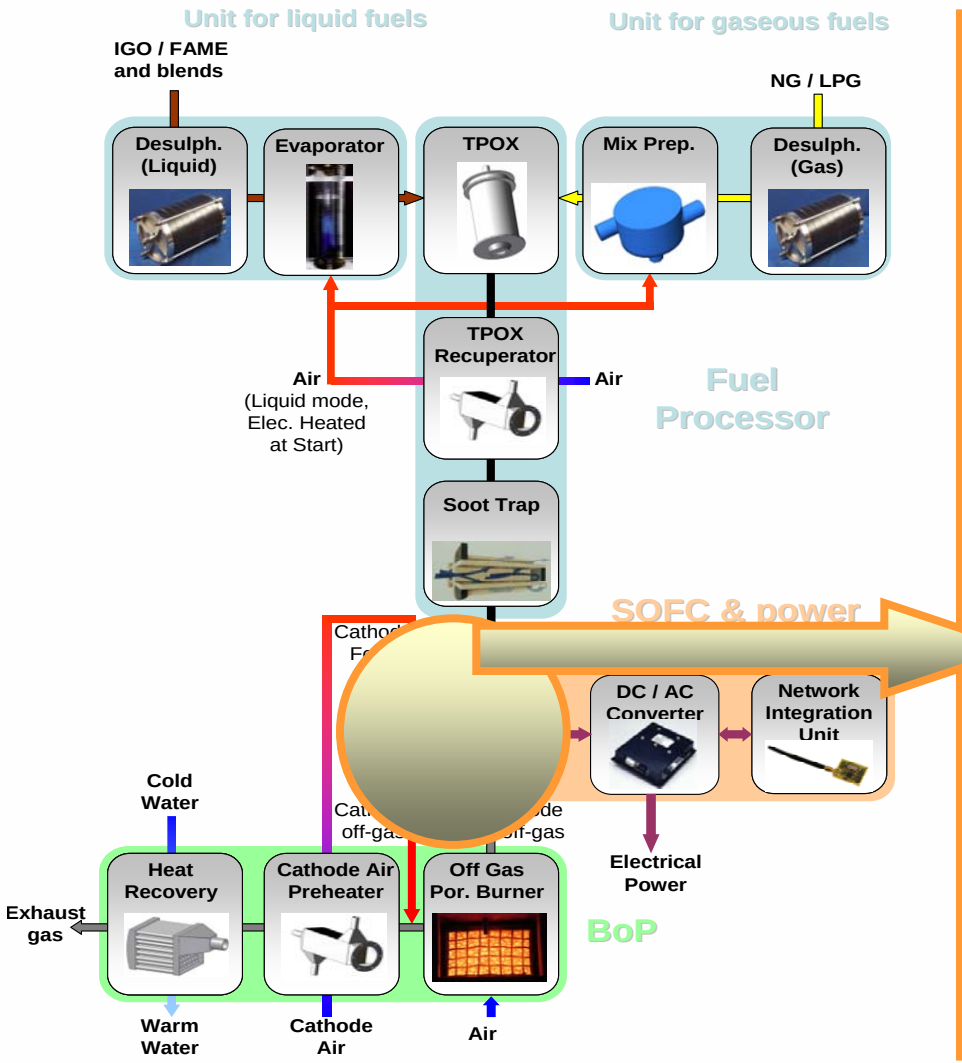
At current state soot limit at $\lambda_c = 0.42$ air ratio, target $\lambda_c = 0.4$ for NG fuel

