Premium Act
(256776)

Second Act
(621216)

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www.mrtfuelcell.polimi.it/premiumact.html

www.second-act.eu *(in preparation)*

Premium Act OVERVIEW

- PREdictive Modelling for Innovative Unit Management and ACcelerated Testing procedures of PEFC
- AIP SP1-JTI-FCH.2009.3.1 Fundamentals of fuel cell degradation for stationary power application
- 01/03/2009 to 28/02/2014
- Total budget: 5 370 190 € - FCH JU contribution: 2 513 251 €

- Overall purpose of project: **Improvement of stationary PEFC systems durability (40000h required!)** → ***A reliable method to predict system lifetime, benchmark components and improve operating strategies***
- 100% (project ended)

Premium Act

Premium Act TARGETS AND ACHIEVEMENTS

Status before project	AIP target	Project Target
Limited knowledge of degradation mechanisms when related to different fuels for stationary applications European FC systems durability lower than the target of 40000 hours	• **Basic research** to better **understand** degradation/ failure **mechanisms** for **different fuels** and levels of power • **Critical parameters** and operating conditions • **Methodologies** as well as tools for modelling, operational controls and diagnostics.	• Improvement of degradation understanding (**advanced** in-situ and ex-situ **characterizations** coupled with **modelling** for **mechanisms** understanding) • Investigations conducted for 2 types of technologies & systems (**Reformate** and **Direct Methanol**) • Ageing data at **cell**, **stack** & levels ➔ Identification of **main parameters enhancing or reducing degradation** ➔ Development of **specific accelerated stress tests** ➔ Proposal of **operating strategies** and of **lifetime prediction methodology**

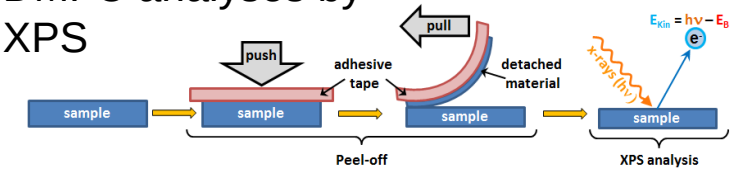
Premium Act TARGETS AND ACHIEVEMENTS

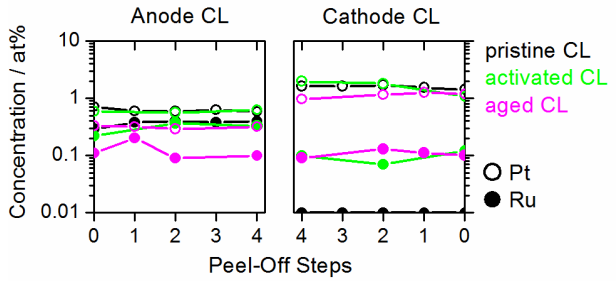
Achievements

Analyses & Mechanisms

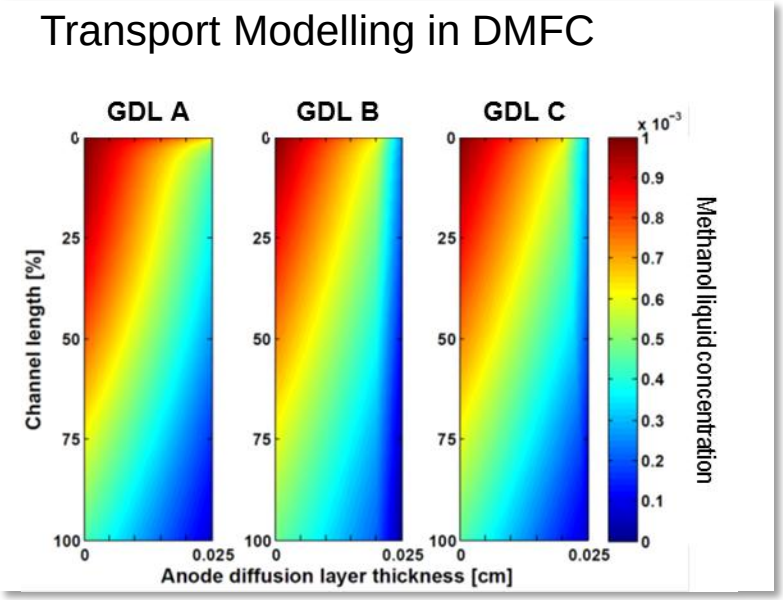
- **Specific degradation mechanisms**
  - Non-reversible: *Pt and PtRu catalysts degradation related to local conditions*
  - Reversible: *CO pollution in PEMFC; Anode CO2 accumulation in DMFC; Pt/Ru oxides formation in DMFC*

