STAGE-SOFC
Innovative SOFC system layout for stationary power and CHP

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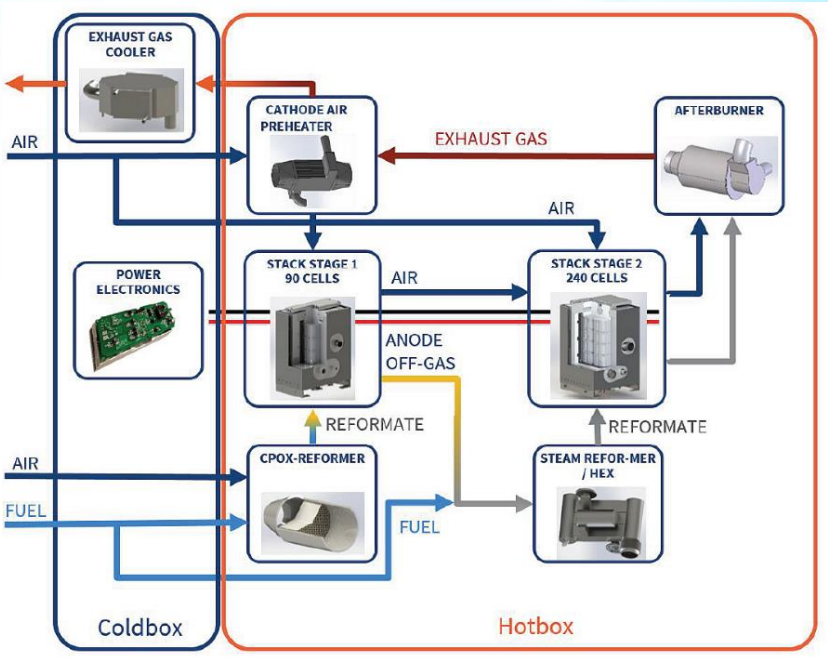
PROJECT OVERVIEW

- Call year: 2013
- Call topic: SP1-JTI-FCH.2013.3.4 - Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale
- Project dates: 01/04/2014 – 30/04/2018
- % stage of implementation 01/11/2017: 95%
- Total project budget: 3,970,268.20 €
- FCH JU max. contribution: 2,165,724.60 €
- Other financial contribution: - €
- Partners: *VTT TECHNICAL RESEARCH CENTRE OF FINLAND (VTT)*, Sunfire GmbH (SF), ICI Caldaie S.p.A. (ICI), Lappeenranta University of Technology (LUT), West Pomeranian University of Technology, Szczecin (ZUT)

