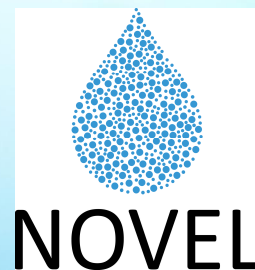


MEGASTACK

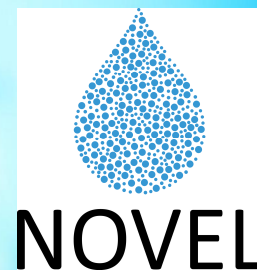


**Cost reduction and performance increase
of PEM electrolyzers**

NOVEL: New materials & components

MEGASTACK: Manufacturing and upscale

***Programme Review Days 2016
Brussels, 21-22 November***



NOVEL

Novel materials and system designs for low cost, efficient and durable PEM electrolysers

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SINTEF**

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magnus.s.thomassen@sintef.no**

***Programme Review Days 2016
Brussels, 21-22 November***

PROJECT OVERVIEW



Project Information	
Call topic	SP1-JTI-FCH.2011.2.7 - Innovative Materials and Components for PEM electrolyzers
Grant agreement number	303484
Application area (FP7) or Pillar (Horizon 2020)	Hydrogen production and distribution
Start date	01/09/2012
End date	30/11/2016
Total budget (€)	5 743 445
FCH JU contribution (€)	2 663 445
Other contribution	310 683 (Norwegian Research Council)
Stage of implementation	100% project months elapsed vs total project duration, at date of November 1, 2016
Partners	SINTEF, Fraunhofer ISE, CEA Liten, AREVA H2Gen, Johnson Matthey Fuel Cells, Teer Coatings, PSI

PROJECT SUMMARY - Objectives

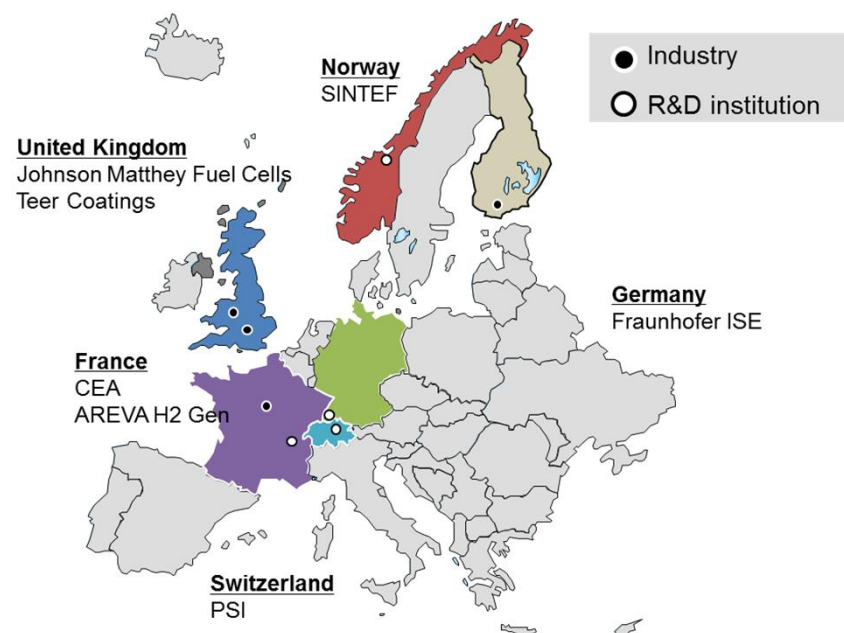


Develop and demonstrate a PEM water electrolyser using beyond state of the art materials.