Current project state
Development state of selected components



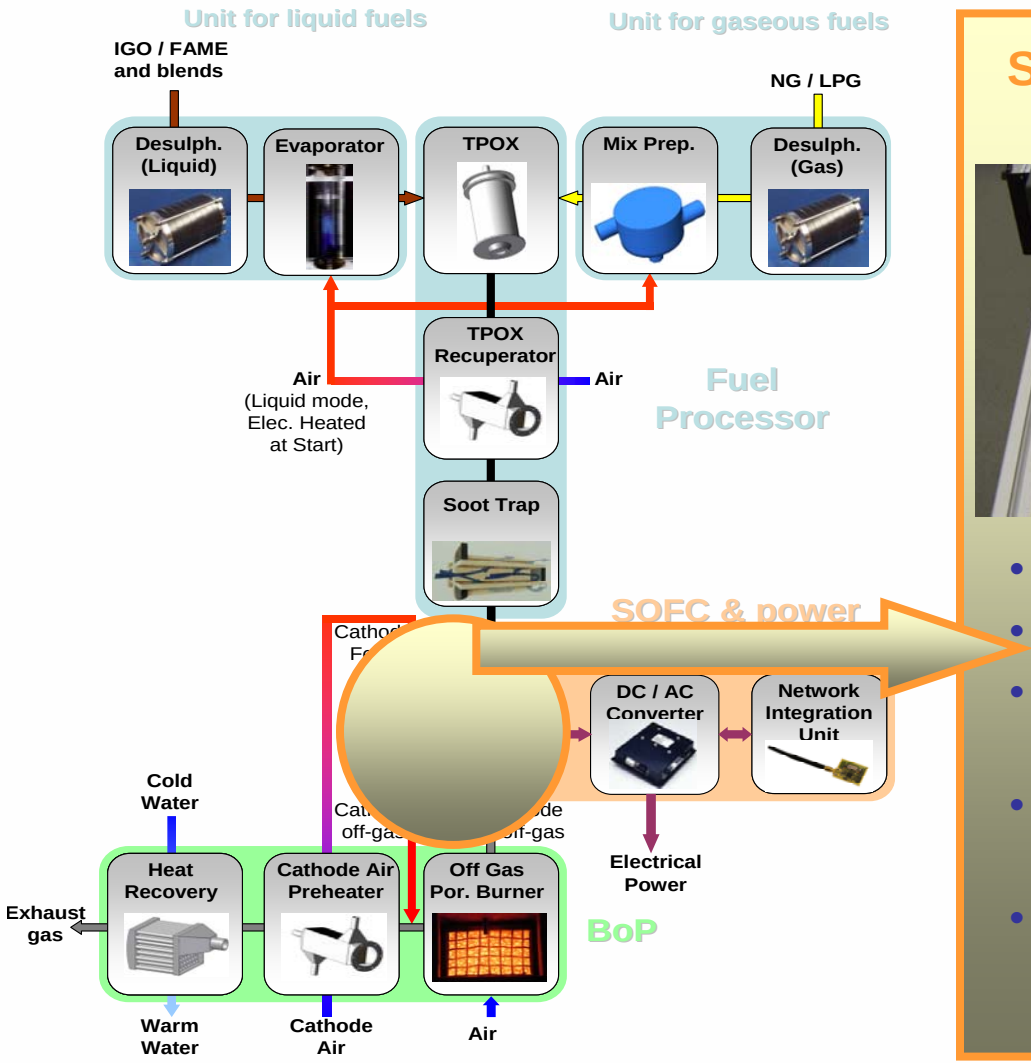
- Full size lab samples Ø144xL102 mm 150 cpsi
- Pressure drop 2 mbar (unloaded) up to 10 mbar (loaded)

Current project state
Development state of selected components

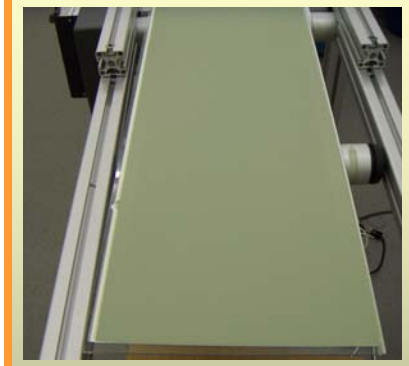


- Several stacks tested (5 to 24-cells stacks)
- 500W-class stack operated in HTc HoTBox™
- Power densities of > 400mW/cm^2