PROJECT OVERVIEW

Project objectives

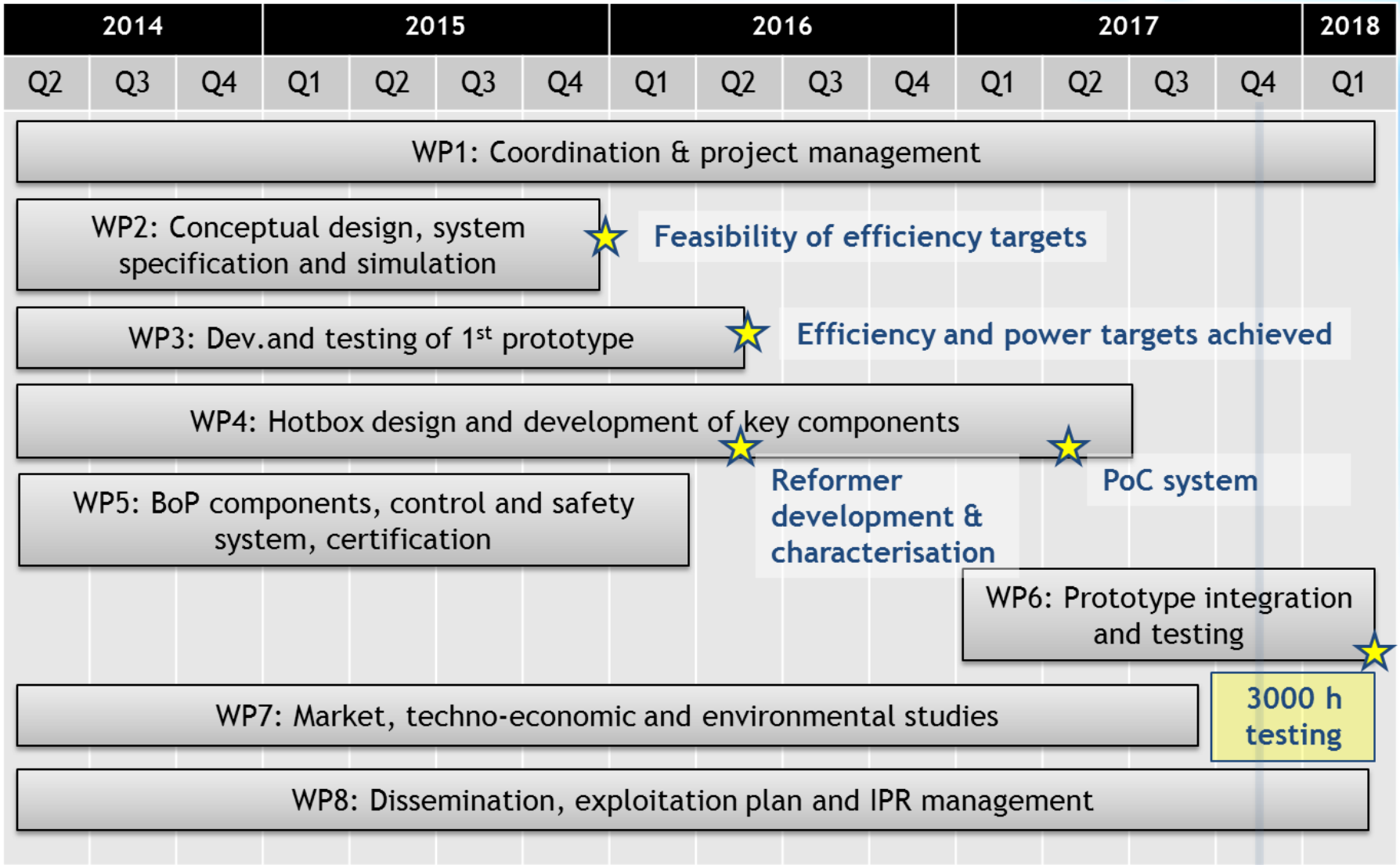
- Development of a 5 kW_{el} PoC prototype of a new SOFC concept with a serial connection of one CPOX stage and one steam reforming stages.
- Combination the benefits of the simple and robust CPOX layout with the high efficiencies obtained by the steam reforming process.
- The system should achieve an electrical efficiency of 45% and an overall efficiency of 80%



Applications

- Small-scale CHP or CCP for apartment houses or commercial sector
- Off-grid power generator for pipeline, telecommunication or remote measurement applications
- Back-up power for data centers

PROJECT OVERVIEW



PROJECT SUMMARY

STAGE SOFC

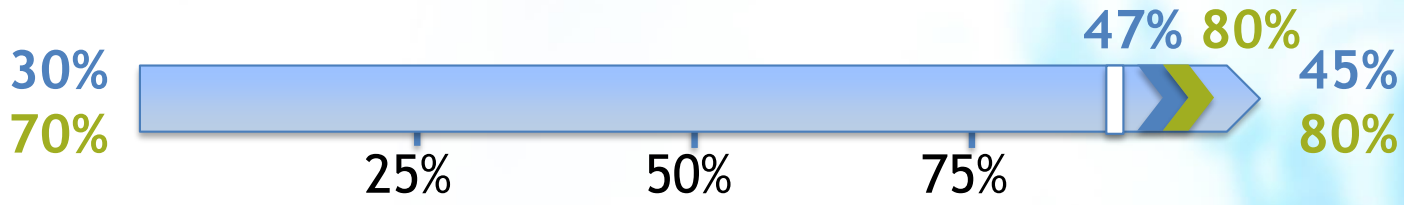
Global positioning vs international state-of the art

Key performance indicator (KPI)	Unit	Internatio-nal SoA (2012)	Global positioning (FCH-JU target)		
			2017	2020	2023
CAPEX	€/kW	16,000	14,000	12,000	10,000
Durability	Years of operation	10	12	13	14
Availability	% of the plant	97	97	97	97
Electrical efficiency	$\%_{LHV}$	30-60	33-60	35-60	35-60
Thermal efficiency	$\%_{LHV}$	25-55	25-55	25-55	25-55
LCOE	€ Ct/kWh	3*grid parity	2.5*grid parity	2*grid parity	<2*grid parity
Emissions	mg/kWh	NO_x<2 ppm, no SO_x	NOx<2 ppm, no SO_x	NO_x<2 ppm, no SO_x	NO_x<2 ppm, no SO_x

PROJECT PROGRESS/ACTIONS - Efficiency

Achievement to-date

% stage of implement.