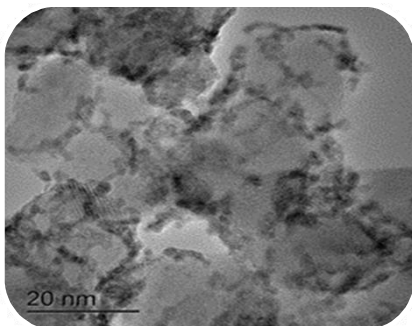
75% Efficiency (LHV), electrolyser stack cost < €2,500 / Nm³h⁻¹,
target lifetime of 40,000 h (< 15 μVh⁻¹)



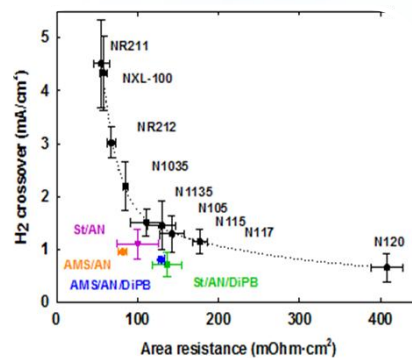
PROJECT SUMMARY - Partners



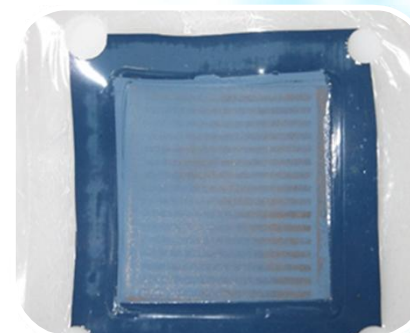
PROJECT SUMMARY - Main achievements



Highly active supported electrocatalysts



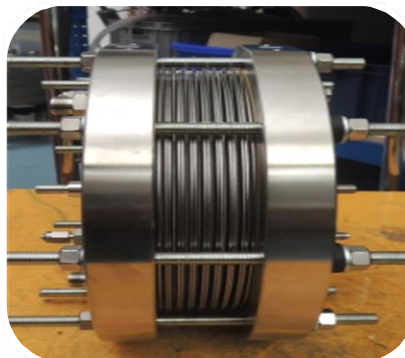
Membranes with lower cost and H₂ crossover



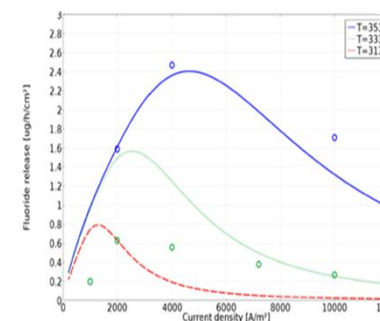
Advanced CCMs with higher performance



Non-noble metal coatings for bipolar plates

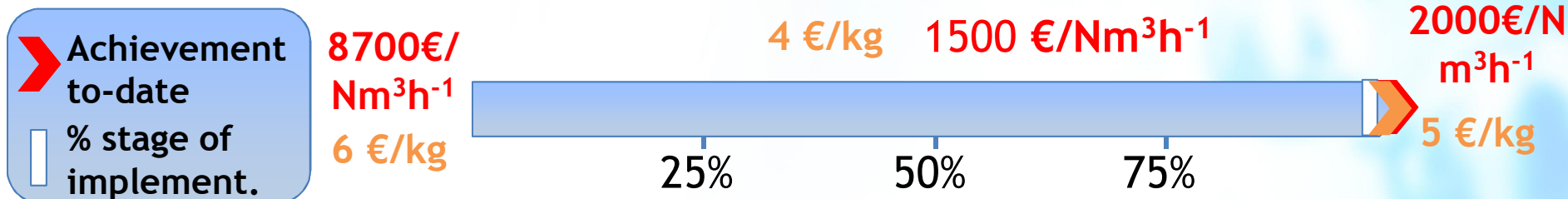


Low-cost stack design



Degradation mechanisms and AST protocols

PROJECT PROGRESS/ACTIONS - Cost



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Cost	CAPEX (stack only)	€/Nm ³ h ⁻¹	8700	2500	4000	2100
	H ₂ Cost	€/kg	5-13	-	5-11	5-9

Future steps:

- *Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.*
- *Improve manufacturability of new components*

