STAYERS

Stationary PEM fuel cells with lifetimes beyond five years

FCH-JU 256721

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www.stayers.eu

STAYERS PROJECT OVERVIEW

5TAYERS 1 2 3 4 5

Stationary PEM fuel cells with lifetimes beyond five years

SP1-JTI-FCH.2009.3.2: Materials development for cells, stacks and balance of plant
SP1-JTI-FCH.2009.3.1: Fundamentals of fuel cell degradation for stationary power applications

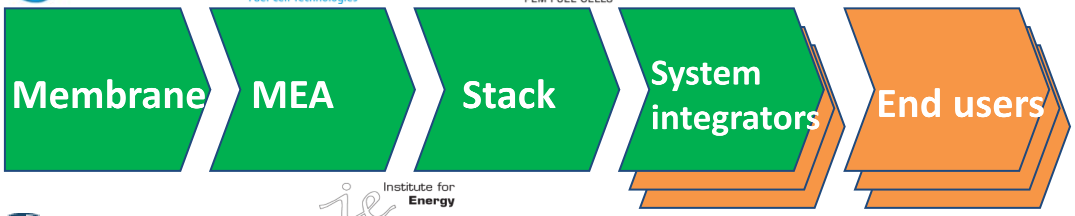
Duration: 42 months; 1 Jan 2011 – 30 Jun 2014

Budget/FCH-JU funding: 4.1/1.9 M€

Goal: lifetime of PEM fuel cell > 40,000 hours in stationary operation

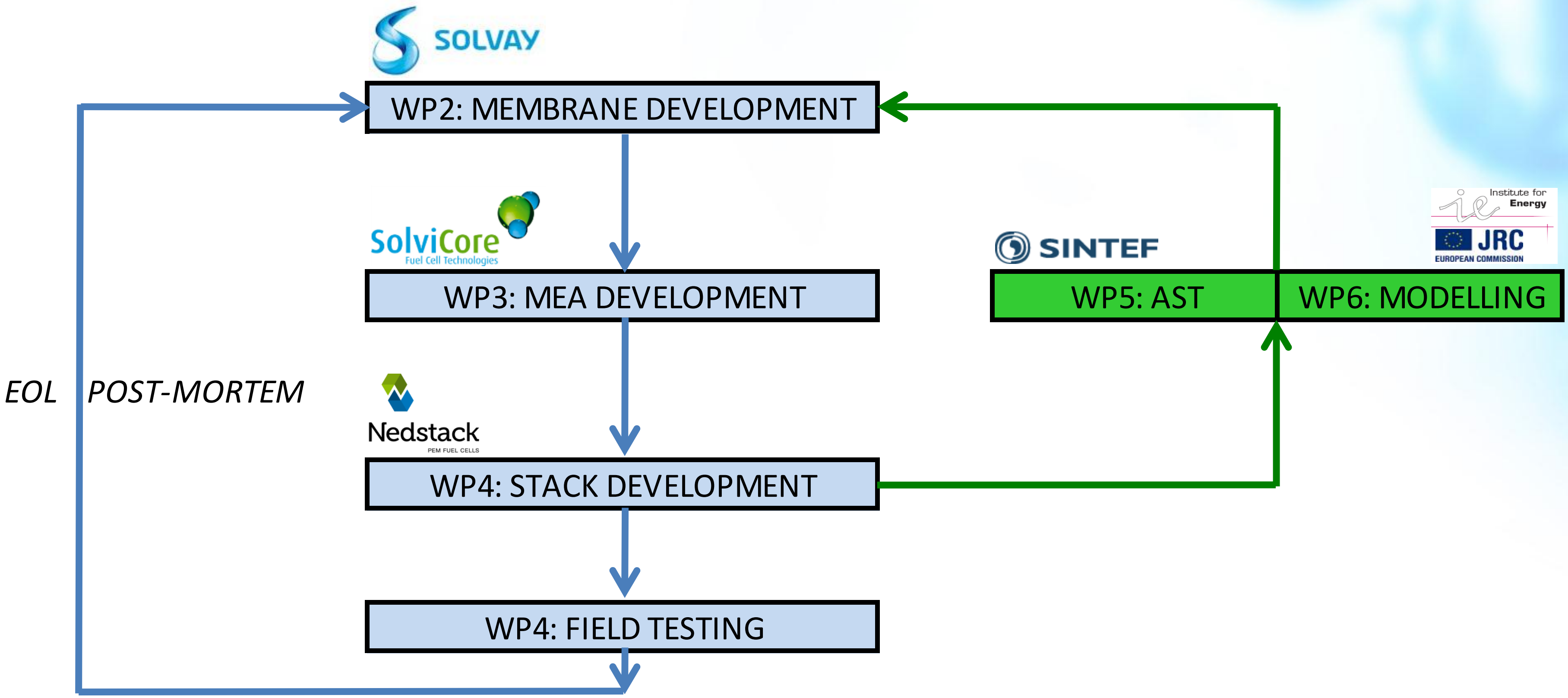
Motivation: lower OPEX/TCO of PEM power plant

Development & Commercialization: SOLVAY, SolviCore (Fuel Cell Technologies), Nedstack (PEM FUEL CELLS)