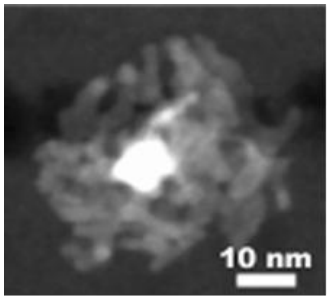
DMFC analyses by XPS

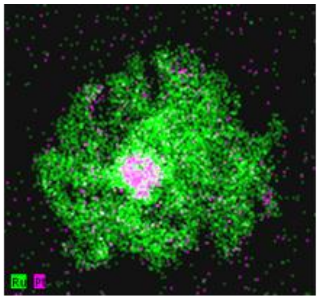




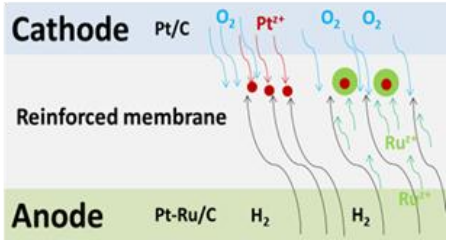
Transport Modelling in DMFC







PEMFC analyses by TEM & X-EDS



Premium Act

Premium Act TARGETS AND ACHIEVEMENTS

Achievements

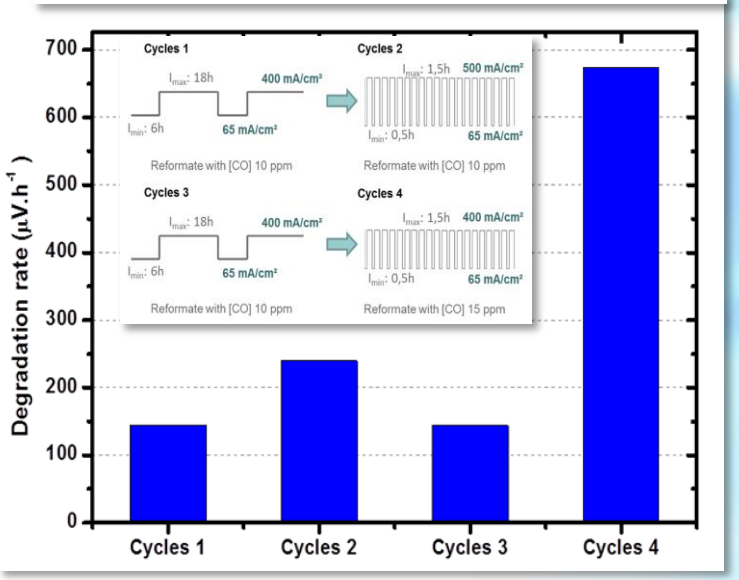
Protocols & strategies

- **AccST protocols**: analysed in single cells and stacks for DMFC and reformate PEMFC.