PROJECT PROGRESS/ACTIONS - Cost



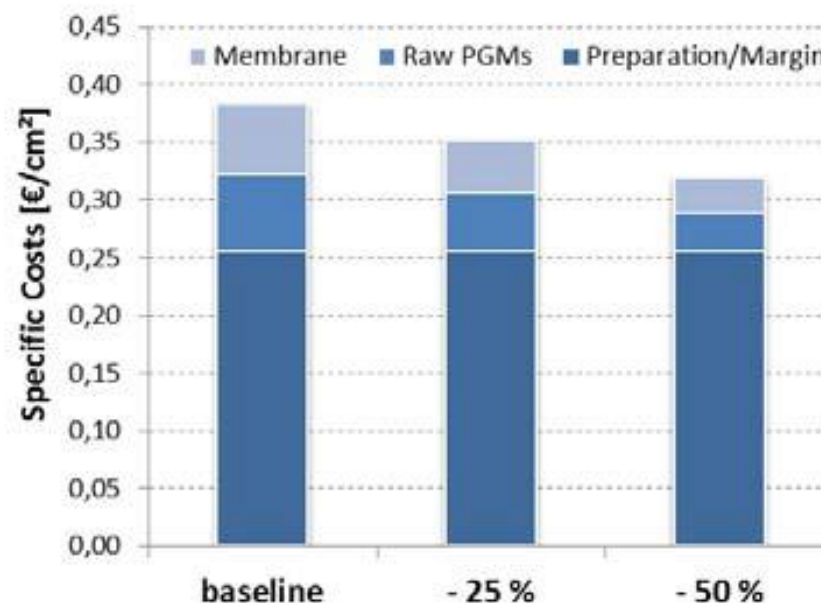
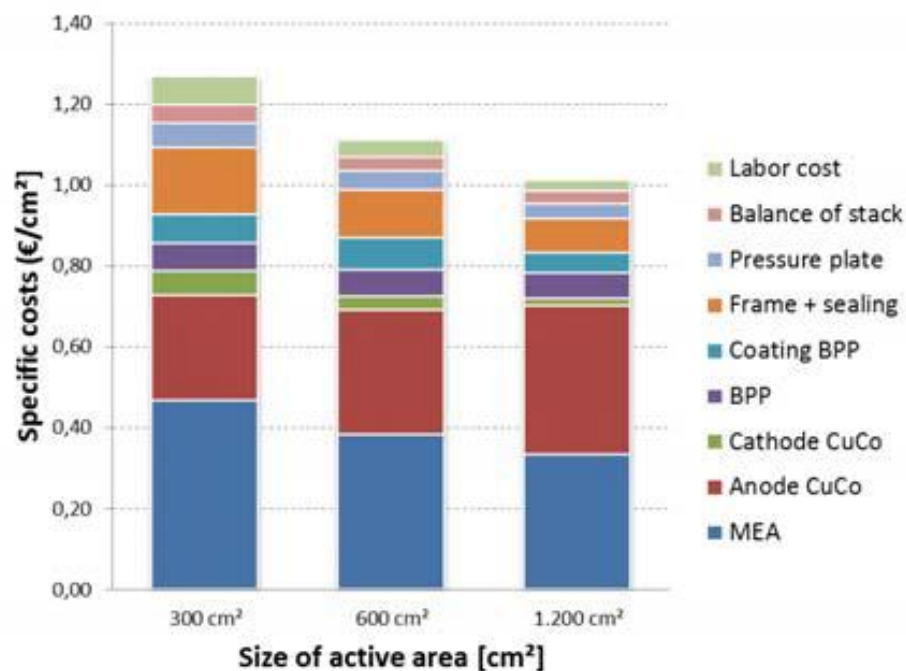
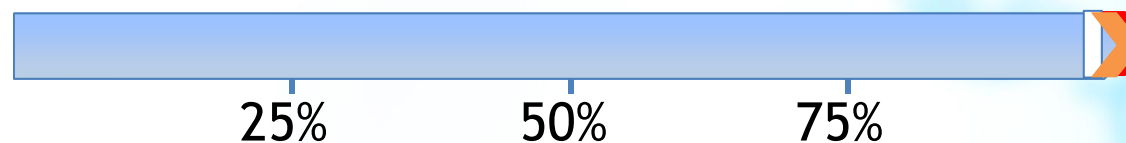
 Achievement to-date
 % stage of implement.

