



Solid oxide fuel cell combined heat and power:
Future-ready Energy



Designing for flexible use of hydrogen and natural gas: the SO-FREE project

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SO-FREE at a glance

- Primary objective:
Demonstration of a fully fuel-flexible,
5kW-class CHP system
- Project start: 1 January 2021
- Project duration: 52 M (4.3 y)
- Project budget: 2.7M€



Stack suppliers:

- Elcogen (ASC, 650°C)
- Fraunhofer IKTS (ESC, 850°C)

CHP System developers:

- AVL
- ICI

CHP prototypes manufacturer: ICI

Stack test labs:

- ENEA
- IEN

Demo sites:

- KIWA
- IEN

Pre-certification of the systems: KIWA

Other assessments: PGE, KIWA, USGM, ENEA

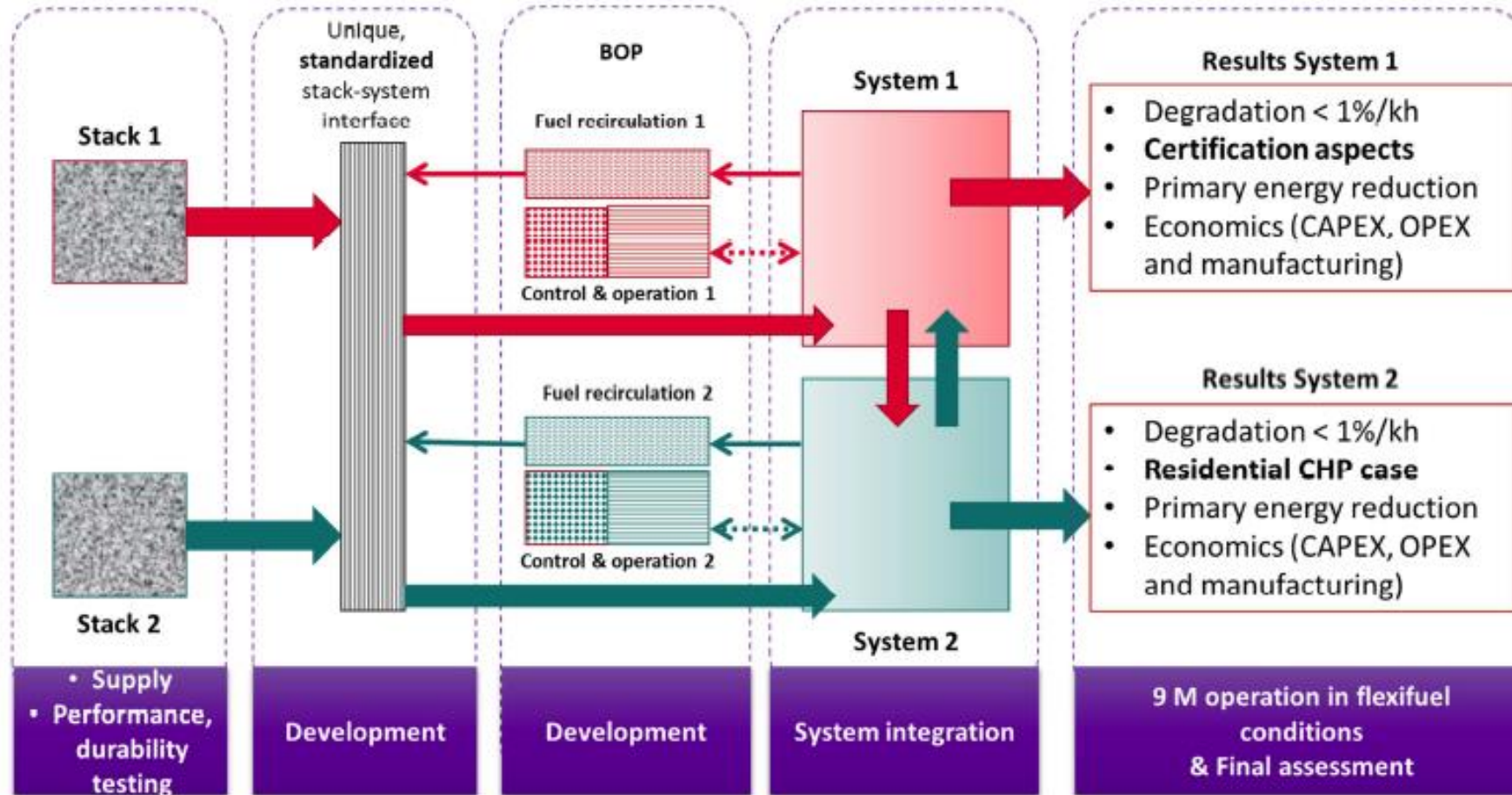
SO-FREE at a glance



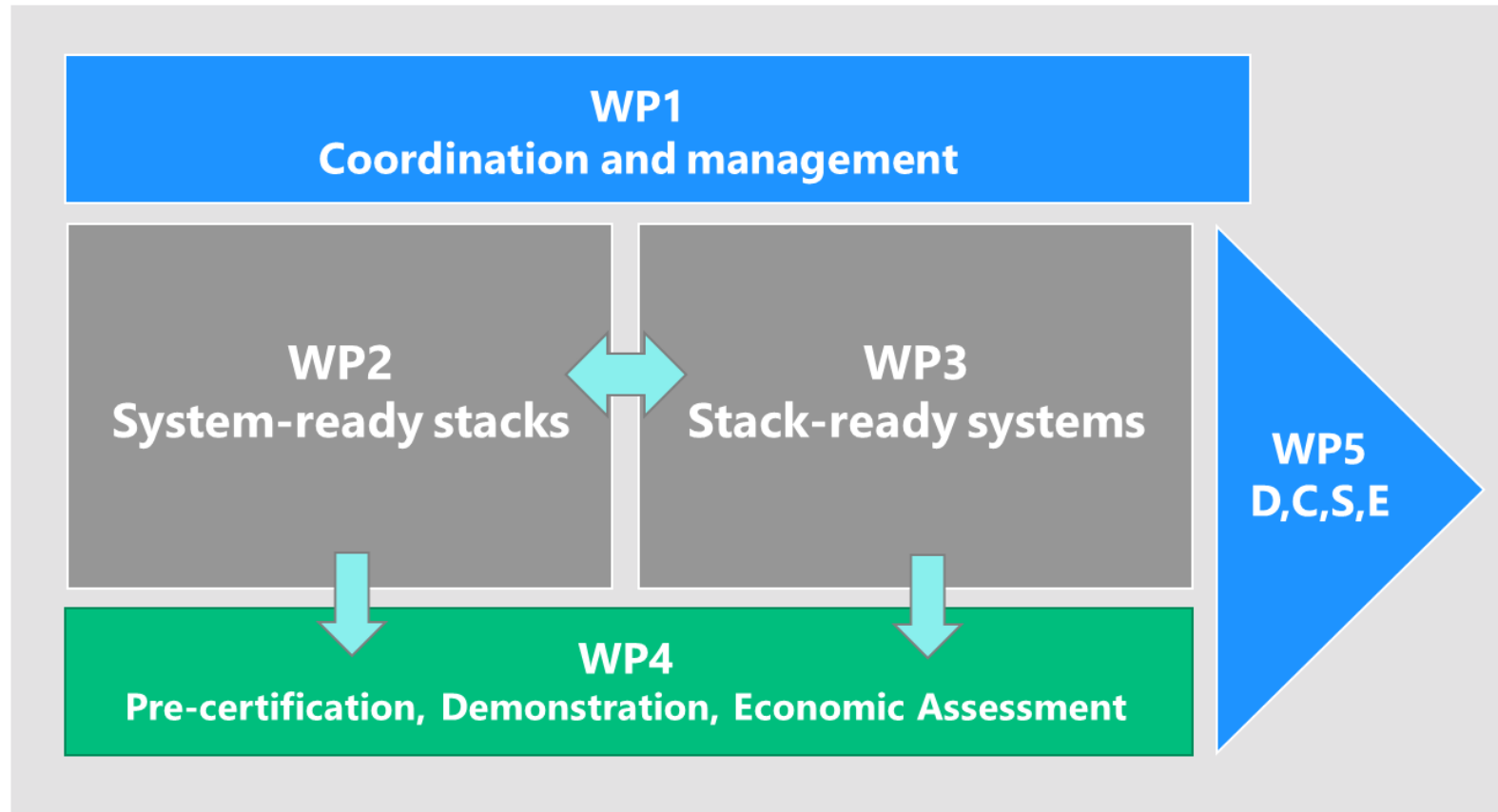
SO-FREE objectives

- Study the effects of mixtures of natural gas, biogas and hydrogen on SOFC stacks (600-850°C), integrated in a 5 kWe-class combined heat and power (CHP) system
- Optimisation of system architecture and Balance-of-Plant compatibility for a fuel-flexible and stack-flexible system
- Standardization of the stack module-system interface for full interchangeability of SOFC stack modules in any application-ready system
- Demonstration of two systems for 9 months and >6000 operating hours each