Current project state
Development state of selected components

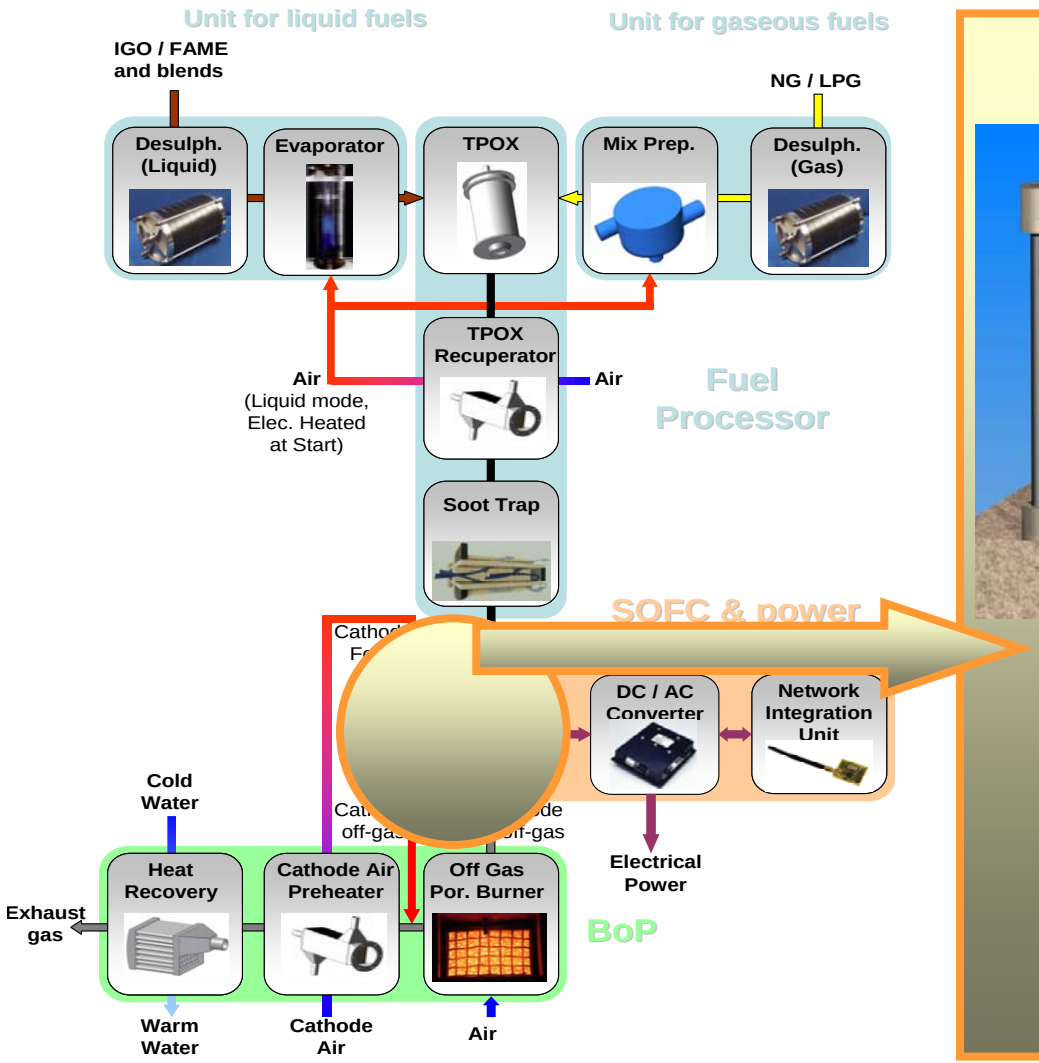


Stack components development for 2nd phase full scale stack

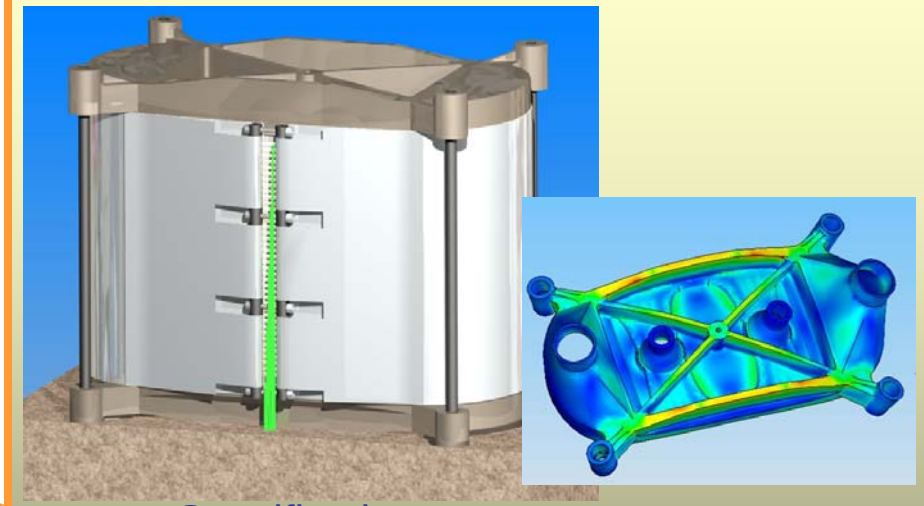


- 139 x 231 mm plain cells
- Optical QC
- New fully automatic screen printer installed for cathode deposition
- First manufacturing trials for other large area components (SOFConnex™)
- Production and QC control procedures optimization on-going