Testing + modeling: SINTEF, Institute for Energy JRC (EUROPEAN COMMISSION)

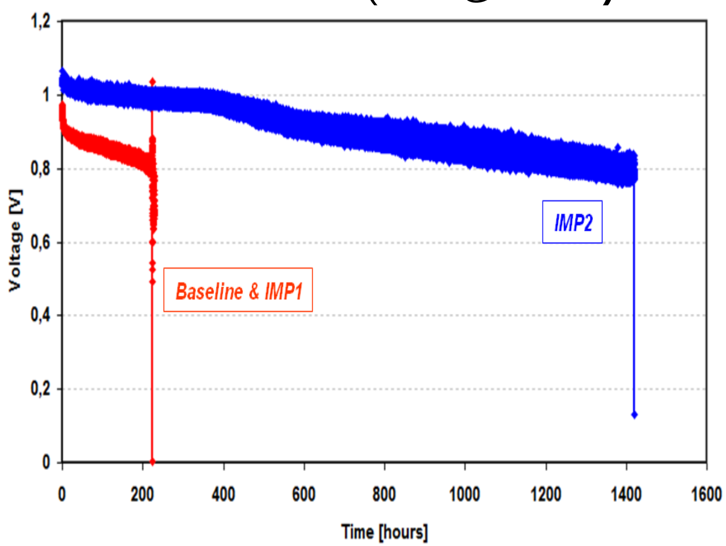
PROJECT APPROACH: 4+1 ITERATIONS

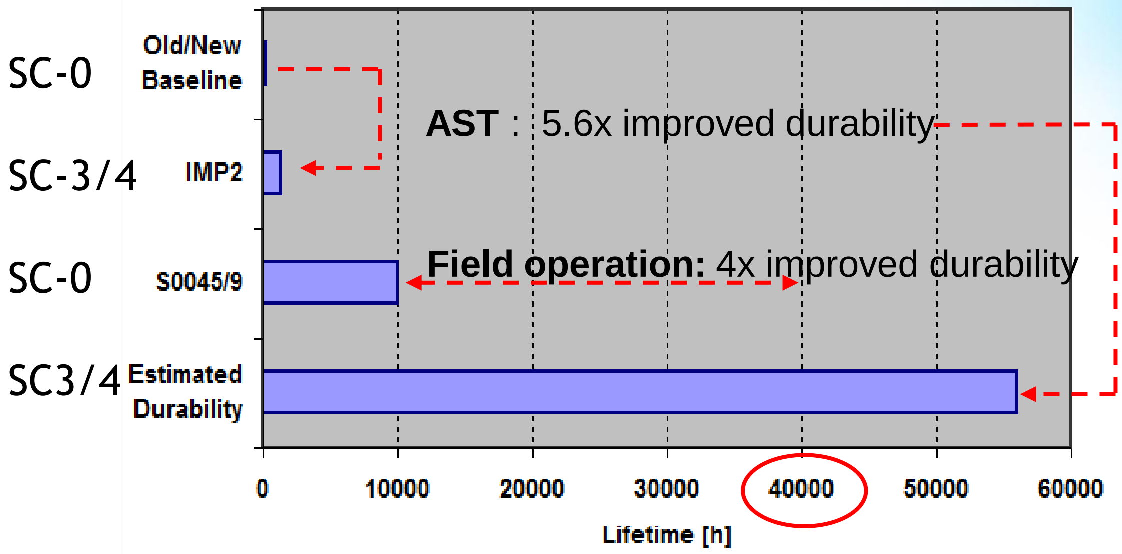


WP-2 MEMBRANE DEVELOPMENT

- Process development & scale-up
- Product development: different membrane generations
  - First baseline membrane (SC-0) showed proven lifetime >10,000 hrs
    - No substantial degradation observed in eol/post-mortem tests
  - Final IMP-2 membrane estimated to surpass 40,000 hrs based on AST

