STAYERS

Stationary PEM fuel cells with lifetimes beyond five years

FCH-JU 256721

Programme Review Day 2011
Brussels, 22 November

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Nedstack fuel cell technology B.V.

1. Project achievements: STAYERS project parameters

Themes:

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:	36 months; 1 January 2011 - 31 December 2013
Budget:	4.1 M€
FCH-JU funding:	1.9 M€

1. Project achievements STAYERS consortium

Membrane → MEA → Stack → System integrators → End users

Development + Commer-cialisation

Solvay Solexis

SolviCore Fuel Cell Technologies

Nedstack PEM FUEL CELLS To be sure.

Testing + modeling

SINTEF

Institute for Energy

JRC EUROPEAN COMMISSION

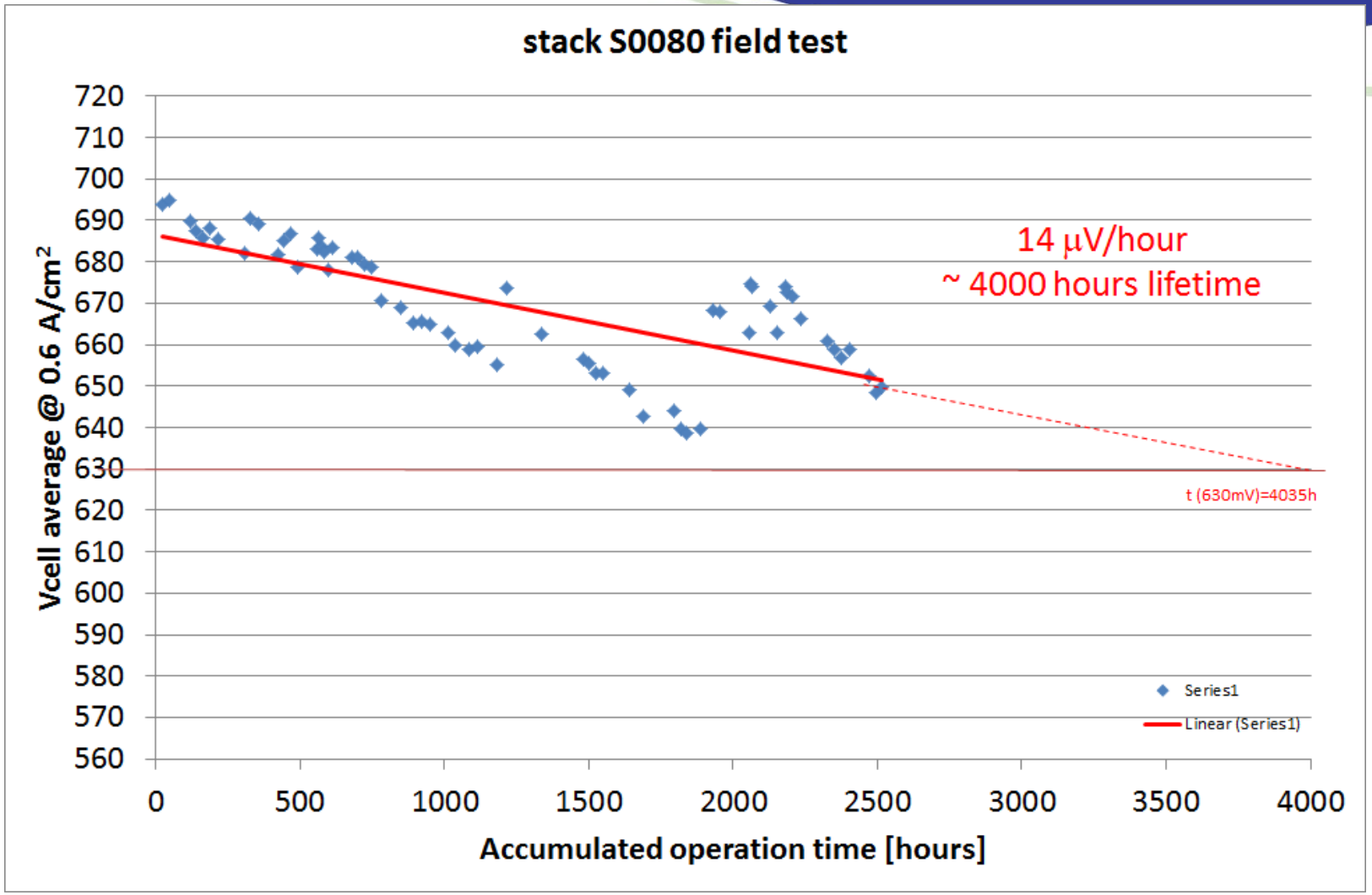
1. Project achievements: STAYERS background