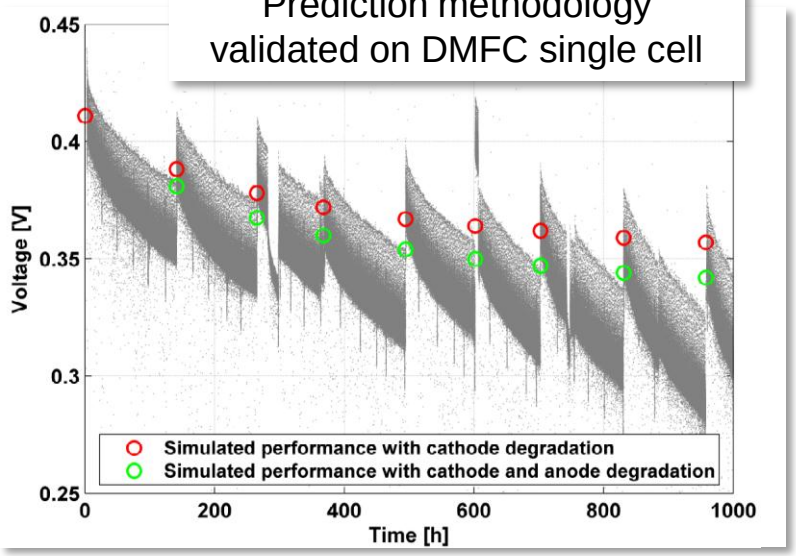
→ ***Performance decay acceleration by ~ 5 to 7***

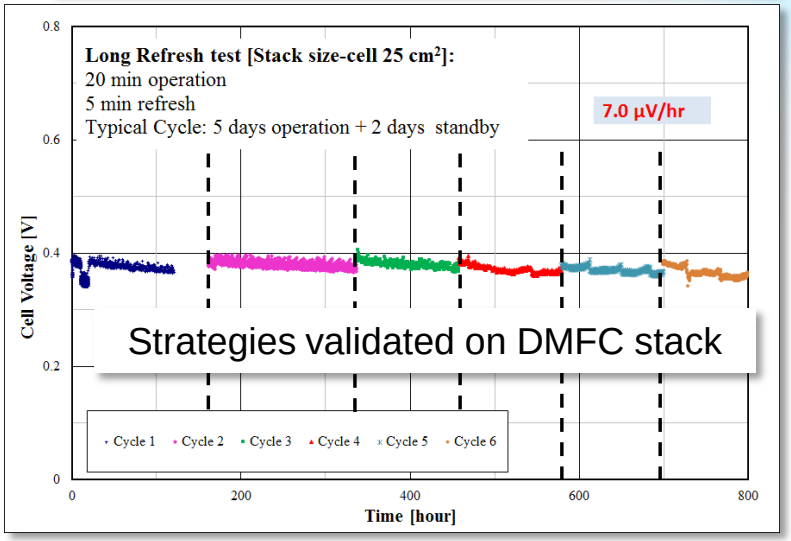
- **A lifetime prediction methodology** including experiments and simulations
- **Operating strategies** addressing reversible degradation

AccST validated on a PEMFC stack



Prediction methodology validated on DMFC single cell





Strategies validated on DMFC stack

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SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- Interaction of Italian partners with the national **Real FC** project with regard to experimental data and testing methodology
- Part of methodology and knowledge used for experimental and modelling investigations from **DECODE**
- **Common workshop** with two FCH-JU projects on stationary application: **STAYERS & KEEPEMALIVE**

"Degradation of PEM Fuel Cells" (held by Sintef - Oslo - April 2013) → *Presentation of Premium Act PEMFC and DMFC degradation studies*

➔ ***starting point of Second Act proposal***

https://www.sintef.no/Projectweb/STAYERS/News--Events/Degradation-of-PEM-Fuel-Cells---experience-exchange-and-discussions/

Premium Act

Second Act OVERVIEW

- **S**imulation, statistics and **E**xperiments **C**oupled to develop **O**ptimized a**N**d **D**urable µCHP systems using **AC**celerated **T**ests
- AIP SP1-JTI-FCH.2013.3.1 - Improving understanding of cell & stack degradation mechanisms using advanced testing techniques, and developments to achieve cost reduction and lifetime enhancements for Stationary Fuel Cell power and CHP systems

