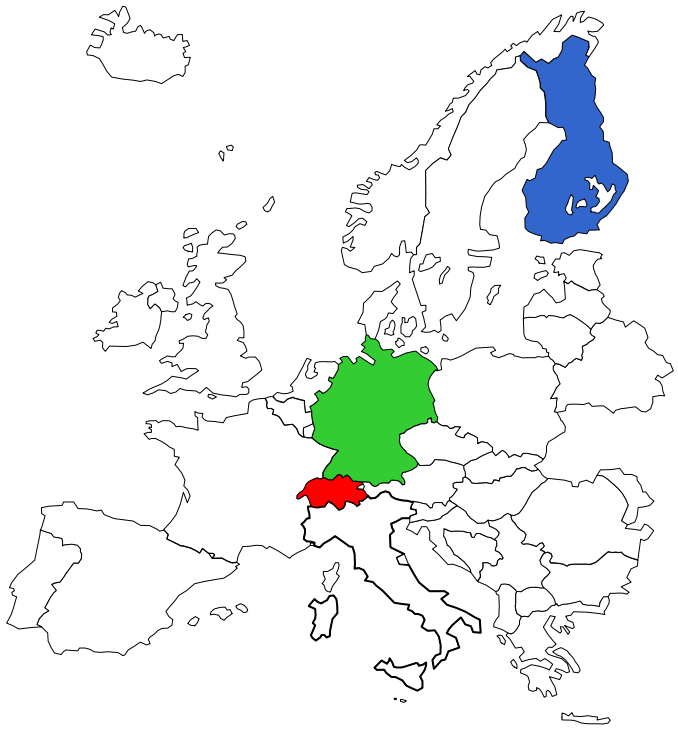
ASSENT
(Contract number 244821)

Jari Kiviaho
VTT/Chief Research Scientist

ASSENT / General Overview

Anode Sub-System Development & Optimisation for SOFC systems



3 years project: 01-01-2010 to 31-12-2012

Total budget: 4 855 k€

FCH JU Grant: 1 955 k€ (+ national 200 k€)

Participant	Country	Type
VTT	Finland	R&D
FZJ	Germany	R&D
HTc	Switzerland	SME
Hexis	Switzerland	SME
EBZ	Germany	SME
Wärtsilä	Finland	Industry

ASSENT / Goals, Target & Milestones

- The overall goal is to find optimal anode subsystem concepts that are validated for small-scale and large-scale SOFC system.

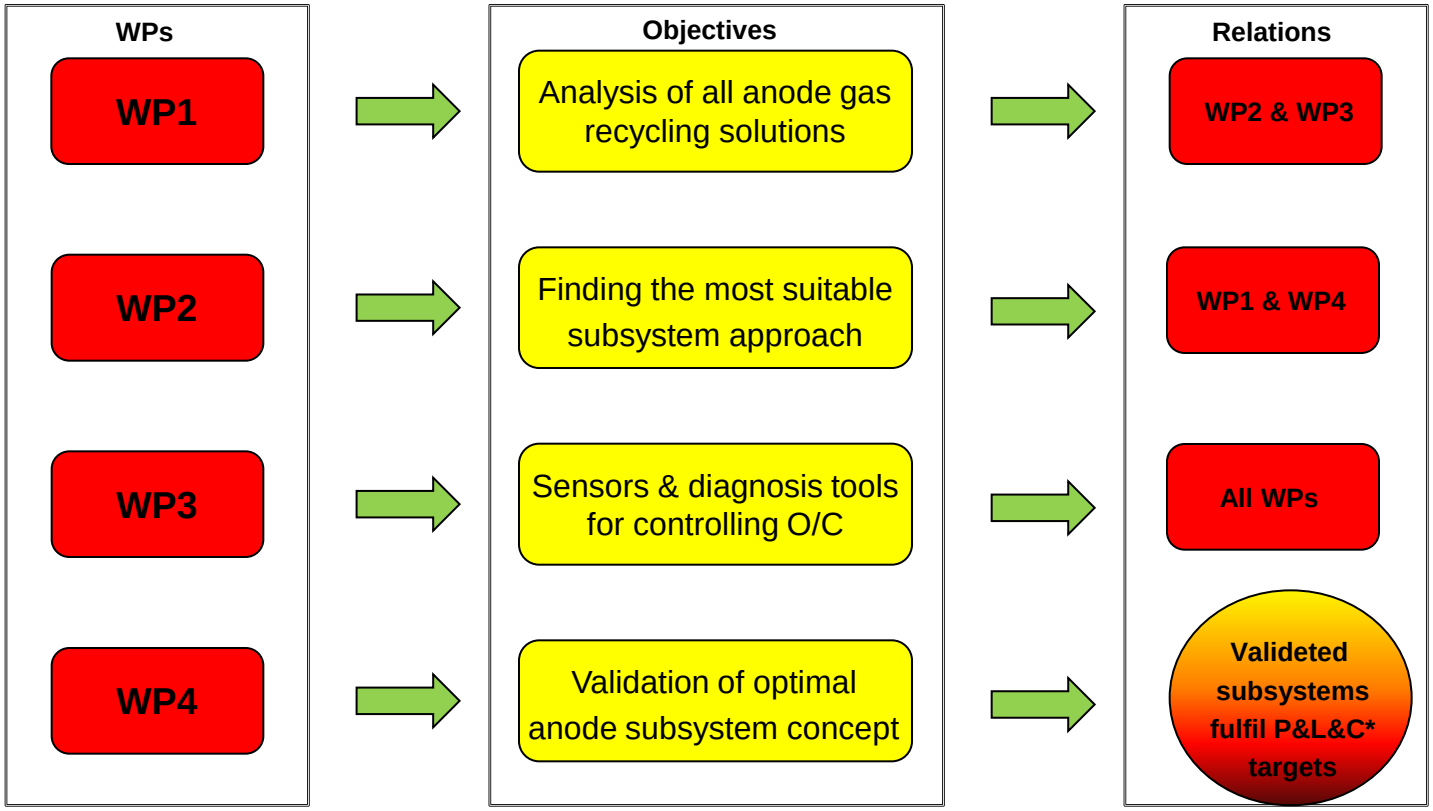
- Subsystem should fulfil performance, lifetime and cost targets for stationary applications:

  - ✓ 45 - 60% electrical efficiency
  - ✓ 40 000/60 000 hours (S/L)
  - ✓ Cost 3500/1750 €/kW_e (S/L)

- Main milestones: Protypes are manufacuted and passed tests (S/L)

ASSENT / Approach

Test procedures and workin methods have been shared between the all partners



* = performance, life-time and cost target

ASSENT / Progress (WP1)

- Analysis of all possible anode gas recycling solutions (220 cases modelled) → Nine concepts for more detailed analysis in WP2

Lay-out	Rec. cooled by	NG	BG	Power kW AC_net	Cell type	Rec. ratio	u_F stack	Pre-ref.	Water cond.	variants	Calc. by
Type 0.1 (Ref.): Water condens., no recycling	–	2 x	–	250 3	ASC ESC	0	80%	heated	Yes	4	Jülich
Type 1.1: Blower (hot)	anode off-gas	2 x	2 x	250 3	ASC ESC	50/60/ 70	60/70/ 80%	not heated	No	72	VTT
Type 1.2: Blower (< 200°C))	air	2 x	2 x	250 3	ASC ESC	50/60/ 70%	60/70/ 80%	heated	No	72	Jülich
Type 1.3: Blower (< 100°C)	air + water	2 x	–	3	ESC	50/60/ 70%	60/70/ 80%	heated	Yes	18	Jülich
Type 2.1: Ejector steam driven	–	–	2 x	250	ASC	50/60/ 70%	60/70/ 80%	not heated	Yes	18	VTT
Type 2.2: Ejector Fuel driven	–	2 x	–	250 3	ASC ESC	50/60/ 70%	60/70/ 80%	not heated	No	36	Jülich

ASSENT / Progress (WP2)

- Detailed analysis for nine concepts → Prototype options for validation

Chosen large-scale prototypes:

- ✓ System based on a hot temperature blower (AGB)
  - More mature and not high risk solution
- ✓ System based on a steam driven ejector
  - More potential and high risk solution

Chosen small-scale protypes:

- ✓ System based on recycled liquid water in Hexis
  - Suitable for current stack design
- ✓ System based on a medium temperature blower in HTc
  - Suitable for current stack design