Membrane AST (OCV@90° C**)**





WP-3: MEA DEVELOPMENT

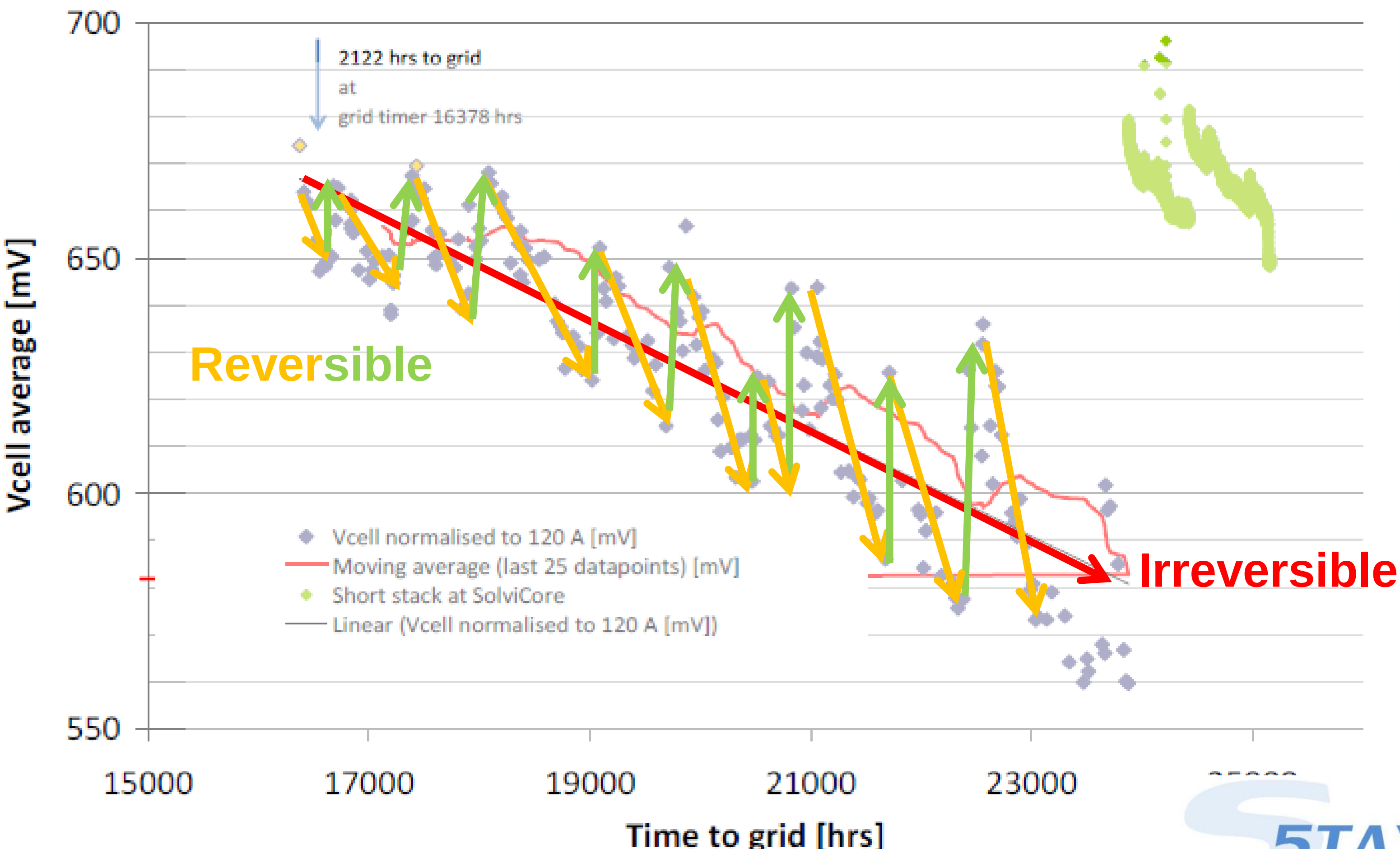
Evolution of MEA generations in course of STAYERS (simplified):

MEA generation	Membrane	Electrode	RIM type	objective
SC-0	old baseline	CCB type 1/3	4-layer	reference
SC-1	new baseline	CCB type 3	2-layer	apply new baseline membrane
SC-2	IMP-1	CCM - type 3 based	simplified 2-layer	apply new membrane, CCM, process automization, improve durability
SC-3	IMP-1/2	CCM rainbow	simplified 2-layer	improve durability, conditioning, costs
SC-4	IMP-1/2	CCM multiple	simplified 2-layer	demo extrapolated life 40,000 hrs

- SC-3: multiple variations for evaluation
- SC-4: selected best performers of SC-3