8700€/Nm³h⁻¹
6 €/kg

4 €/kg **1500 €/Nm³h⁻¹**

2000€/Nm³h⁻¹

5 €/kg

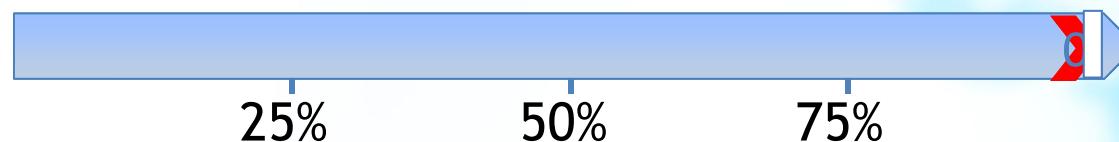


PROJECT PROGRESS/ACTIONS - Efficiency



 Achievement to-date
 % stage of implement.

75%
(HHV)



84%

83%
(HHV)

Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Efficiency	Efficiency (HHV)	%	68	88	71	75
	Energy use	kWh/kg	57	44	55	52

Future steps:

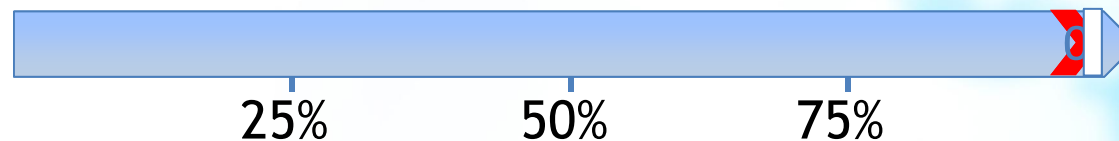
- *Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.*
- *Improve manufacturability of new components*

PROJECT PROGRESS/ACTIONS - Efficiency



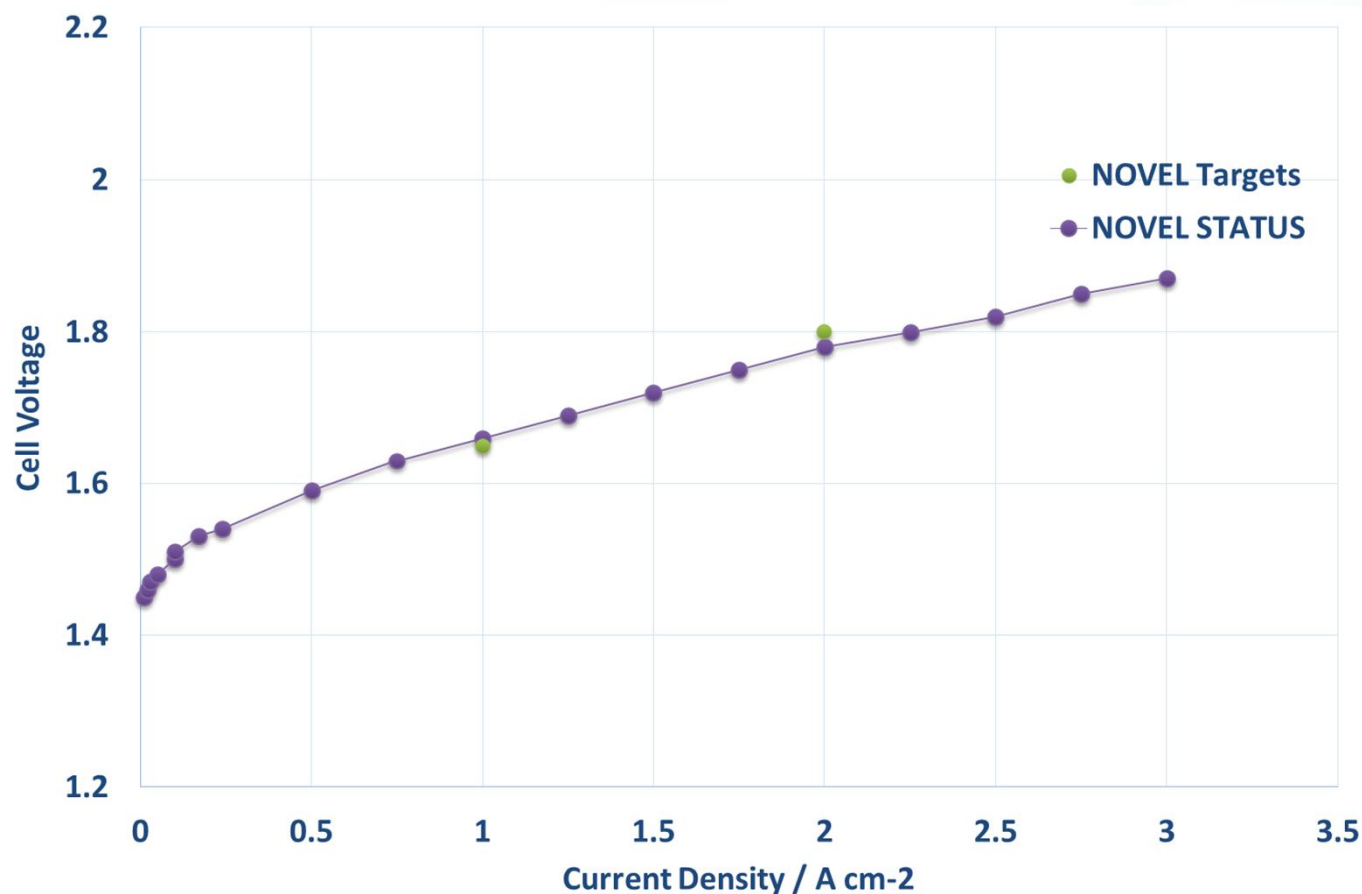
> Achievement to-date
% stage of implement.