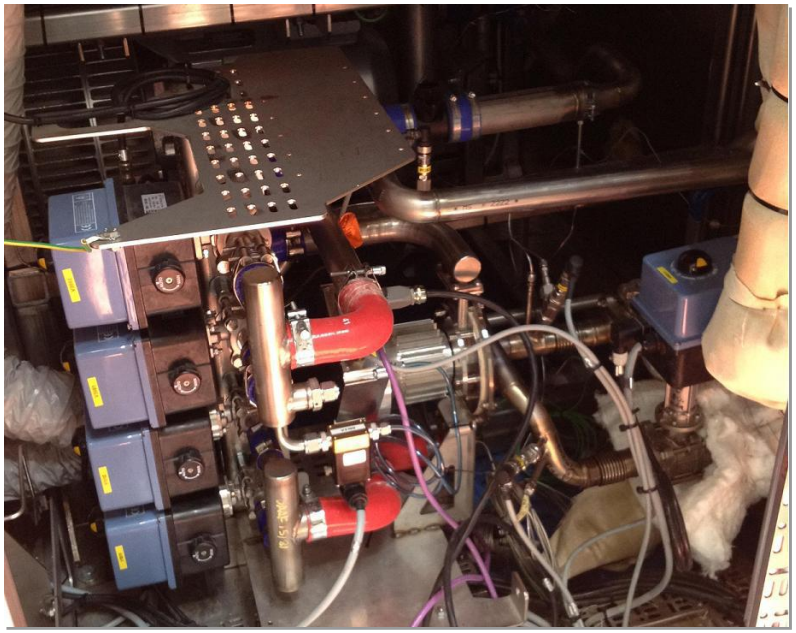
ASSENT / Progress (WP3)

- Evaluation of different sensors and diagnostics techniques in controlling anode recirculation subsystem → stable operation of SOFC system
  - ✓ Controlling O/C ratio
    - Gas analysis, Flow - and Temperature measurement
  - ✓ Valuable information about sensor and diagnostic options
  - ✓ First systematic approach
  - ✓ Availability, cost, accuracy and durability of sensors/techniques were evaluated
    - Gas analysis by cheap methods - Difficult
    - Flow measurement by cheap methods - Possible
    - Temperature by cheap methods - Possible
  - ✓ Experimental validation for possible techniques under way
    - Three deliverables coming (M34) → final conclusions

ASSENT / Progress (WP4)

Large-scale subsystem by Wärtsilä:

- Blower based approach designed and manufactured
- Validation tests partly completed (will be reported M33)
- Potential near term solution for products → up 250 kW and even beyond



Manufactured anode blower module.

ASSENT / Progress (WP4)

Large-scale subsystem by Wärtsilä:

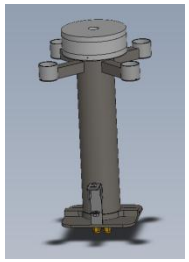
- Steam ejector subsystem test bench done
- Validation tests partly competed
  → will be reported M33
- Steam ejector based approach
  → Highly feasible solution but still many questions
  → Potential solution for future products

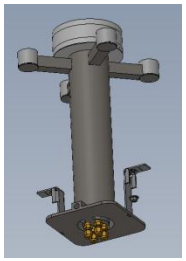
Steam ejector based recirculation test system

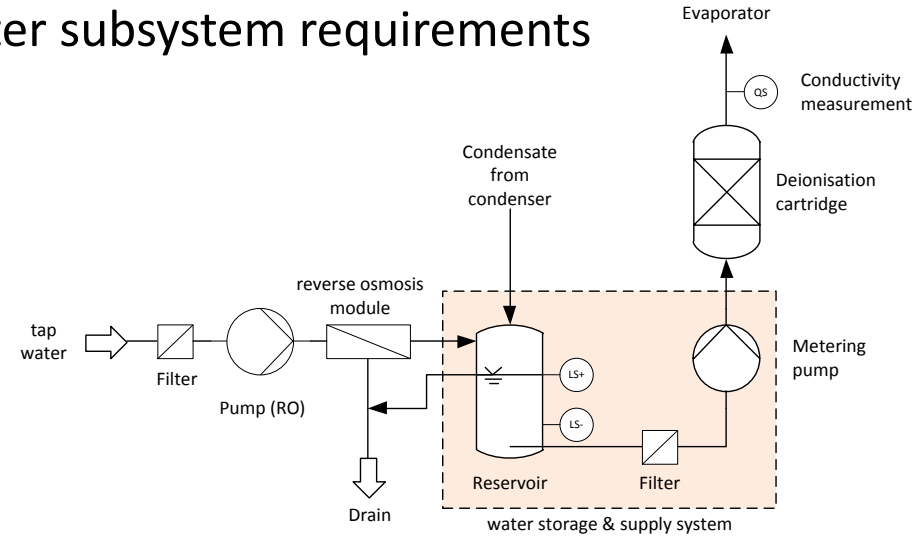
ASSENT / Progress (WP4)

Small-scale subsystem by Hexis:

- Hexis Galileo 1000N System has been modified by adding water subsystem:
  - ✓ Condensate recovery (water storage and supply box)
  - ✓ Water treatment for condensate (deionisation cartridge)
  - ✓ Water pre-treatment (reverse osmosis) for back water supply
  - ✓ System control extended for water subsystem requirements
  - ✓ Test running