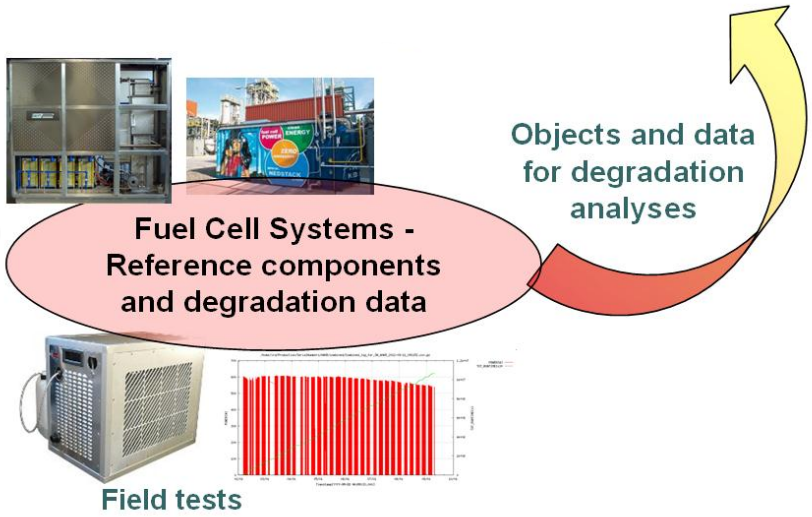
- 01/05/2014 to 30/04/2017
- Total budget: 4 643 707 € - FCH JU contribution: 2 523 254 €
- Overall purpose of project: **to improve understanding of stack degradation and propose durability improvements for µCHP systems using PEMFC or DMFC.**
- 15% completed

Second Act

Second Act OVERVIEW / Link Premium Act *

Concept

Step (1)



** Similar link with projects Stayers & Keepemalive for pure H2 PEMFC*

Second Act

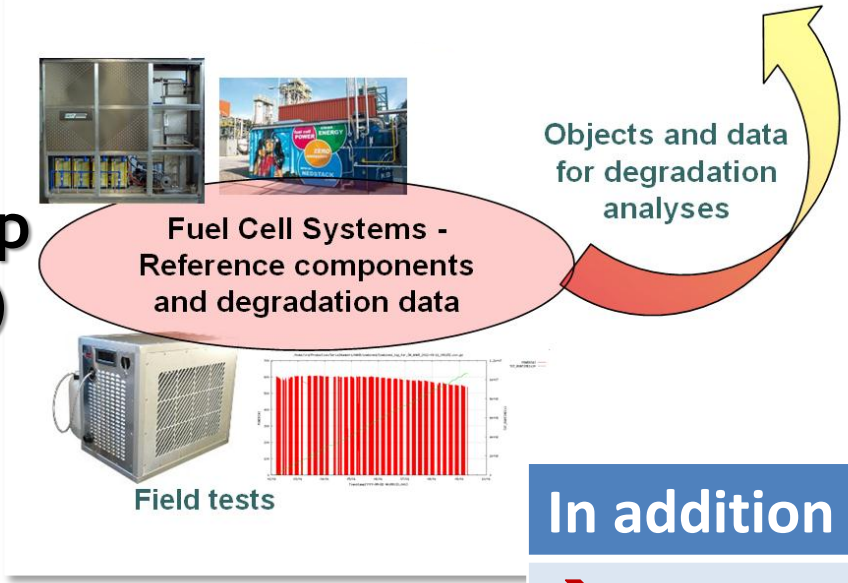
Second Act OVERVIEW / Link Premium Act *

Concept

Exploitation of Premium Act

- Ageing data for statistical analyses
- Qualified components, stack, system (for DMFC and Reformate PEMFC)

Step (1)