75% (HHV)

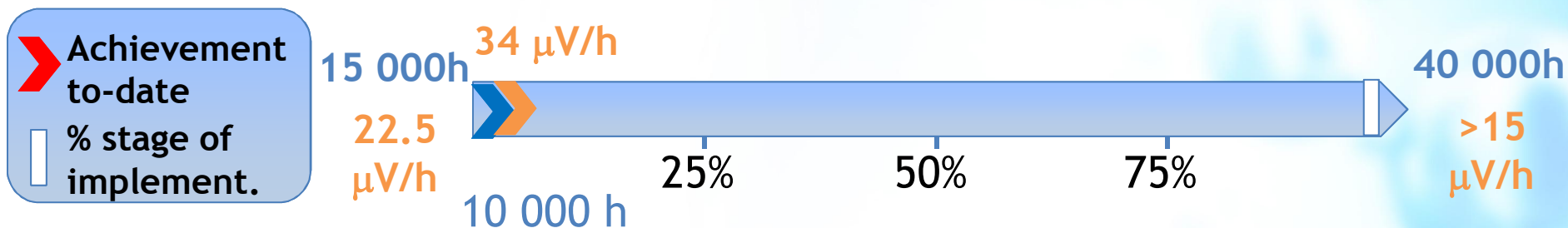


84%

83% (HHV)



PROJECT PROGRESS/ACTIONS - Durability



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Durability	Lifetime	h		40000 h	-	-
	Degradation rate	μV/h		< 15	< 4	< 3

Future steps:

- Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.
- Improve manufacturability of new components

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES



Interactions with projects funded under EU programmes

<i>NEXPEL</i>	The NOVEL project is building upon the results generated in the FCH-JU NEXPEL project. Further development of the most promising technical solutions and introducing more novel materials and degradation mitigation strategies
<i>SMARTCAT</i>	Complementary activities on the fundamental understanding of electron mobility in oxides and methods for increasing the electronic conductivity of such materials
<i>MEGASTACK</i>	Collaboration on development of testing protocols for components and cells. AST development and dissemination events.

Interactions with national and international-level projects and initiatives

<i>Moxilayer</i>	Development of oxide supported electrocatalysts for PEM electrolyzers
<i>IEA-ANNEX 30</i>	Collaboration on development of standardized testing protocols for PEM electrolyzers and cost reduction strategies.