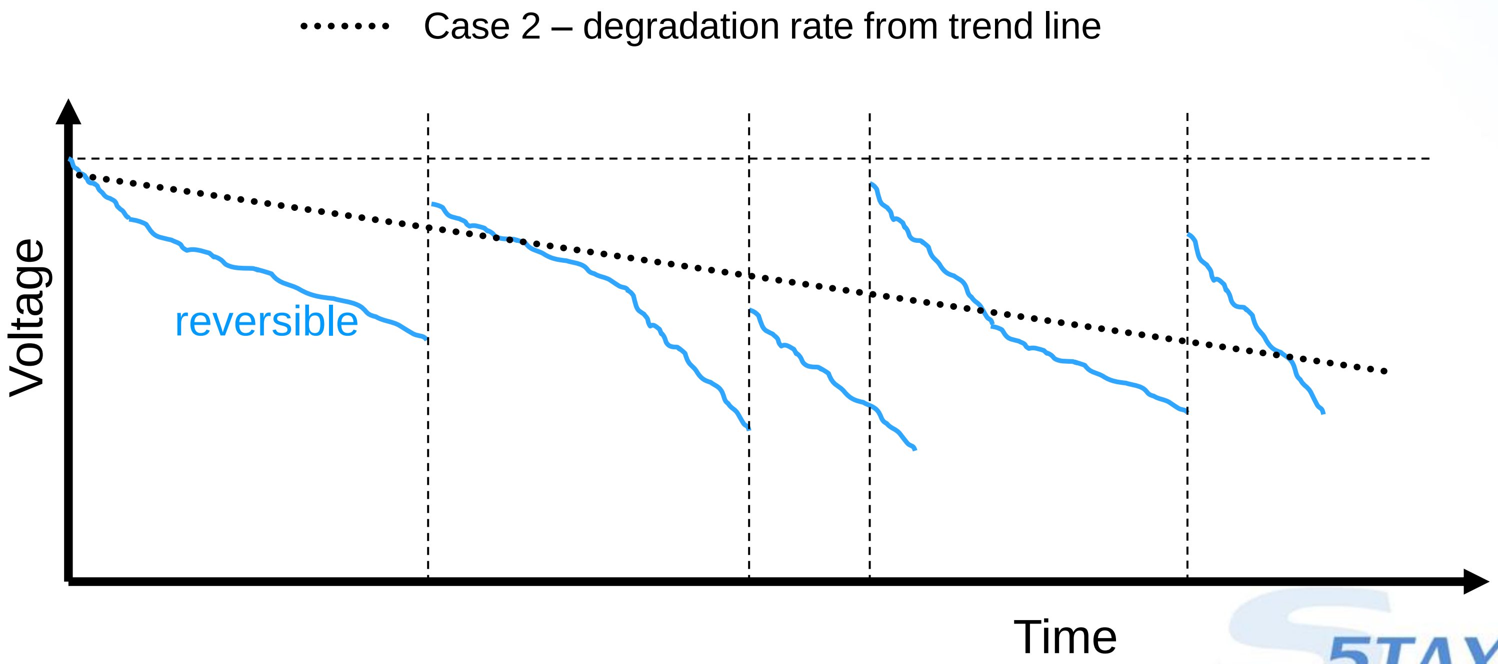
SC-0 MEA PERFORMANCE IN FIELD TESTS

Divided in reversible and irreversible effects



VALIDATED EXTRAPOLATION METHODS

- Validation of lifetime prediction after 4 khs
- Using field data in retrospect (SC-0, 1, 2, ext. reference)
- 2 extrapolation methods selected (min/max window):
  - Case 2: conservative, based on all data
  - Case 4: optimistic, based on retrievable performance only