Background / motivation:

- In 2008: 200 kTon of vented H_2 per year (~400 MW, 50% conv. Eff.) from chlorine production
- 150 kTon H_2 per year available (~300MW) at bleach factory near sawmills
- Chlorine transport restrictions → more local chlorine plants → 1 MW PemPowerPlants; ***1 system being commissioned (sept. 2011)***
- Stack life is major cost driver in total cost of ownership
- PemPowerPlant Delfzijl
  (50-70 kW) @ average load of 0.55 A/cm^2
  a) system demonstrator
  b) field test site for PEMFC prototypes
  c) (Un)planned stops of chlorine plant result in quasi continuous operation

1. Project achievements: STAYERS background

STARTING POINT STAYERS PROJECT



1. Project achievements: STAYERS goals and targets

Goal:

> 40.000 hours stationary
operation lifetime of PEM fuel cell

Motivation: lower replacement frequency PEMFC stacks over economic lifetime Power Plant → lower cost of ownership PEMFC Power Plant

Objectives:

- translate lifetime target into degradation rate at defined operating conditions
- Understand degradation mechanisms in current generation PEMFC
- Evaluate performance parameters of membrane, electrode, GDL, MEA, flow field, stack assembly and operating conditions
- Cross link component development to reach system optimum
- Enhance understanding and predict improvements by modeling
- Relate duration testing in the field, in the laboratory and at accelerated stress conditions
- Extrapolate duration test data and determine projected lifetime

1. Project achievements: STAYERS milestones

Membrane (WP2)

Demo (AST) improved durability membrane:	M15
Demo (AST) 40,000 hours membrane:	M25
Pilot production reinforced membrane:	M29

MEA (WP3)

Aging mechanism report base line MEA generation 1:	M12
Aging mechanism report improved MEA generations 2, 3, 4:	M18, 23, 33

Stack / BoP (WP4)

New flow field demonstrated	M28
Assessment 1,2 of improved stack	M19, 34

1. Project achievements: STAYERS milestones

<u>Accelerated durability investigations</u> (WP5)

Translation of accelerated tests to duration test data	M23
Assessment of degradation data from all types of tests	M36

<u>MEA modelling and data analysis</u> (WP6)