Aspect addressed	Parameter (KPI)	Unit	SoA 2017	FCH JU Targets		
				Call topic	2017	2020
Efficiency*)	Electrical efficiency	$\%_{LHV}$	30-60	45	33-60	35-60
	Overall efficiency	$\%_{LHV}$	85	80	85	85

Achievements:

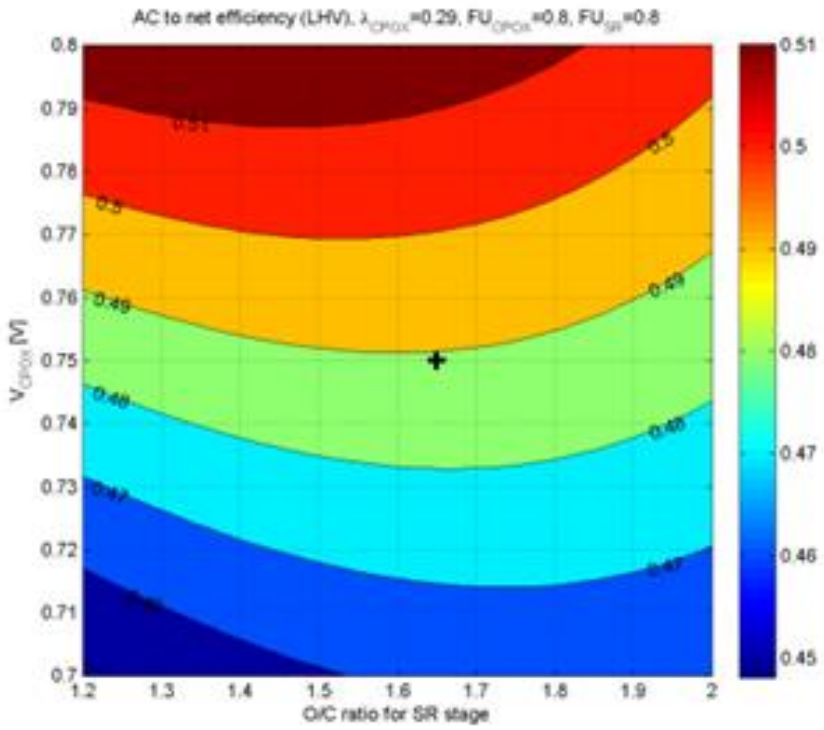
- Confirmation of feasibility of efficiency targets by detailed multi-parameter simulations
- Electrical efficiency proven in initial lab prototype

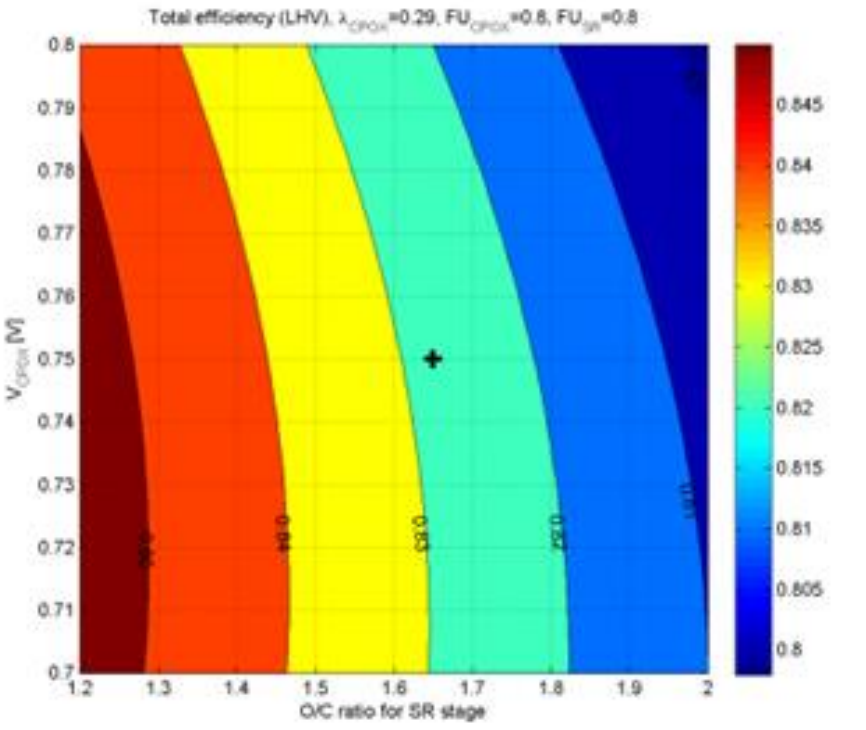
Future steps:

- Evaluation of the efficiency curves for the Proof-of-Concept system

*) The overall efficiency is derived form the MAIP 2014-2020 instead of the thermal efficiency

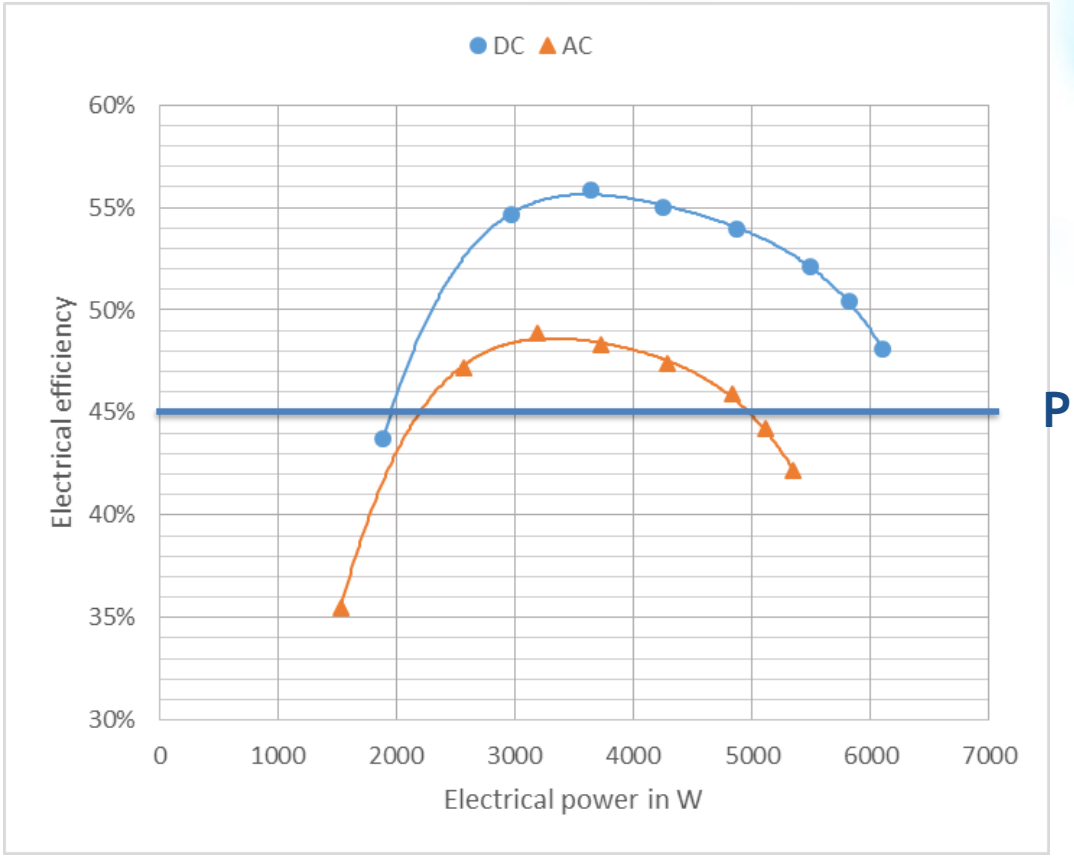
PROJECT PROGRESS/ACTIONS – Efficiency





Example of parameter variations in the simulation showing the potentials in electricial (left) and overall (right) efficiencies