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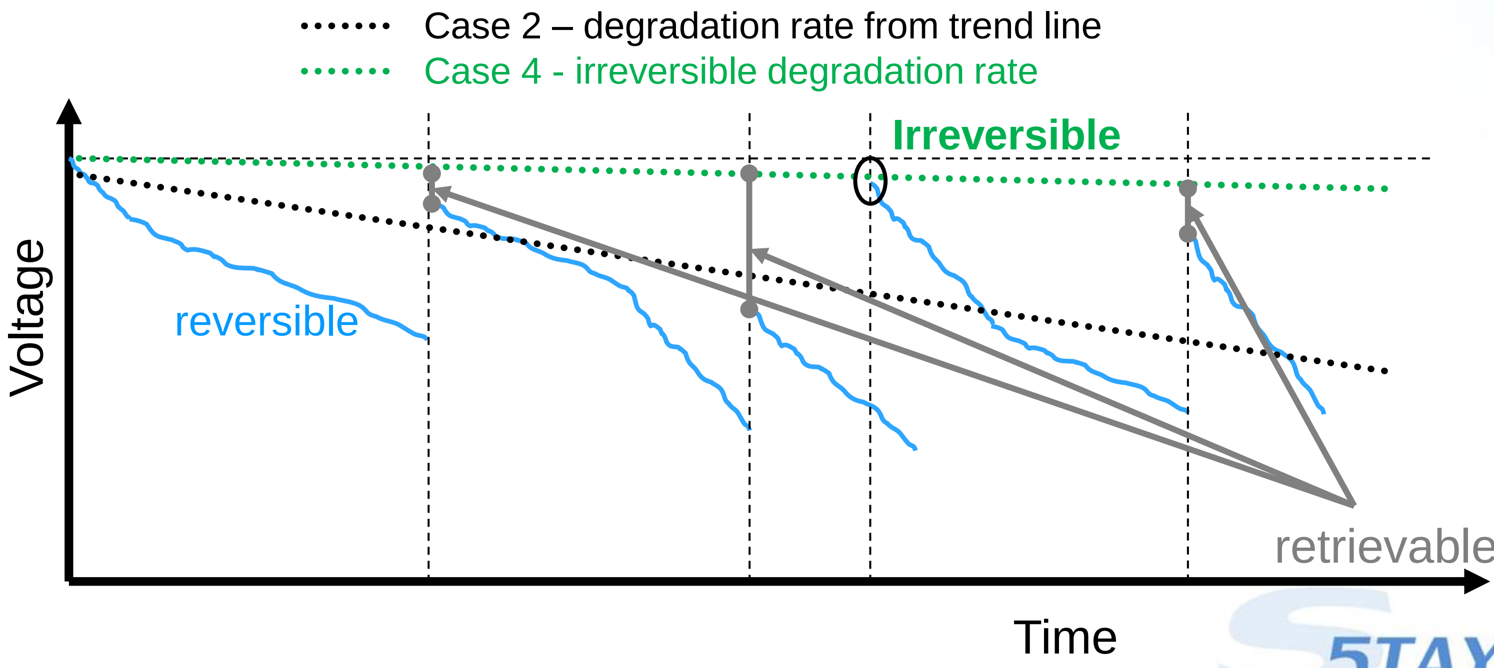
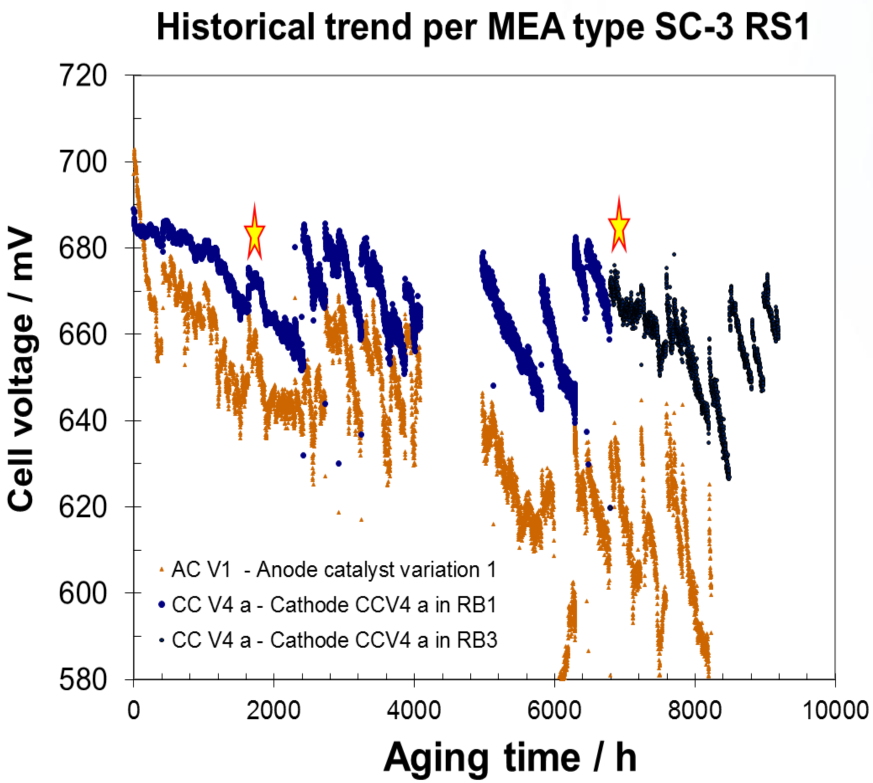
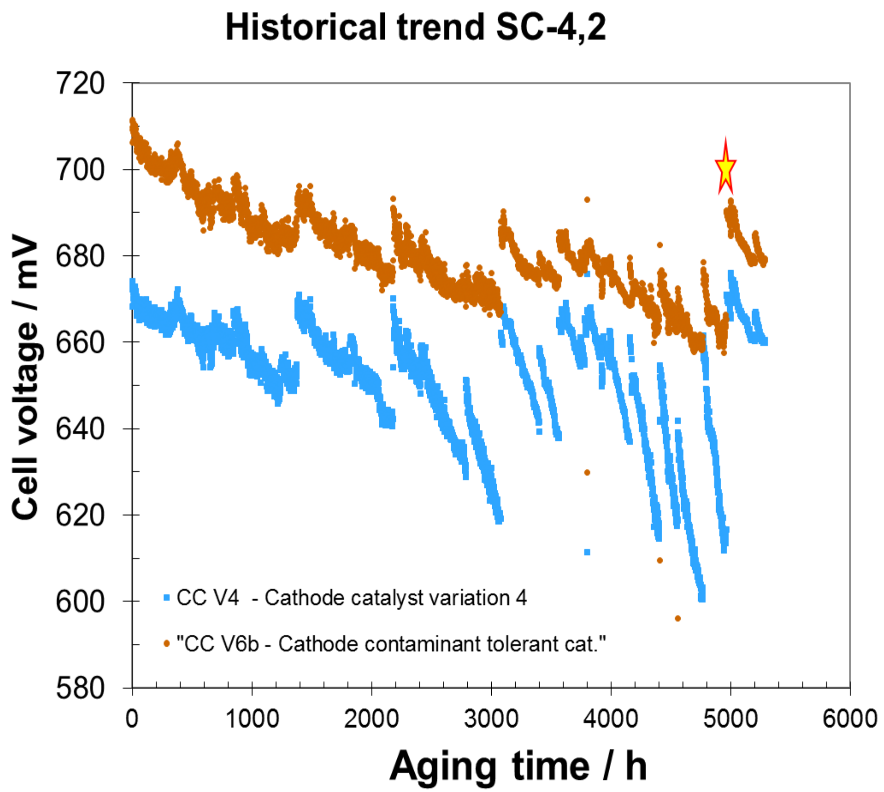


FIELD TESTING - EXAMPLES





- > 50 MEA variations (type of cat, loading, GDL, process) have been tested and analyzed (BOL, EOT, PM)
- Predominant decay mechanisms have been identified