Validated integrated model	M12
Model projected lifetime of 40,000 hours	M34

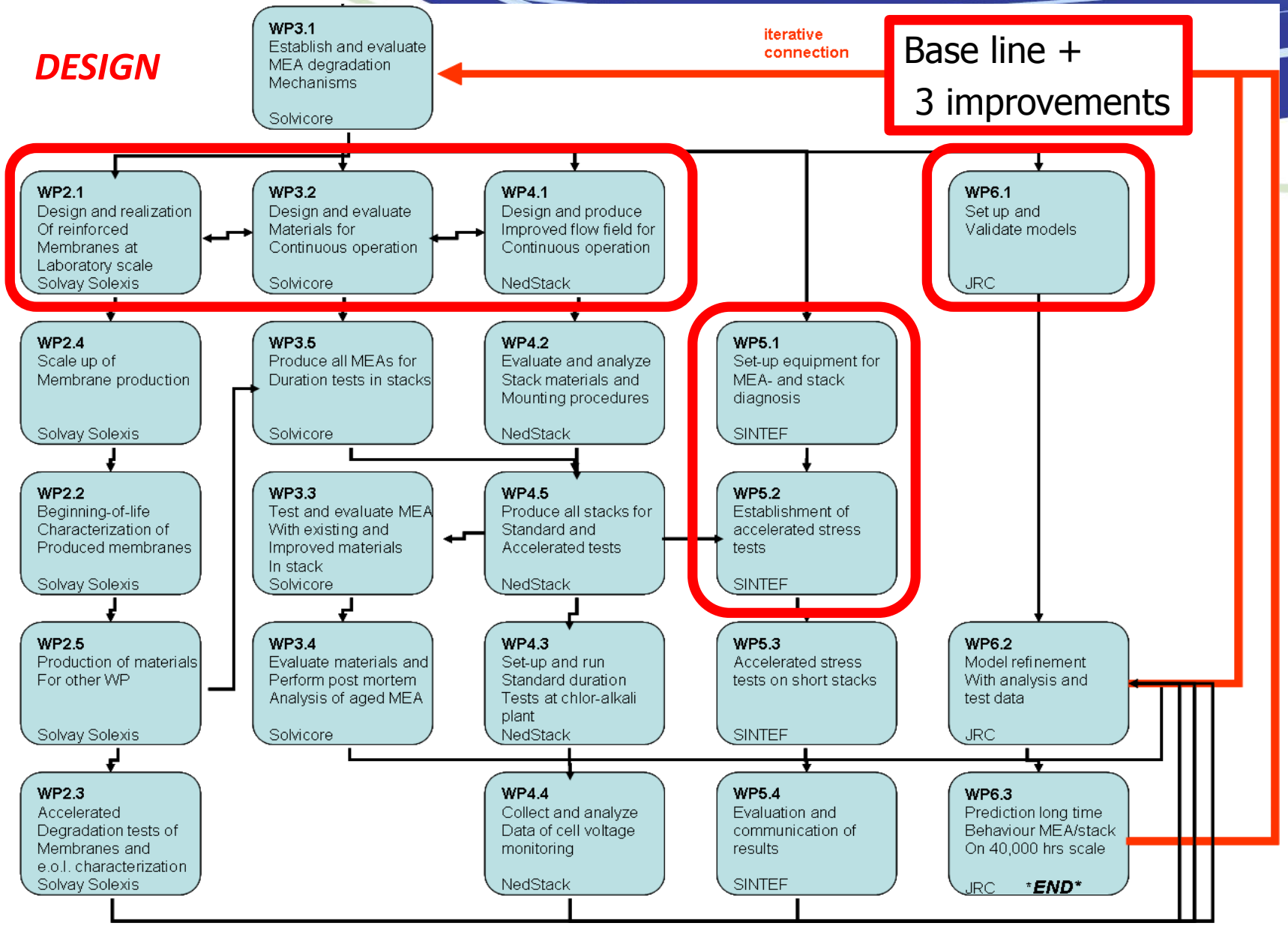
1. Project achievements: approach

Produce, test and analyse 1 reference type and 3 improved prototypes during the project

Work package	Activity	Partner
WP1	Coordination of the project	Nedstack
WP2	Membrane development	Solvay Solexis
WP3	MEA development	Solvicore
WP4	Stack- and Balance-of-Plant development	Nedstack
WP5	Accelerated durability investigations	SINTEF
WP6	MEA modeling and data analysis	JRC-IE