Current project state
Development state of selected components



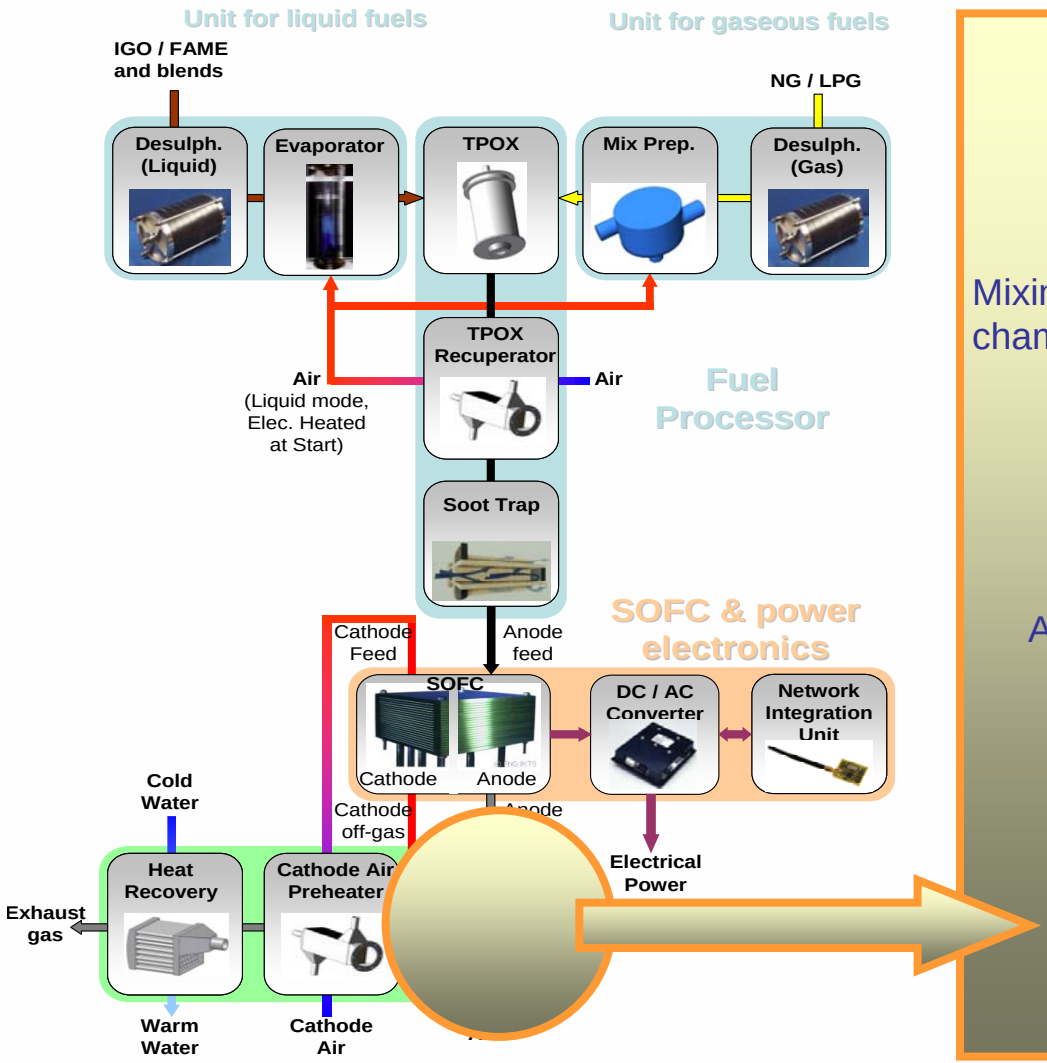
Development of 2nd phase stack

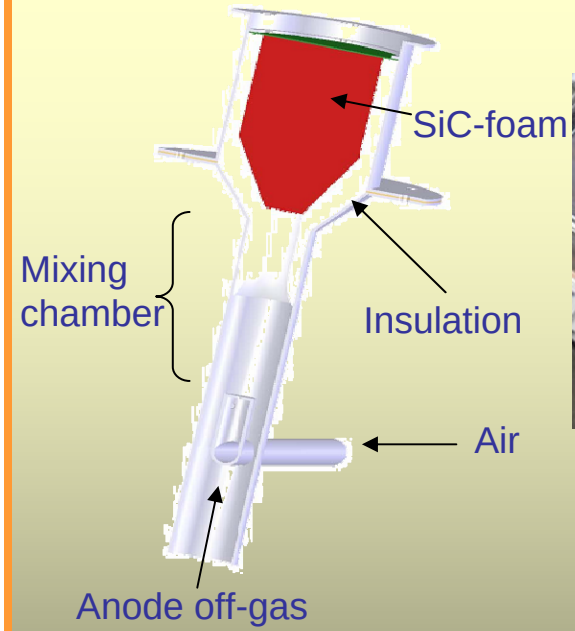


Specifications:

- Stack Power: 2.3kW$_{el}$ – 0.5kW$_{el}$
- Power density: 1kW$_{el}$/l
- Specific Power: 0.3W/cm^2
- Active Area: 200cm^2
- Nominal Pressure Drops:
  - Air side: 16 mbar
  - Fuel side: 10 mbar