- Pre-certification of the prototype according to applicable EU/international directives
- Demonstrate decrease of CO₂ emissions through flexi-fuel operation by at least 40%
- Assessment of residential SOFC-CHP market for NL, IT, PL and UK

SO-FREE approach



SO-FREE approach



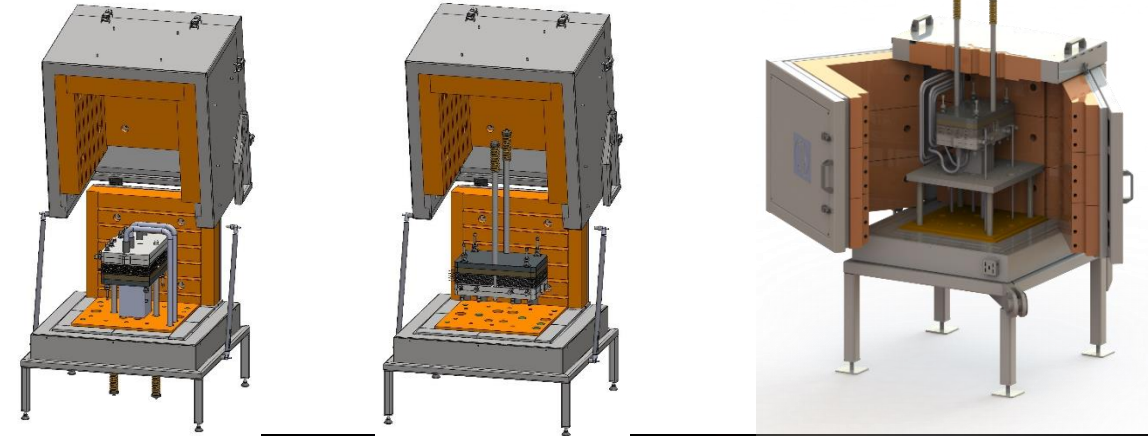
SO-FREE results – stack characterization

Primary objective:

Validated performance maps of 2 stack types

- Developed a unique testing interface for validation in 2 labs
- Testing under 100% H₂/CH₄ & 67:33
- IV curves, Fuel utilization curves, Temperature sensitivity

→ ±0,88% average difference between 2 test labs on all measurements (all < 4%)