DISSEMINATION ACTIVITIES



Public deliverables

- D6.2: condensed findings and conclusions from the organised international workshops on PEM electrolysis
- D6.3 Annual public progress reports

Conferences/Workshops

- 2 organised by the project
- >15 (with >20 presentations) in which the project has participated

Social media



Publications: 5

- M. Chandesris; *Membrane degradation in PEM water electrolyzer: numerical modeling and experimental evidence of the influence of temperature and current density*, Int.J. Hydrogen Energy, 1353-1366 (40) 2015
- A. Albert, A. Barnett, M.Thomassen, T. J. Schmidt, L. Gubler; *Radiation-Grafted Polymer Electrolyte Membranes for Water Electrolysis Cells: Evaluation of Key Membrane Properties*. ACS Appl. Mater. Interfaces, 22203 (7) 2015

Patents:



MEGASTACK

Stack design for a megawatt scale PEM electrolyser

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Programme Review Days 2016
Brussels, 21-22 November

PROJECT OVERVIEW



Project Information	
Call topic	SP1-JTI-FCH.2013.2.3 - Large capacity PEM electrolyser stack design
Grant agreement number	621233
Application area (FP7) or Pillar (Horizon 2020)	Hydrogen production and distribution
Start date	01/10/2014
End date	30/09/2017
Total budget (€)	3 451 654
FCH JU contribution (€)	2 168 543
Other contribution	363 375 (Norwegian Research Council)
Stage of implementation	70% project months elapsed vs total project duration, at date of November 1, 2016
Partners	SINTEF, Fraunhofer ISE, CEA Liten, ITM Power

PROJECT SUMMARY - Partners

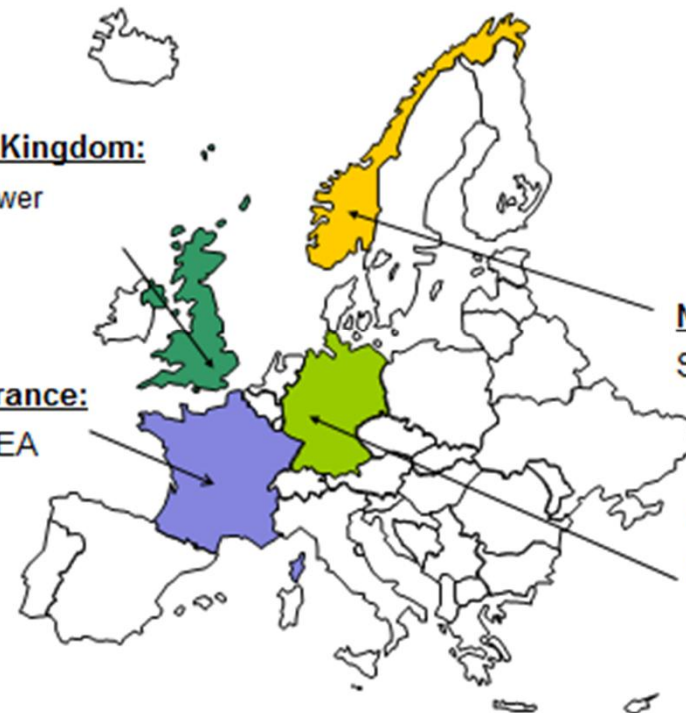


United Kingdom:
ITM Power

France:
CEA

Norway:
SINTEF

Germany:
Fraunhofer ISE



PROJECT SUMMARY - Objectives



Megastack main objectives:

Develop a cost efficient
stack design for MW-sized
PEM electrolysers.

Construct and demonstrate a
prototype stack

75% Efficiency (LHV) @ 1.2
 Acm^{-2} ;

stack cost < €2,500 / Nm^3h^{-1}
target lifetime of 40,000 h (
< $15 \mu\text{Vh}^{-1}$)



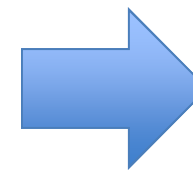
PROJECT SUMMARY - Approach



- Go large & smart
 - Increase active area and current density, reduce waste (square design)
 - Reduce part count and improve manufacturability/assembly
 - Develop new and more more cost efficient, large volume supply chains