Current project state
Development state of selected components





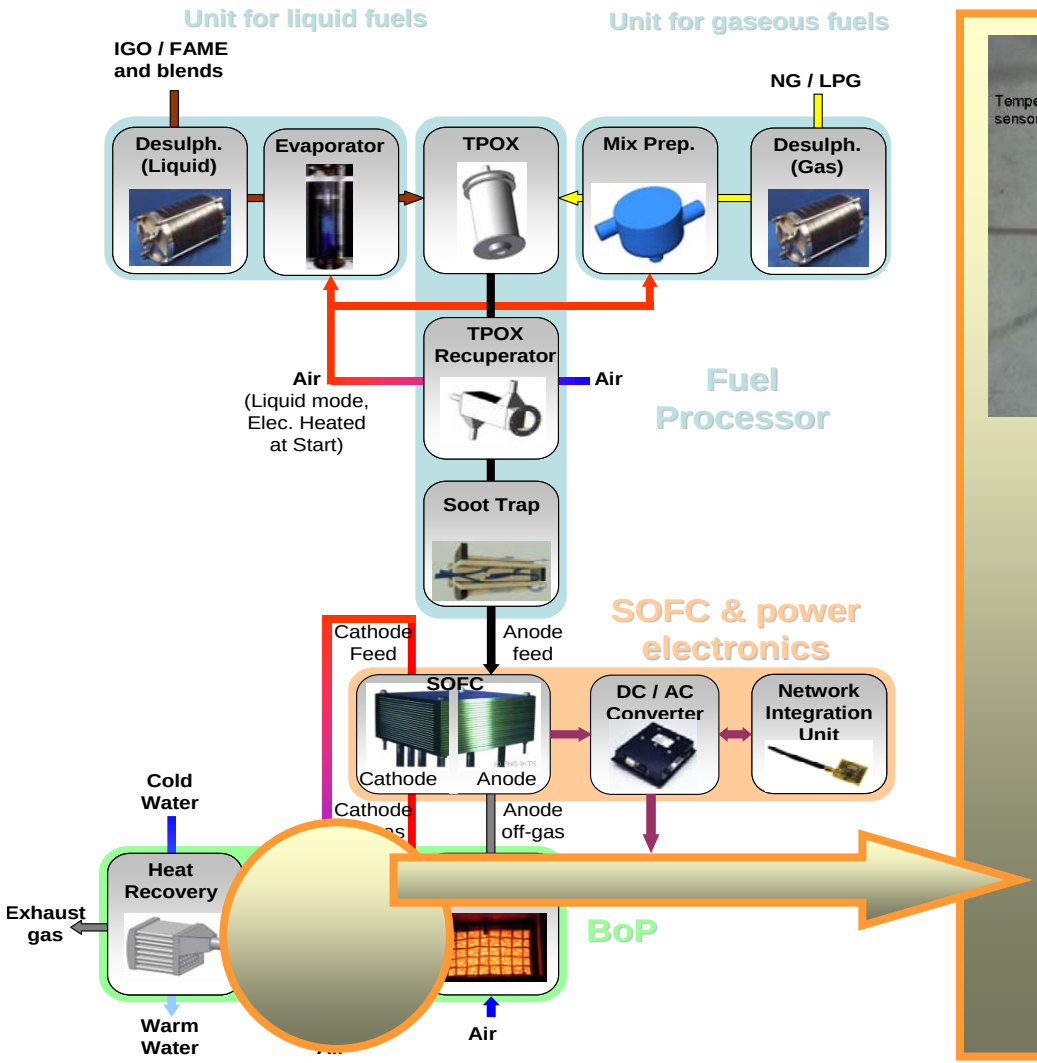
Burner in operation with reformate gas

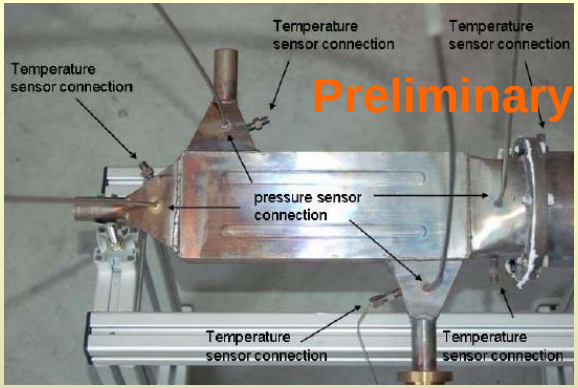
The burner can operate with reformate gas (cold/hot, start-up/load rejection) and anode off-gas (low heating value)

Dimensions:

- ø 130 mm housing diameter
- ø 80 mm x 125 mm porous body
- 10 mm wall insulation

Current project state
Development state of selected components





- Plate type heat exchanger from high temperature alloy
- Preliminary prototype almost fulfills specification from process scheme
- Optimized prototype (genetic algorithm optimization with modeFRONTIER) under construction

Final remarks

- The close collaboration between industry, SMEs, industrial and scientific research centres representing a wide variety of technological and socioeconomic expertises assure the practical realisation of the FlameSOFC micro-CHP system and indicate the pathway for a market introduction in the mid term.
- The vertical development activities on the component level (SP2000) are effectively integrated through horizontal continuously monitoring actions (SP1000) harmonizing the individual development efforts for the sake of the overall system performance optimization.
- The horizontal sustainability activities (SP3000) will elaborate the relevant socioeconomic information and indicate the necessary strategies for a wide societal acceptance of the advanced technology.
- A final concept evaluation through certified FlameSOFC micro-CHP systems in two demonstration sites will enable an overall assessment of the developed technologies and their practical performance (WP1400).
- The project started smoothly; The current development state is on track
- Results of the first integrated unit are expected in the second quarter of 2007

Thank you for your attention!