In addition to Premium Act approach

➔ **Pure H2 PEMFC systems**

** Similar link with projects Stayers & Keepemalive for pure H2 PEMFC*

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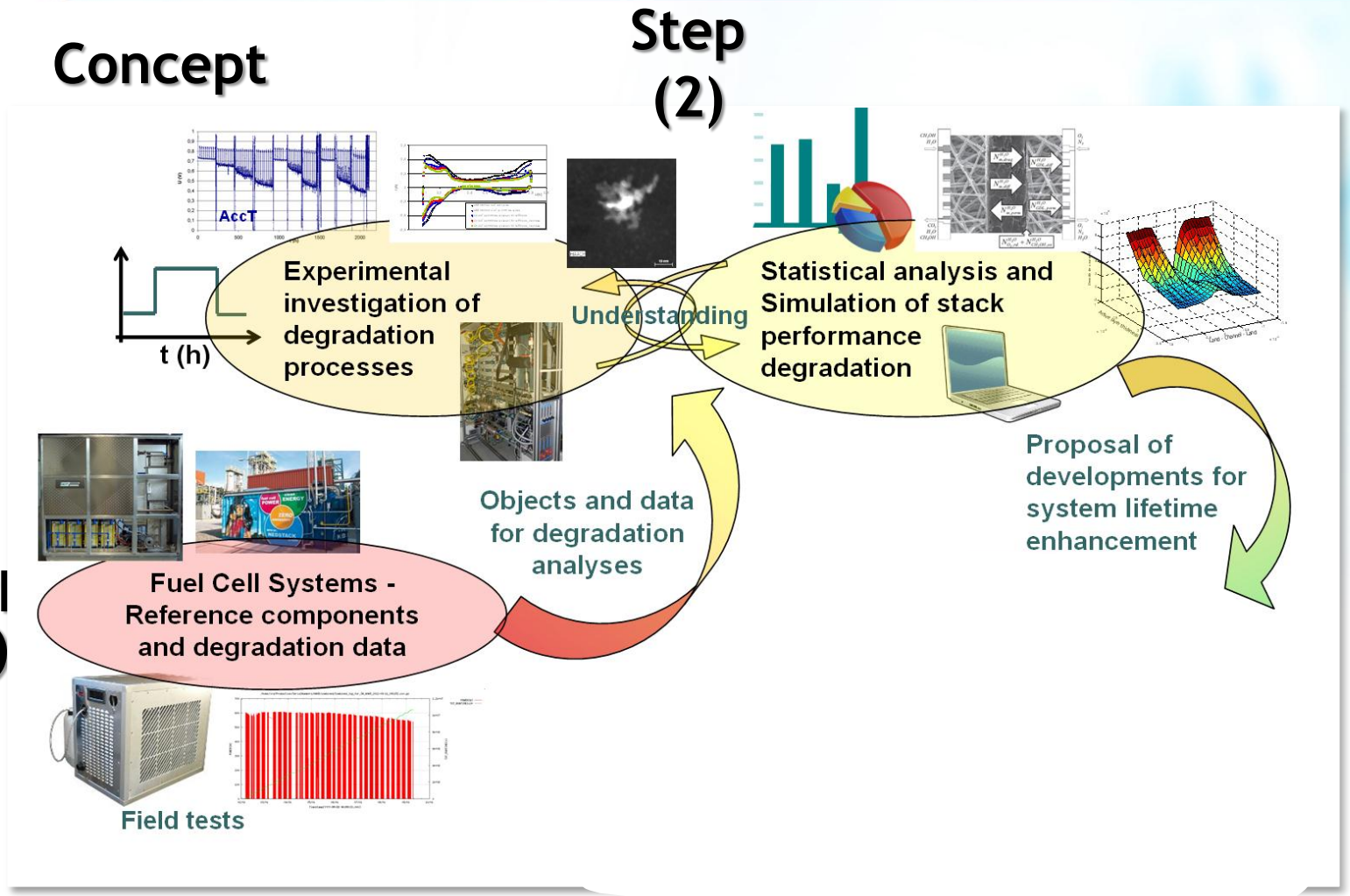
Second Act OVERVIEW / Link Premium Act *



