SAPPHIRE

System Automation of PEMFCs with Prognostics and Health management for Improved Reliability and Economy

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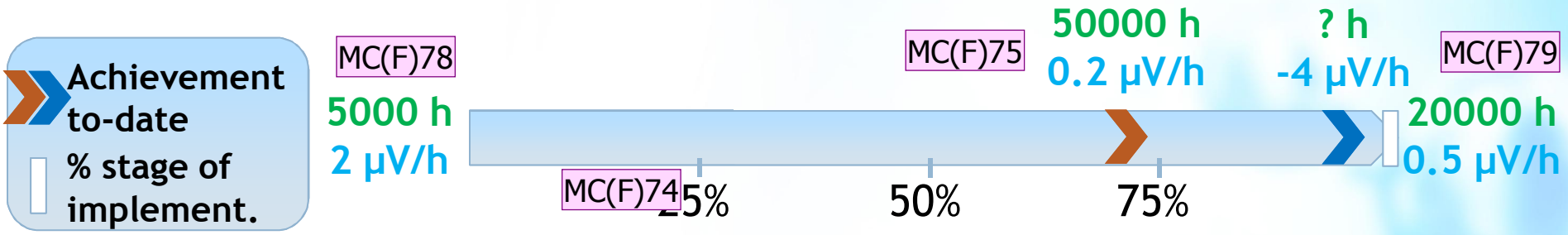
PROJECT OVERVIEW

Project Information	
Call topic	Robust, reliable and cost effective diagnostic and control system design for stationary power and CHP fuel cell systems
Grant agreement number	325275
Application area	Stationary Power Generation and CHP
Start date	May 1, 2013
End date	April 30, 2016
Total budget (€)	3 269 417,10
FCH JU contribution (€)	1 745 140,60
Other contribution (€, source)	~650 000 €, Norwegian Research Council
Stage of implementation	100% (ended April 30, 2016)
Partners	SINTEF; EIFER; ENSMM/UFC; FESB; ZSW; Dantherm Power (*now Ballard Europe*)

PROJECT SUMMARY

- Increase lifetime of fuel cells in µCHP
- Use prognostics to estimate Remaining Useful Life
- Design controllers to increase lifetime
- Apply on current stack technology
  - No development of new membranes, catalysts etc.
  - Compare to e.g. KeePEMalive
- State of the art at project start:
  - Guaranteed *5000 hours*
  - Degradation rate per cell *2 µV/h*
  - Regulatory control
- Target market: domestic applications

PROJECT PROGRESS/ACTIONS - Durability



Aspect addressed	MC(F)76 Parameter (KPI)	Unit	SoA 2016	MC(F)77 FCH JU Targets		
				Call topic	2017	2020
Durability	Lifetime	h	≈50000	20000	*N/A*	30000
	Cell degradation rate	µV/s	0.2 µV/h			

Future steps:

- Basic research in rejuvenation mechanisms
- How long does it last? (Tested 7500 hours)
- Does it promote other degradation modes?

Slide 4

MC(F)74 Position white cursor according to % project stage of implementation at date of 01/11/2016
The position of the white cursor should remain the same throughout the presentation
MARENCO Claudia (FCH), 15/02/2016

MC(F)77 Indicate the targets defined in the specific call topic to which you had originally applied and/or in the multi-annual programmes (MAIP/MAWP)
MARENCO Claudia (FCH), 16/02/2016

MC(F)76 Please refer to the objectives/targets/KPIs set in the multi-annual work plans (MAIP or MAWP) or in the topic description for the call for proposals to which you successfully applied (see the relevant annual plan - AIP or AWP - for reference).

Please add extra rows in case you have more than one objective/target/KPI adressing the same aspect
MARENCO Claudia (FCH), 08/09/2016

MC(F)78 Indicate here the value of the parameter monitored at the beginning of the project and the corresponding unit.
If another parameter monitored in the project addresses the same aspect, add a second value in a different colour.
MARENCO Claudia (FCH), 08/09/2016

MC(F)79 Indicate the project target value for this parameter and the corresponding unit.
If another parameter monitored in the project addresses the same aspect, add a second value in a different colour.
MARENCO Claudia (FCH), 08/09/2016

MC(F)75 Position red cursor according to achievement to date (Oct/Nov 2016) (in scale between starting point and target value) + indicate achieved value and unit.
If another parameter monitored in the project addresses the same aspect, add a second arrow in a different colour.
Repeat for any additional paramaters addressing the same aspect.
MARENCO Claudia (FCH), 08/09/2016