0.5MW

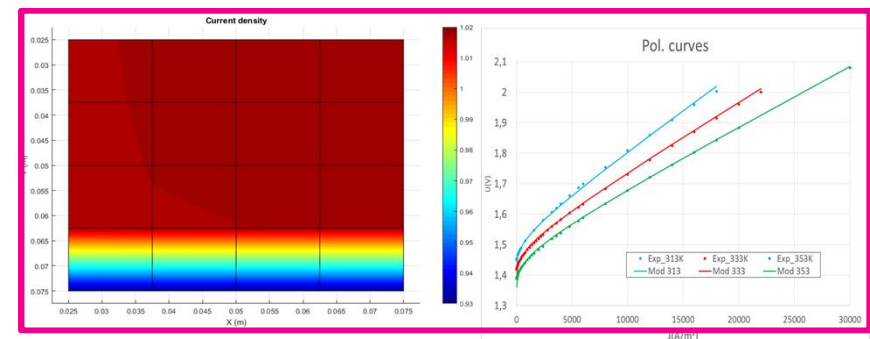
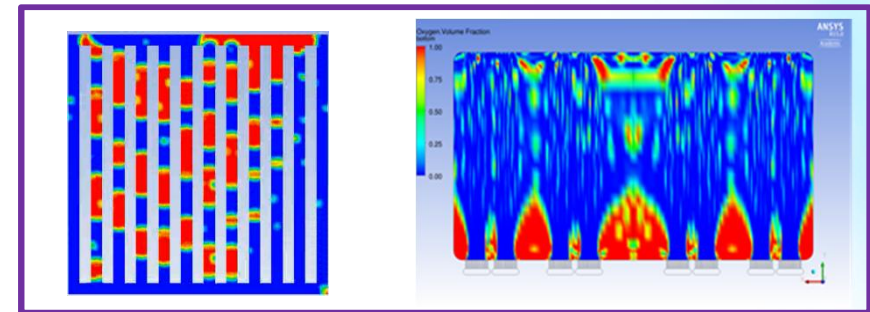
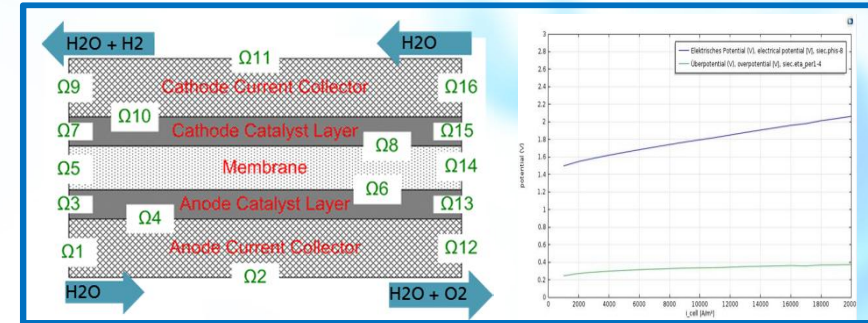


1MW

PROJECT SUMMARY - Approach



- Multiscale/multiphysics design tools
 - Improved understanding of fundamental transport processes in PEM electrolyser components
 - Two phase flow model for optimisation of cell designs
 - Multiphysics stack model for stack design and control



PROJECT PROGRESS/ACTIONS - Cost



MEGASTACK

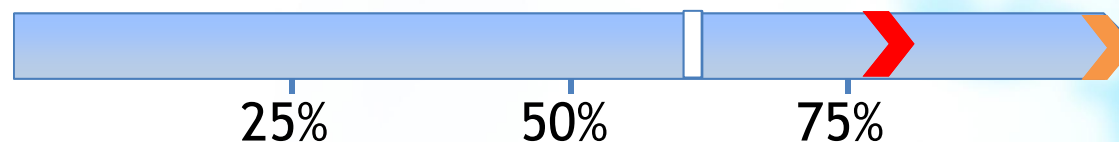
➤ Achievement to-date
▮ % stage of implement.