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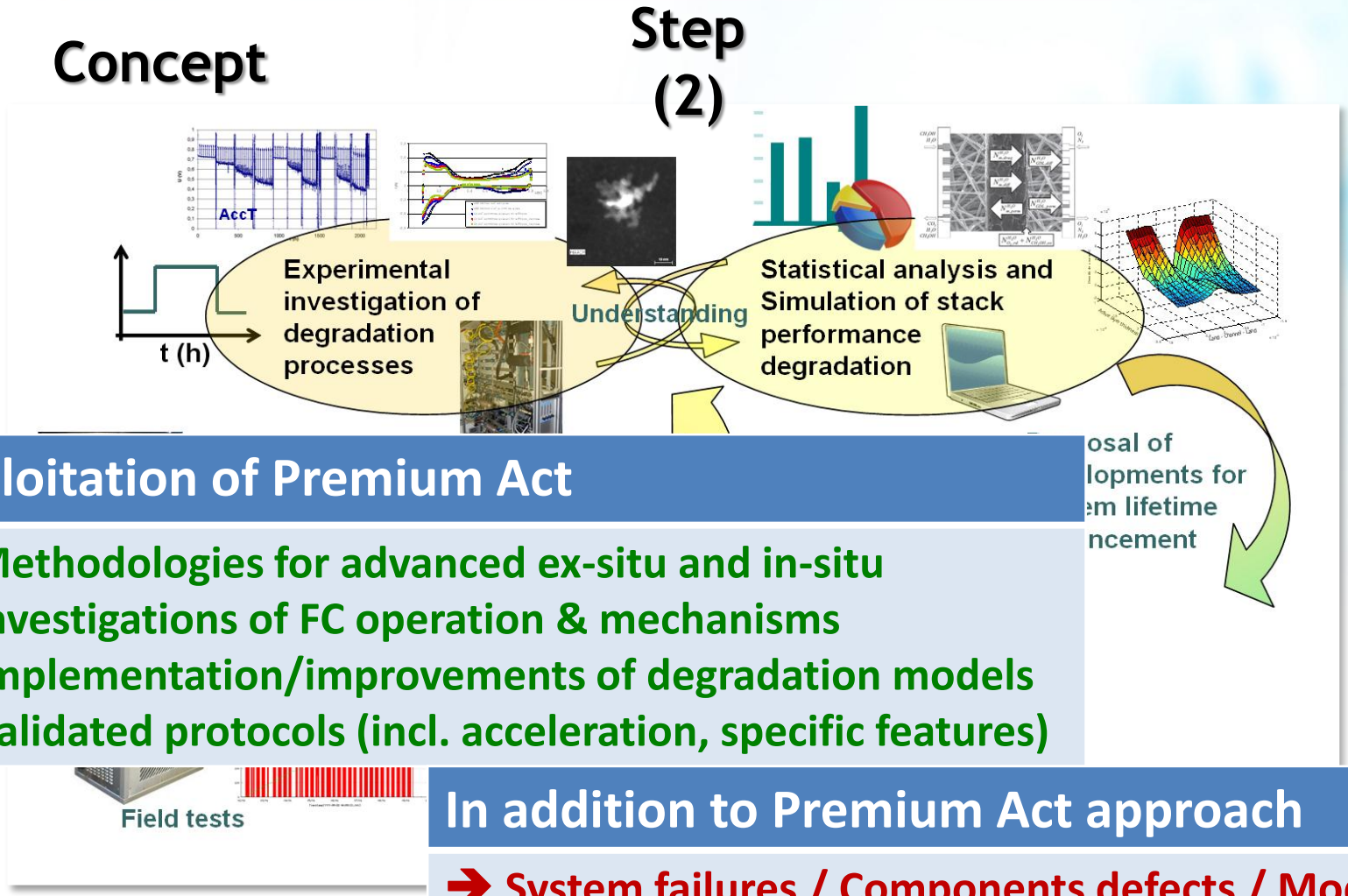
Second Act