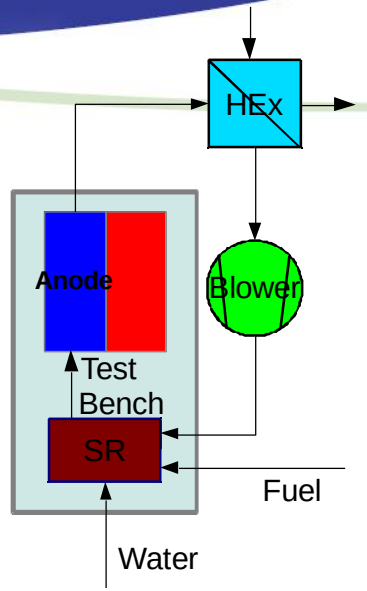


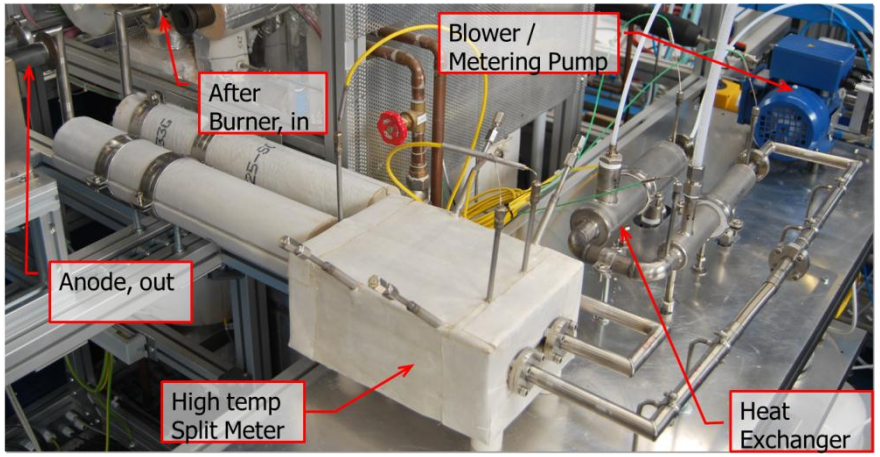


ASSENT / Progress (WP4)

Small-scale subsystem by HTc:

- Test system equipped with a 0.5kW$_{el}$ stack
- Selected blower suitable for metering: twin membrane pump, heated to avoid condensation
- Blower control strategy developed between the partners FZJ, HTc and EBZ
- High temperature recycle ratio meter included (FZJ and EBZ)
- Test is ongoing





ASSENT / Accomplishment

- All Milestones will be reached
- All deriverables will be delivered
- Progress is very much towards overall project plan
- Improvement coming from the project to the following topics:
  - ✓ Performance (45-60% electrical efficiency)
  - ✓ Lifetime (40 000/60 000 hours)
  - ✓ Cost (3500/1750 €/kW_e)
  - ✓ Component viable for massproduction
  - ✓ Availability of suitable sensor and diagnostic methods

ASSENT / Alignment to MAIP/AIP

The project is contributing to the objectives of Call FCH-JU-2008-1, Area SP1-JTI-FCH.3: Stationary Power generation & CHP, Topic SP1-JTI-FCH.3.2:

Component and system improvement for stationary applications by following fuel cell functions and the corresponding components:

- Reforming and fuel processing
- Thermal management
- Humidification
- Fluid supply and management including pumps, valves and flow meters

- Gaps or bottlenecks were not identified so far

ASSENT / Cross-cutting issues

- No special training and education activities arranged by the project but many internal workshops and technical meeting were held

- No special contributes to develop regulations, codes and stadards but safety in developing subsystems is highly appreciated

- Dissemination activities:
  - ✓ 5 conference presenatations
  - ✓ 7 patent applications
  - ✓ 1 submitted paper

ASSENT / Collaboration & Future Perspective

- Project has strong interlinkages with already terminated European Projects such as Large-SOFC and Real-SOFC projects
- Interaction with current FCH JU projects as Cation, Genius, DeSign and SOFCOM.
- International working groups as IEA Annex 24
- National projects as SofcPower 2007-2011, RealDemo 2012 -2013 (Finland), and SOF-CH (Switzerland) are also linked.
- Nice progress have been made but world is not coming ready
- System development including individual BOP component and whole sub-systems development must have important role also in future FCH JU programmes.
- One main partner withdrawn from the FC business (Wärtsilä → Convion Oy)

Thank you for your time !