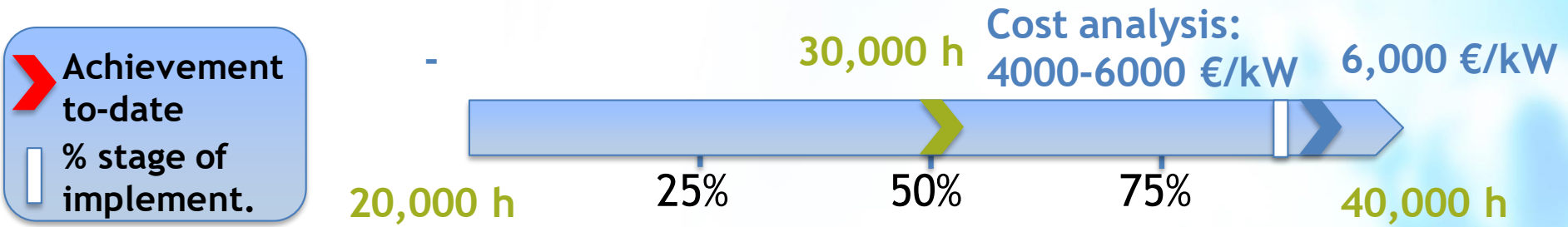
PROJECT PROGRESS/ACTIONS – Efficiency



Project target

Relationship between electrical efficiency and electrical power output measured in the first lab prototype system