Second Act OVERVIEW / Link Premium Act *



Exploitation of Premium Act

- Methodologies for advanced ex-situ and in-situ investigations of FC operation & mechanisms
- Implementation/improvements of degradation models
- Validated protocols (incl. acceleration, specific features)

In addition to Premium Act approach

➔ System failures / Components defects / Modelling heterogeneities & reversible degradation

** Similar link with projects Stayers & Keepemalive for pure H2 PEMFC*

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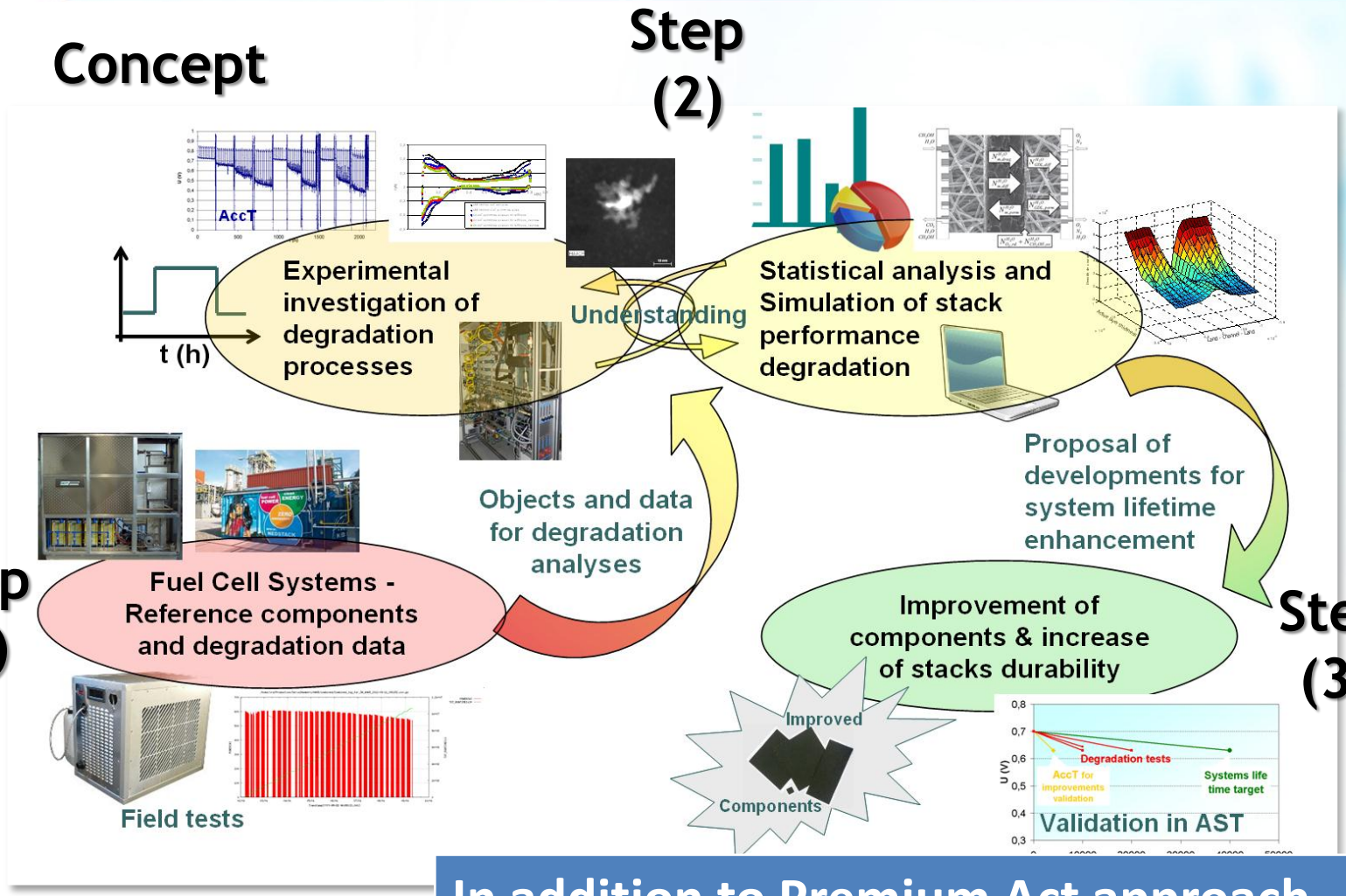
Second Act OVERVIEW / Link Premium Act *