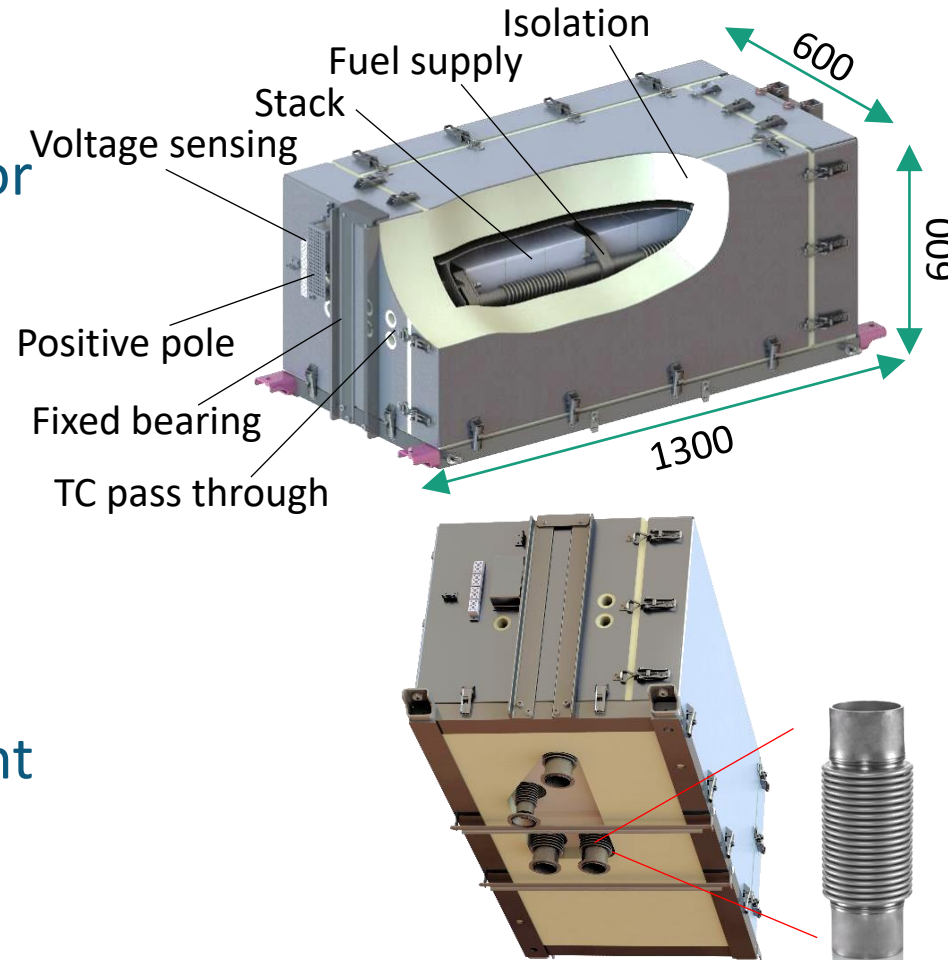


SO-FREE results – stack module-system interface

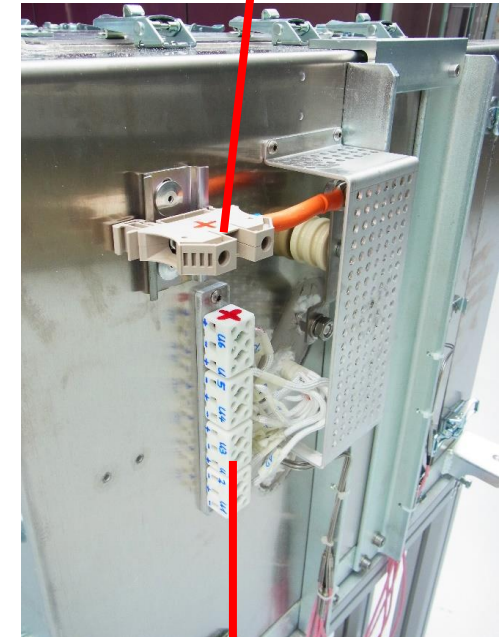
Primary objective:

Develop a common stack module for both stack types and both systems.
Standardization?

- Unique module to house both ASC & ESC stack, in flexifuel operation
 - Allows quick module replacement during system operation
- Design finalized for SO-FREE