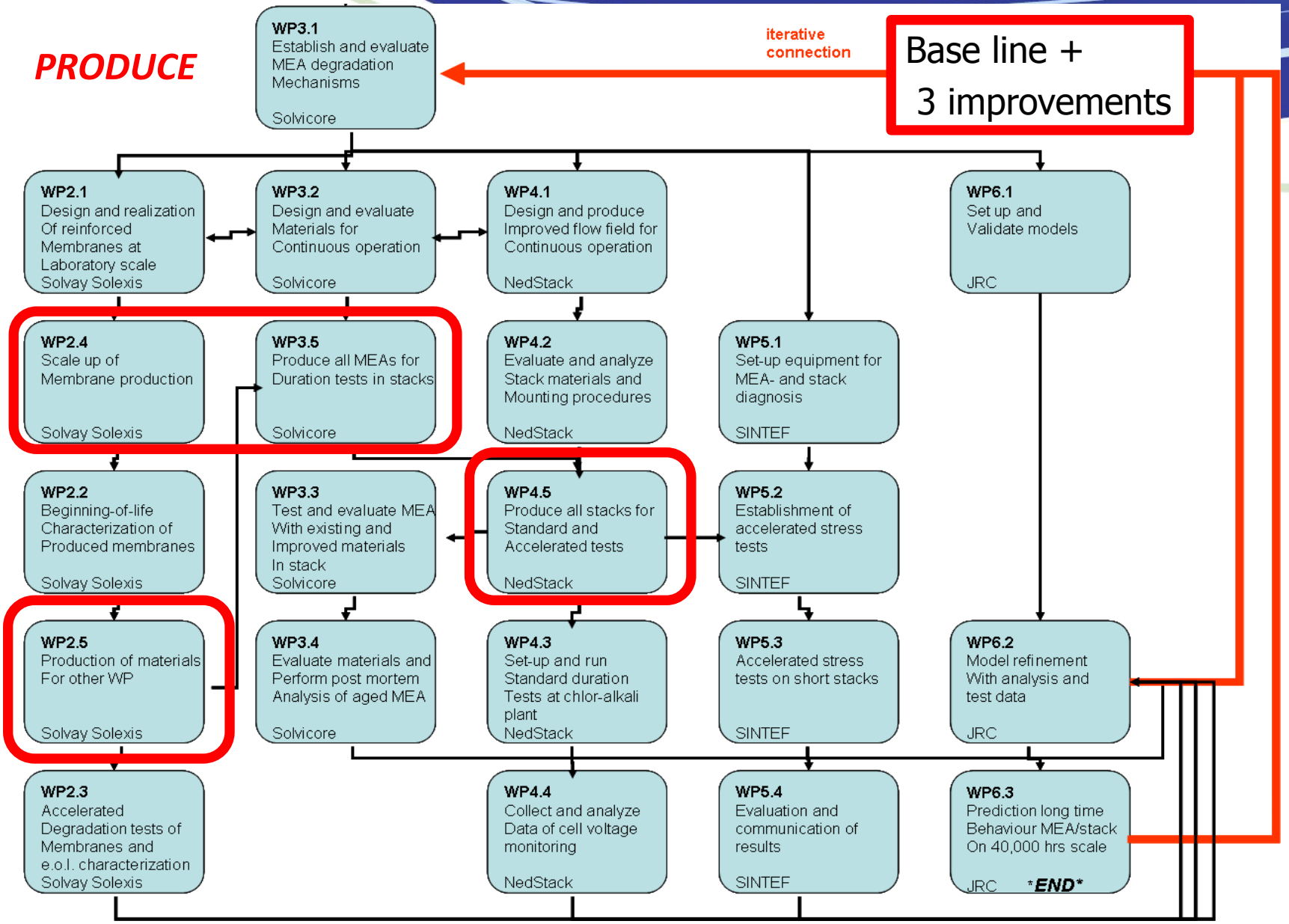
1. Project achievements: approach

Membrane | MEA | Stack