In addition to Premium Act approach

➔ **Proposal & Validation of improvements vs. applications specific durability requirements**

Second Act

RISKS AND MITIGATION

- *2 main targets for 3 technologies (DMFC; pure H2 & Reformate PEMFC)*
  1. *Better **understanding** of cell and stack degradation*
  2. *Demonstrating lifetime **improvements** (increased tolerance to applications' relevant cycling or operating modes through stack components modifications)*

- Related main risks
  - Quantification of degradation only partial

    → additional analyses or models validation
  - Difficulty in implementing proposed modifications / Durability improvement lower than expected /

    → Iterative process/selection & implementation of another core modification

Acknowledgements

Premium Act

cea
IRD Fuel Cell Technology
Politecnico di Milano
DLR
ICI Caldaie
JRC European Commission
Soprano

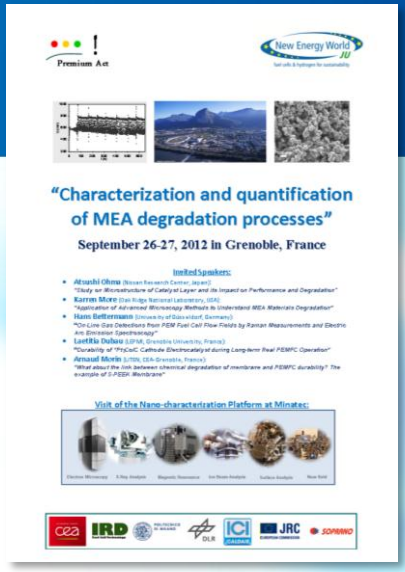
Thank you for your attention

cea
IRD Powering People Anywhere
Nedstack PEM Fuel Cells To be sure.
ICI Caldaie high heat technology
Politecnico di Milano
DLR
JRC European Commission
SINTEF
TU Graz Graz University of Technology
Second Act

Additional slides removed from initial template

DISSEMINATION ACTIVITIES

- **Organized workshop: "Characterization and quantification of MEA degradation processes"**, September 2012 in Grenoble, France
- **19 papers** submitted & **35 presentations** in international conferences or workshops



EXPLOITATION PLAN/EXPECTED IMPACT

For the 3 Industry partners involved (IRD - ICI - SOPRANO)

- **Results of interest related to FC system → information: how to operate the systems / parameters degrading stack / *core components***
- **Type of exploitation planned → application of mitigation strategies / Modification of system components or monitoring to enhance lifetime**
- **Impact expected → systems more competitive on the commercial level thanks to better reliability; *use for other applications***

Premium Act

HORIZONTAL ACTIVITIES

- Training & education
  - Involvement of students up to PhD level by R&D partners
  - Yearly summer school between TU Graz and National Yokohama University
- Project work in safety, regulations, codes, standards, general public awareness
  - TC105/WG11 (Single cell test protocols): *SECOND ACT partners are involved in this international Fuel Cell technology committee. Possible to promote the project inside this group and investigate about the possibility to organize sessions about Fuel Cell degradation*
  - IEA Advanced Fuel Cells Implementing Agreement - Annex 25 (Stationary Fuel Cells): *CEA and TUG are members of Annex 25 and can disseminate key aspects of Second Act in Annex 25 workshops.*
  - **EXPO2015 in Milano: dissemination event to general public and end-users** (possibly including demonstrating activities)