PROJECT PROGRESS/ACTIONS - Durability

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Achievement to-date

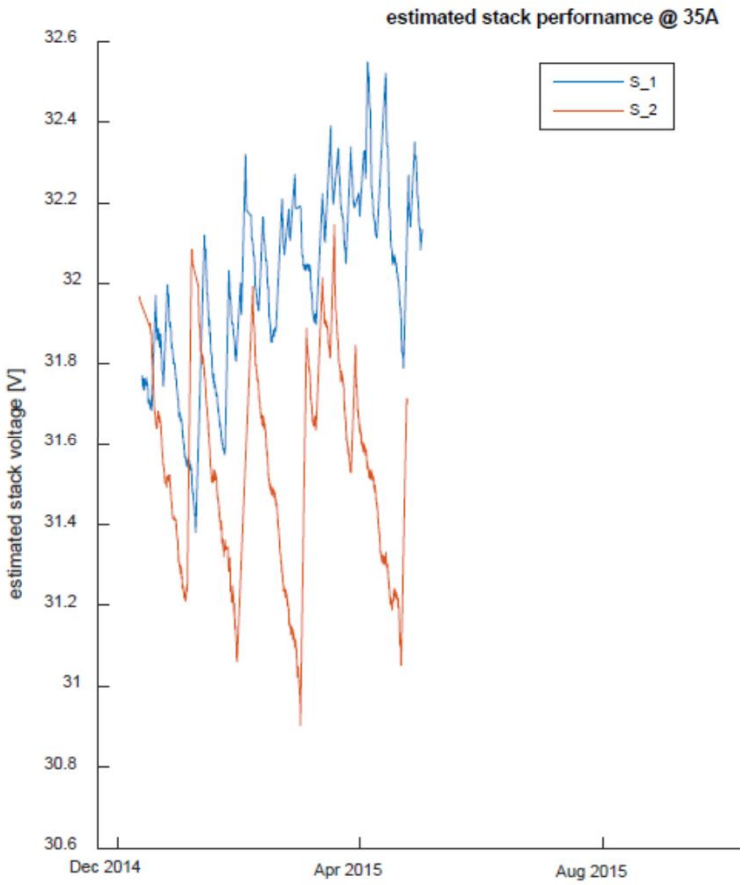
% stage of implement.

5000 h
2 µV/h

20000 h
0.5 µV/h

50000 h
0.2 µV/h

? h
-4 µV/h



1st test campaign

- Computer crashes
- Forced restarts
- Rejuvenation detected

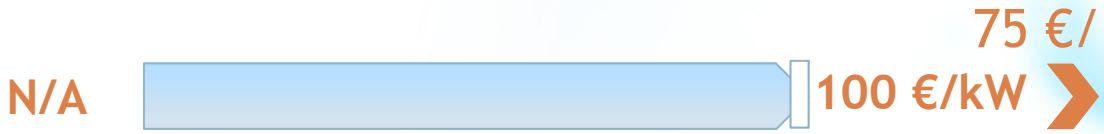
2nd test campaign

- Fixed computer
- Scheduled restarts
  - Only system 2
  - Only for 1000 h
- Forced restarts on system 1 after 2000 h

PROJECT PROGRESS/ACTIONS - Additional cost of control system

Achievement to-date

% stage of implement.



Aspect addressed	Parameter (KPI)	Unit	SoA 2016	FCH JU Targets		
				Call topic	2017	2020
Cost	Additional cost of control system	€/kW	75	100	N/A	N/A

Future steps:

- 68 € pressure sensor on 900 W system
  - All other control implemented in LabVIEW, no extra cost
- Considered only *electric* power (even if it is CHP)
- Much cheaper differential pressure gauges are available

SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

Interactions with projects funded under EU programmes	
KeePEMalive	Shared cell degradation data
D-CODE	Established online EIS diagnostic groundwork
Re4cell	Invited to workshop
Second Act	Invited to workshop
Giantleap	Follow-up project applied on city buses
Interactions with national and international-level projects and initiatives	
Diapason 1 & 2	French projects, established prognostics groundwork

DISSEMINATION ACTIVITIES

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Public deliverables OGY(F)26

- D2.5, Test protocols
- D2.6, Measurement techniques
- D5.1/2/3, Diagnostics
- D6.1/2, Prognostics
- D7.3, Control evaluation

Conferences/Workshops MC(F)80

- Organised **2** workshops
- Participated to **12** conferences and **2** workshops of other projects

Social media MC(F)64

Publications: 23 at co MC(F)67 nces, 3 in journals, 2 PhD theses

- Bezmalinović & al., *Characterization of PEM fuel cell degradation by polarization change curves, J. Pow. Sour. 294 (2015) 82-87.*
- *Lechartier & al., Proton exchange membrane fuel cell behavioral model suitable for prognostics, Int. J. Hydr. En. 40 (2015) 8384-8397.*

Patents: 2 MC(F)63

- Zenith & al., *Control of an electrochemical device with integrated diagnostics, prognostics and lifetime management*, WO2016059203A1

Slide 8

OGY(F)26 Indicate the full name of up to 5 public deliverables
ORTEGA GARCIA Yanaris (FCH), 16/02/2016

MC(F)63 Specify the number of patents and give reference to up to 2
MARENCO Claudia (FCH), 16/02/2016

MC(F)67 Specify the number of publications and give reference up to 2 most relevant ones
MARENCO Claudia (FCH), 22/02/2016

MC(F)64 Project presence on social media:
Create a hyperlink to the relevant project page (Youtube, LinkedIn, Facebook, Twitter, Instagram). Delete the icons that are irrelevant because the project is not present on the social media concerned.
To create a hyperlink: right click on the icon, select "hyperlink" and paste the url in the "address" field
MARENCO Claudia (FCH), 08/09/2016

MC(F)80 Indicate the number of conferences/workshops organised by the project and that the project has attended
MARENCO Claudia (FCH), 08/09/2016

EXPLOITATION PLAN/EXPECTED IMPACT

Exploitation

- Consortium patent licences
  - Handled by EdF & ZSW
- Licensing of EIFER patent
- Ballard product innovation
  - Starting 2017
- Prognostic and control SW
  - FCLAB and SINTEF
  - Freely available
- CFD improvements to flow fields for ZSW

Impact

- All quantitative targets in call were exceed
- On-line catalyst regeneration techniques
- Boosted lifetime for µCHP
- What about automotive?
  - See *Giantleap* for further developments

Thank You!

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