PROJECT PROGRESS/ACTIONS – Total Cost of Ownership

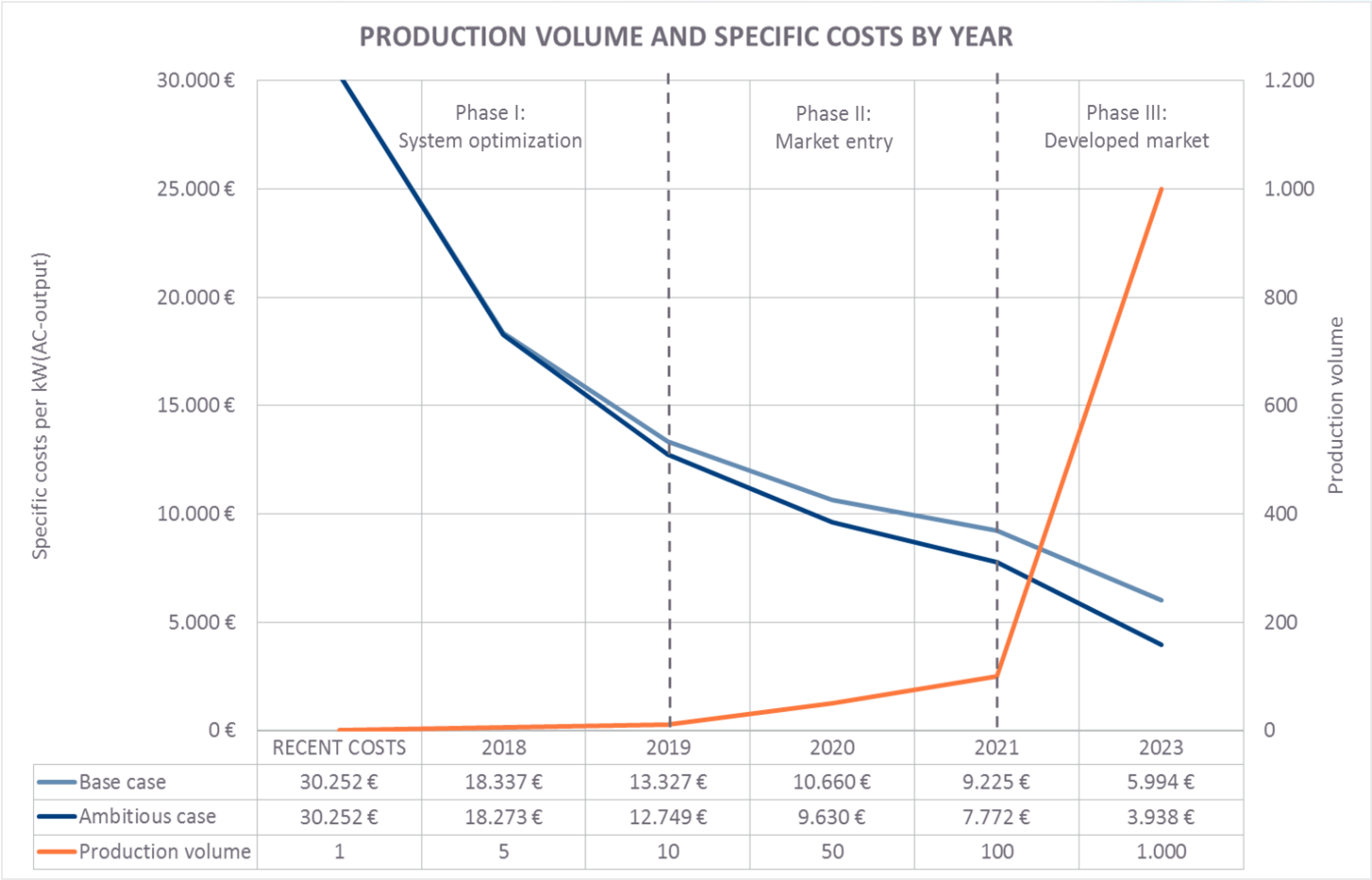


Aspect addressed	Parameter (KPI)	Unit	SoA 2017	FCH JU Targets		
				Call topic	2017	2020
Total Cost of Ownership: µCHP 0.3-5 kW (Commercial 5-400 kW)	CAPEX	€/kW	16,000 (6,000-10,000)	-	14,000 (5,000-8,500)	12,000 (4,500-7,500)
	Lifetime	h	30,000	40,000	30,000	30,000 (40,0000)

- CAPEX feasibility by detailed cost analysis (+1000 pieces)
- Lifetime proven in µCHP application (with partner Vaillant)

*) Cost targets from MAIP 2014-2020, lifetime from MAIP 2008-2013

PROJECT PROGRESS/ACTIONS - Total Cost of Ownership



	RECENT COSTS	2018	2019	2020	2021	2023
Base case	30.252 €	18.337 €	13.327 €	10.660 €	9.225 €	5.994 €
Ambitious case	30.252 €	18.273 €	12.749 €	9.630 €	7.772 €	3.938 €
Production volume	1	5	10	50	100	1.000

Cost analysis of a 5 kW Stage-SOFC based system. Note: increase of power density isn't included.

PROJECT PROGRESS/ACTIONS – Total Cost of Ownership

STAGE SOFC

Stack degradation

- Average degradation rate: 30 mΩcm²/kh (sufficient for > 30,000 h)
- Mid-term target: 15 mΩcm²/kh

Stack lifetime

- Proven lifetime: 30,000 h

System lifetime

- Proof-of-Concept system will be tested for at least 3000 h in simulated application environment (ICI lab)

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

- Interactions with projects funded under EU programmes
  - SOFCOM: Techno-economic evaluation of small-scale CHP cases in various EU countries
  - GrInHy: Development of reformer unit, investigation of carbon formation in reformate
  - CoACH: Mechanical analysis of SOC stack, development of glass ceramics for SOC stack
- Interactions with national and international-level projects and initiatives
  - FOSUS (GER): Stack improvement in terms of cost per power and durability, SOEC scale up 5 to 10 times from 5 kW and cost optimization of stack modules

DISSEMINATION ACTIVITIES

Public deliverables

- D1.1: Project Management Guidelines
- D3.1: Report on design and testing of 1st lab prototype
- D7.3: Technical analysis of the various system configurations
- D7.5: Report on potential CO_2 mitigation including streamlined LCA

Conferences/Workshops

- 1 organised by the project
- 12 oral presentations at conferences
- 15 exhibition stgands Number in which the project has participated (but not organised)

Project Website: http://www.stage-sofc-project.eu

Publications (15 scientific papers):

- J. Kihlman, J. Sucipto, N. Kaisalo, P. Simell, J.Lehtonen, Carbon formation in catalytic steam reforming of natural gas with SOFC anode off-gas, Intern. J. of Hydrogen Energy, 2015, 40, 1548-1558 doi:10.1016/j.ijhydene.2014.11.074
- J. Bachmann, O. Posdziech, P. Pianko-Oprych, N. Kaisalo, J. Pennanen, Development and Testing of Innovative SOFC System Prototype with Staged Stack Connection for Efficient Stationary Power and Heat Generation, ECS Transactions, 2017, 78 (1), 133-144. DOI: 10.1149/07801.0133ecst

Patents: 0

Thank You!

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