8700€/Nm³h⁻¹
6 €/kg

~5 €/kg < 3000 €/Nm³h⁻¹

2500€/Nm³h⁻¹

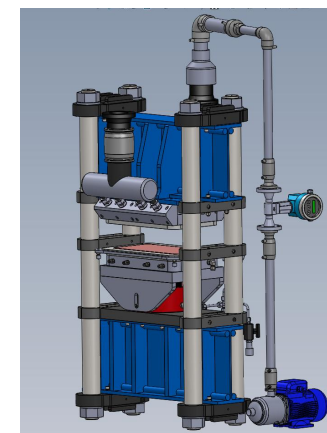
5 €/kg



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Cost	CAPEX	Nm ³ h ⁻¹	8700	2500	4000	2200
	H ₂ Cost	€/kg	5-13	-	5-11	5-9

Future steps:

- Construct "short stack" demonstration unit
- Perform HAZOP study, complete documentation and ensure safe reliable operation
- Demonstrate electrolyser capabilities

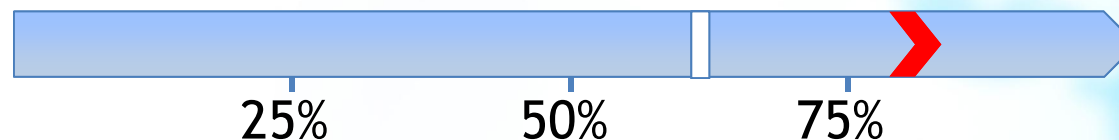


PROJECT PROGRESS/ACTIONS - Efficiency



 Achievement to-date
 % stage of implement.

70%
(HHV)



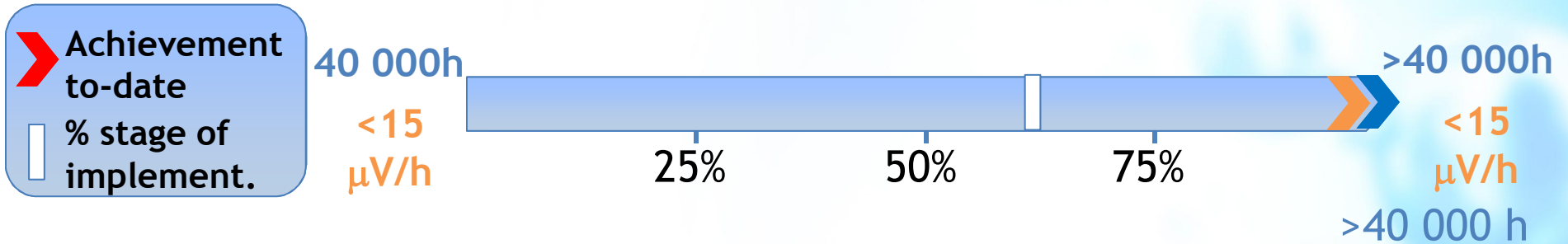
88%
(HHV)

Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Efficiency	Efficiency	%	68	88	71	75
	Energy use	kWh/kg	57	42	55	52

Future steps:

- Further improvement of stack design by use of advanced modelling tools developed in the project
- Improved manufacturability, optimised components, higher current densities

PROJECT PROGRESS/ACTIONS - Durability



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Durability	Lifetime	h		40000 h	N/A	N/A
	Degradation rate	μV/h		< 15	< 4	< 3

Future steps:

- Evaluate long term durability of demonstrator stack
- Investigate possibility for increased current densities and alternative lower cost components without impact on durability

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES



Interactions with projects funded under EU programmes	
<i>NOVEL</i>	Collaboration on development of testing protocols for components and cells. AST development and dissemination events.
<i>PHAEDRUS</i>	Megastack design based on elements from Phaedrus stack design
<i>ELECTROHYPEM</i>	Test protocols for evaluation of CCM durability
Interactions with national and international-level projects and initiatives	
<i>IEA-ANNEX 30</i>	Collaboration on development of standardized testing protocols for PEM electrolyzers and cost reduction strategies.
<i>JRC</i>	Harmonisation of testing protocols and hardware for PEM electrolyzers

DISSEMINATION ACTIVITIES



Public deliverables

- D1.1: Cost benefit analysis and cost and performance target for large scale PEM electrolyser stack
- D2.1: Cost benefit analysis and cost and performance target for large scale PEM electrolyser stack
- D3.2 Large scale MEA manufacture options and suppliers - testing of large scale MEAS

Conferences/Workshops

- 1 organised by the project
- 3 in which the project has participated

Social media



Publications: 0

- Publications on two phase flow modelling and transport processes in porous media in preparation

Patents: 0

-Megastack design based on existing ITM patents



Thank You!

Coordinator: magnus.s.thomassen@sintef.no