Power connection via terminal blocks



Cluster terminal interface for voltage (package) sensing

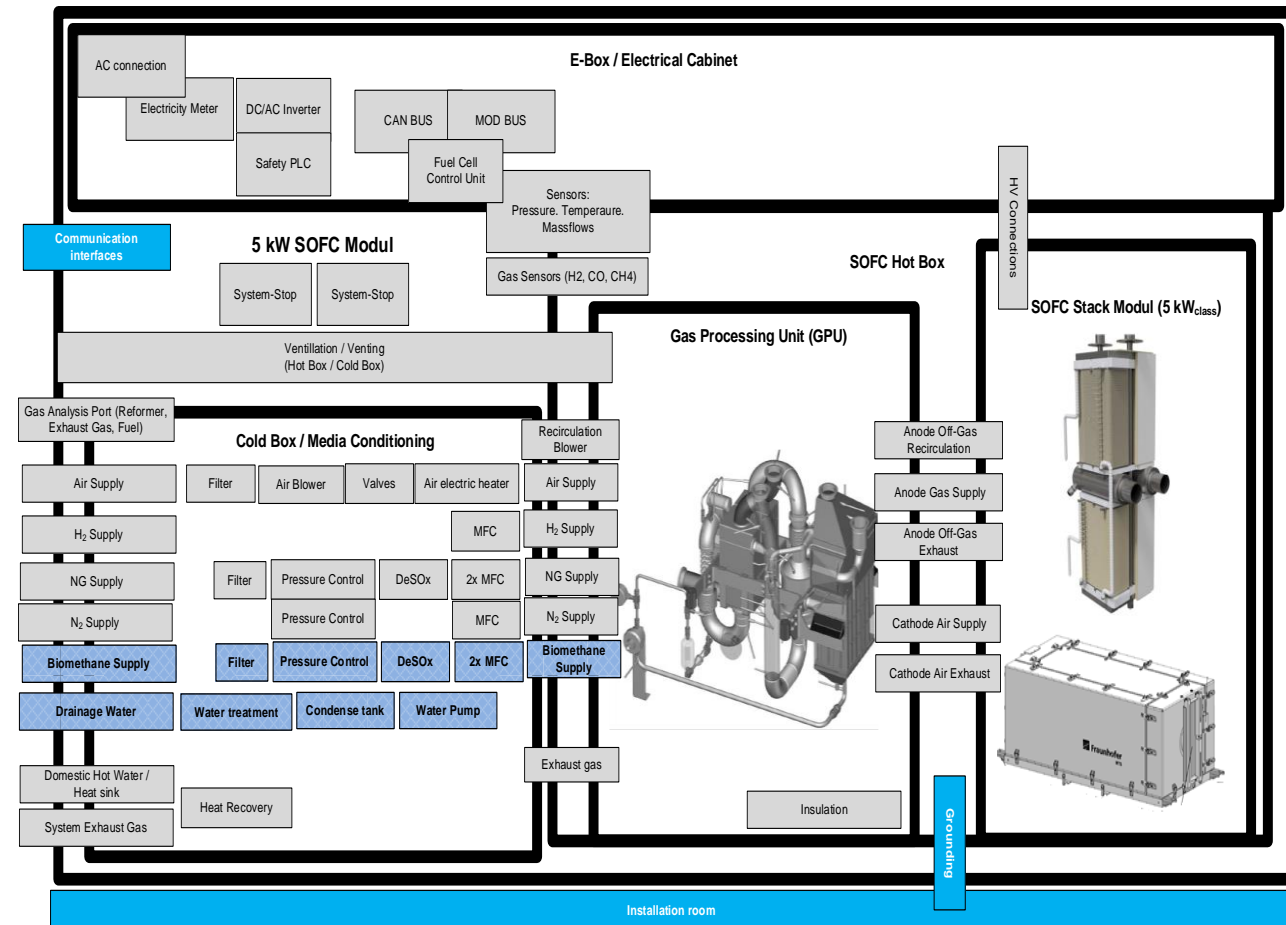
Question: Can such a module become an international standard?

SO-FREE results – system prototypes

Primary objective:

Develop 2 different prototypes for cross-demonstration of stacks and systems at 2 locations

- Unique manufacturer for both systems
 - Pre-assessment for CE certification
 - 9-month demo at TRL 6 (pre-certification) and at TRL7 (quasi-residential)
- System requirements frozen, P&IDs finalized of both systems, RFQs for components out, 3D design started



SO-FREE Outlook

- Complete 3D design and source components for both prototypes – end 2023
- System manufacturing in Q1 2024
- 9-month Demo starting in Q2 2024
- Techno-economic assessment of 5-kW CHP system in 4 markets: NL, PL, UK, IT – validated with demo performance data
- LCA assessment
- Stakeholder workshop at a demo location – stay tuned!

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