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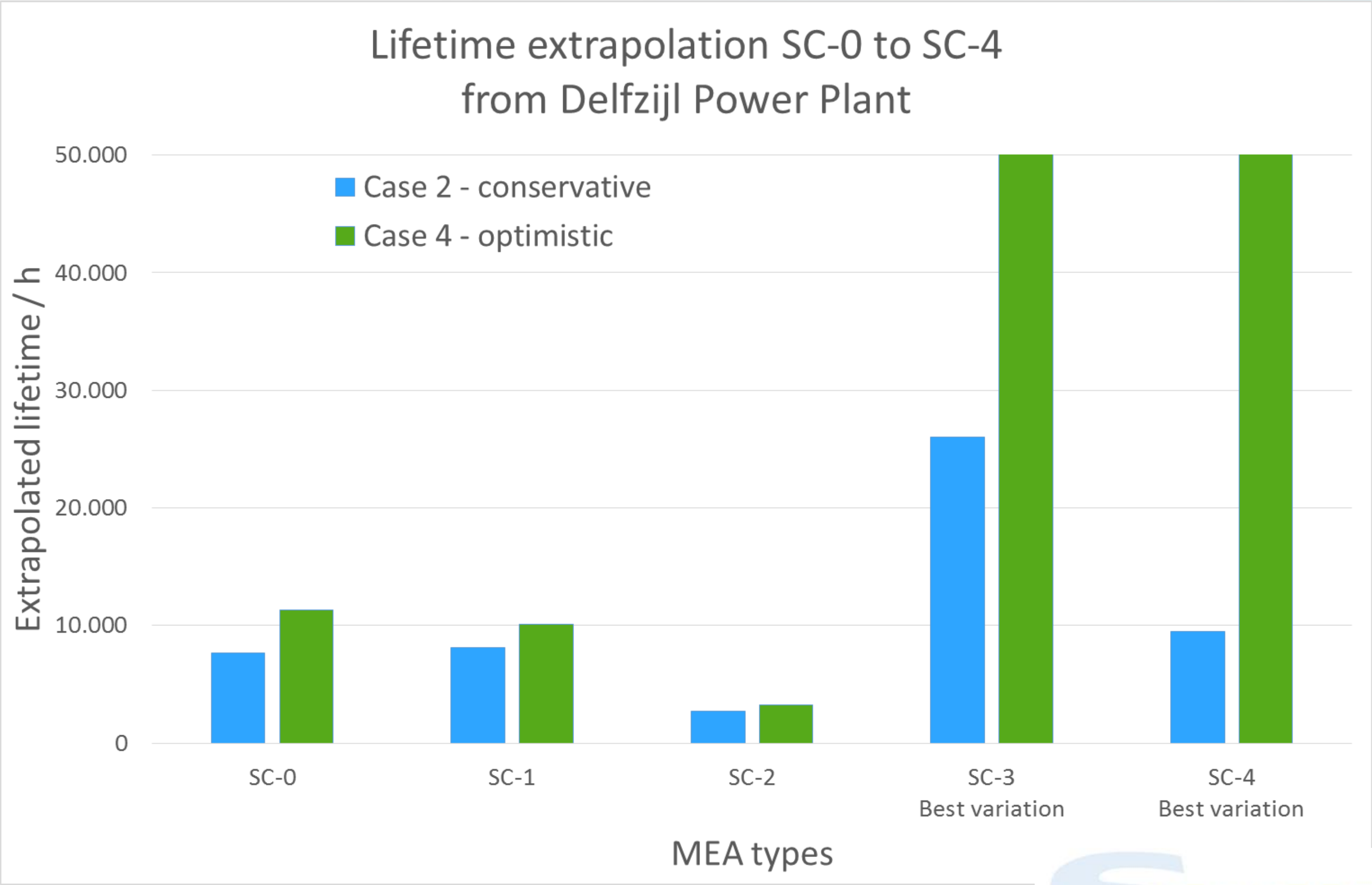
EXTRAPOLATED MEA LIFETIMES SC-0 TO 4



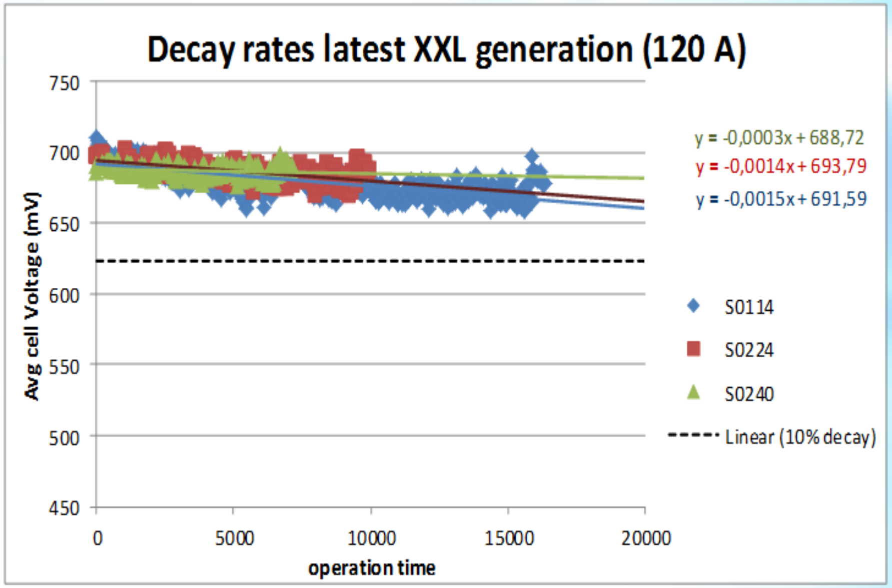
WP-4: STACK COMPONENT DEVELOPMENT

Lifetime prediction by:

- Material analyses 0 to 23,000 hs
- AST's

	Lifetime (hrs)		improvement
component	**proven**	**estimated**	**implemented**
I. Flow fields	> 28,000	40,000	**not required**
II. Cell plates	> 28,000	40,000	**not required**
permeability & dimensional stability			
surface properties / hydrophobicity			
conductivity			
mechanical properties			
III. Seals	20,000 (ref)	40,000	**yes**
IV. Housing & mounting	20,000 (ref)	>> 40,000	**yes**
System / BOP	40,000	80,000	**not required**

SET UP FOR FIELD TESTS



- H_2 from chlorine plant Akzo Nobel
- Operating point 60 kW ~ 0.5 A/cm^2
- Total hrs to grid > 40,000
  M1-M42: >25,000

XXL stack	lifetime (khs)	decay rate (µV/h)	Estim. Life-time (khs)
S0114	16.4	1.55	44.6
S0224	10	1.43	48.3
S0240	7.1	0.32	216.0
avg	**11.2**	**1.1**	**103.0**

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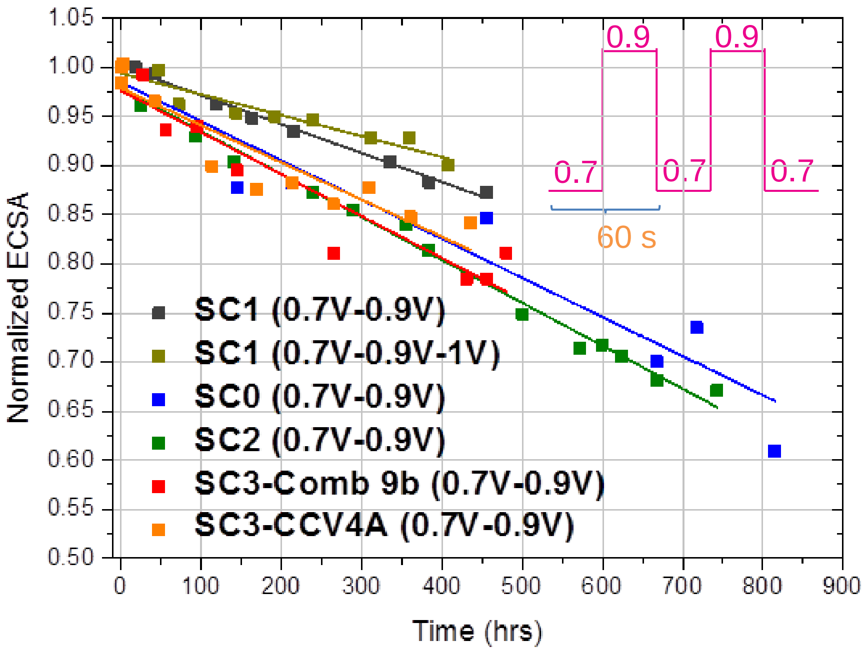
WP-5: CATHODE AST & CONTAMINANTS

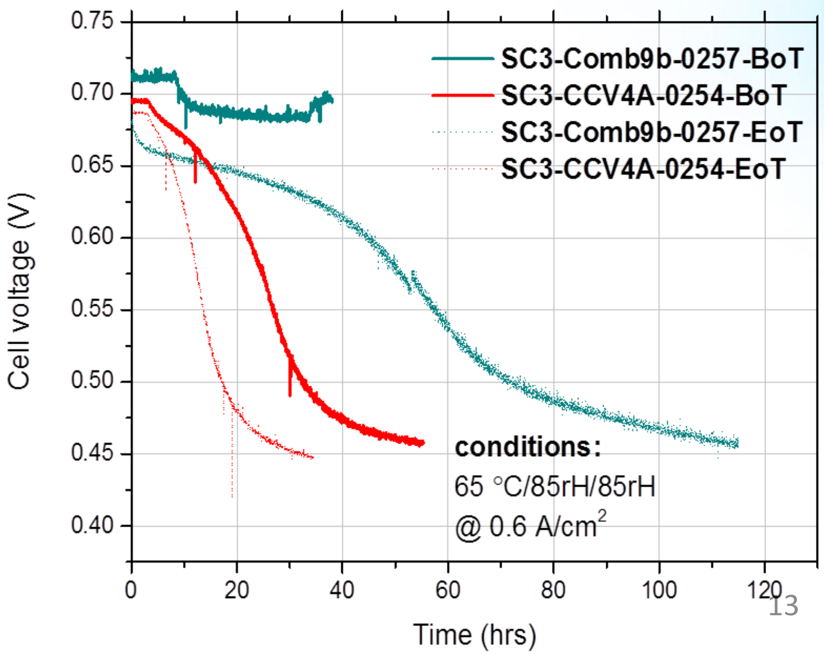
Irreversible decay: Cathode AST

- cycling 0.7 V – 0.9 V
- clear performance & ECSA decrease
- Acceleration factor=5-6



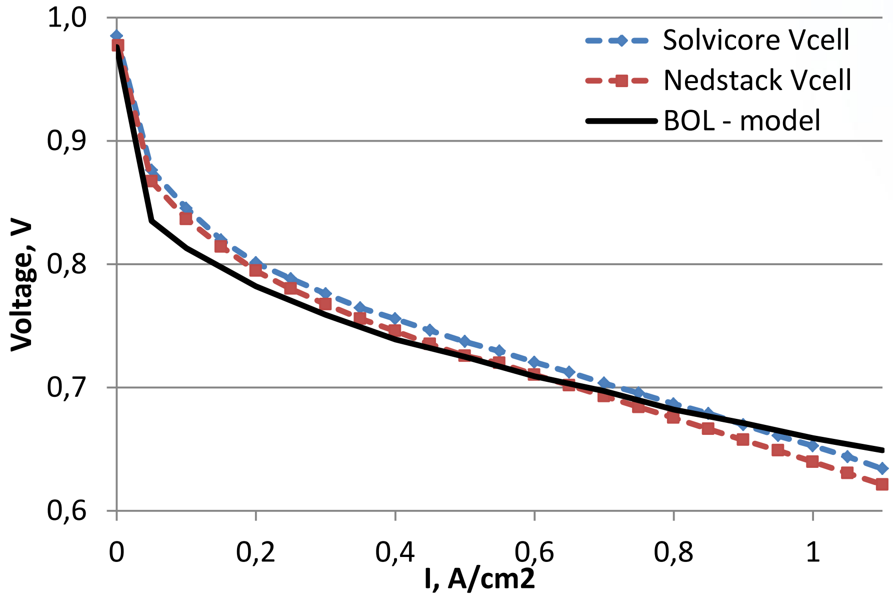
Reversible decay: 0.5 ppm SO_2

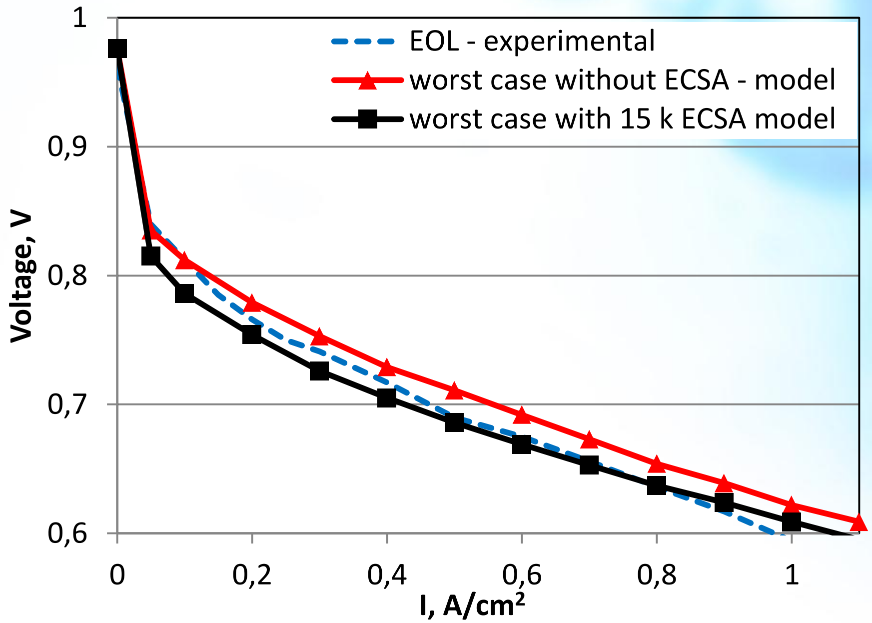
- Comb 9b more tolerant
- Tolerance reduces strongly after Cathode AST



WP-6: MEA MODELLING

3D CFD Model validated with experimental data SC-0 (BOL resp EOL)





Parametric study based on properties from EOL/post mortem analysis:

- Cathode ECSA decrease has main influence on voltage decay
- GDL properties (porosity, contact angle, conductivity) and proton & CL conductivity also contribute

DECAY MECHANISMS FIELD TESTS SC-0 TO 4

1. Cathode loss of active surface area by poisoning - reversible
2. Cathode increase in mass transfer resistance due to loss in hydrophobicity
   - from material degradation (irreversible)
   - change in surface functional groups (reversible)
3. Cathode loss of active surface area – irreversible
   - particle growth / dissolution
   - carbon corrosion
4. Anode loss of active surface area
   - by poisoning (reversible)
   - assisted by loss of active surface area - irreversible (particle growth/dissolution, carbon corrosion)
5. Cathode increase of proton resistance - irreversible

DISSEMINATION

- 2 workshops on degradation (co-)organized
  - 2nd Int. workshop on degradation issues, Greece, 2011
  - Degradation of PEM FC, Oslo, 2013
    - STAYERS, PREMIUM ACT, KEEPEMALIVE
- Website
- Several publications
- Presentations (Grove, StackTest, Carisma)

EXPLOITATION

MAIP/AIP objectives achieved:

- > 20,000 hs proven in real life conditions
- 40,000 hs (extrapolated) stack lifetime
- Improved understanding degradation mechanisms

Exploitation:

- Continuation R&D in Second Act (Sintef, JRC, Nedstack)
- Solvay, Solvicore: products for stationary market
- Nedstack – proven lifetime 20,000 hs & TCO:
  - kW scale: stacks for continuous power / extended backup generators
  - MW scale: DemcoPEM 2 MW Demoproject
    Demonstration of a combined heat and power 2MWe PEM fuel cell generator and integration into an existing chlorine production plant