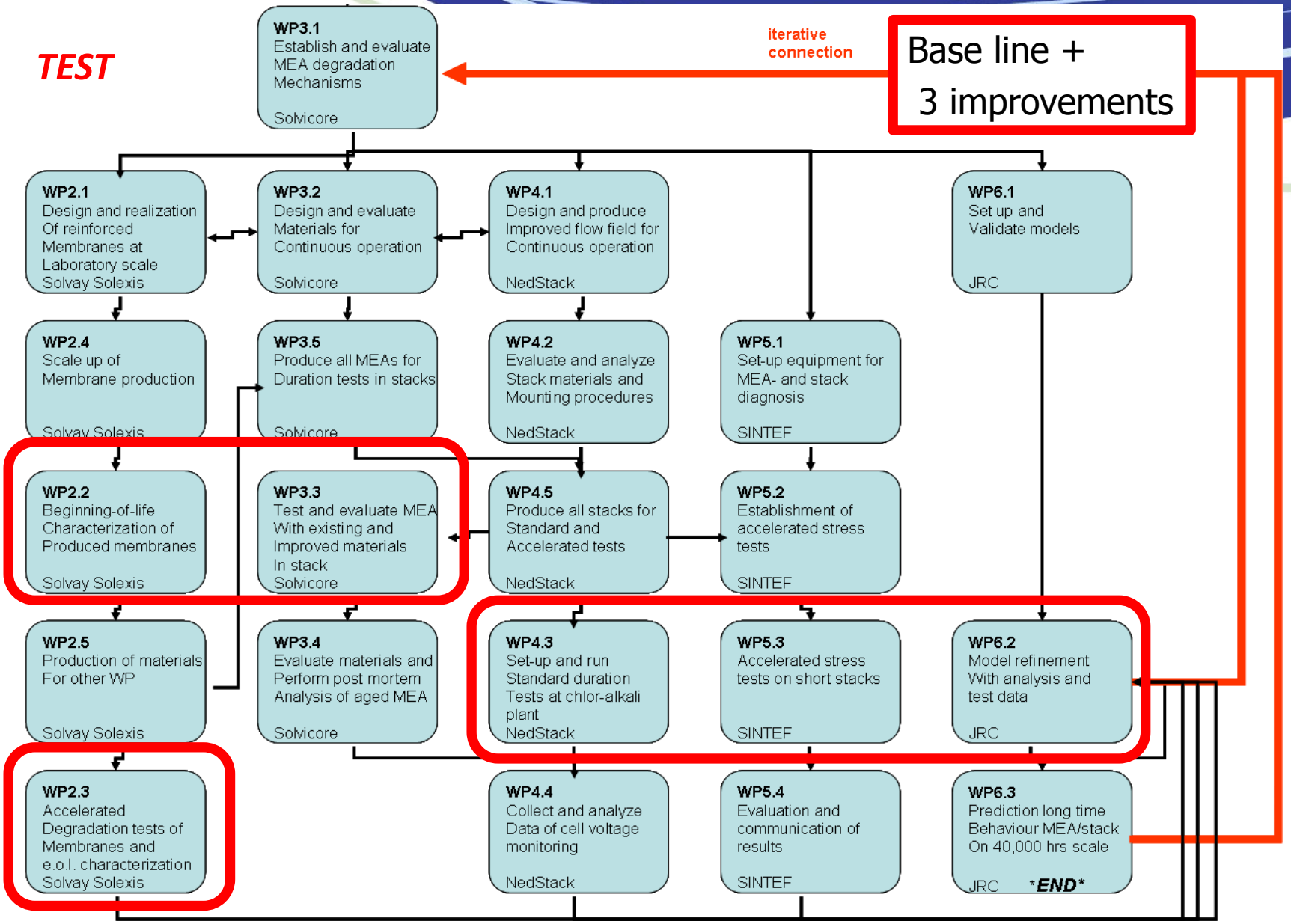
1. Project achievements: approach

Membrane → MEA → Stack



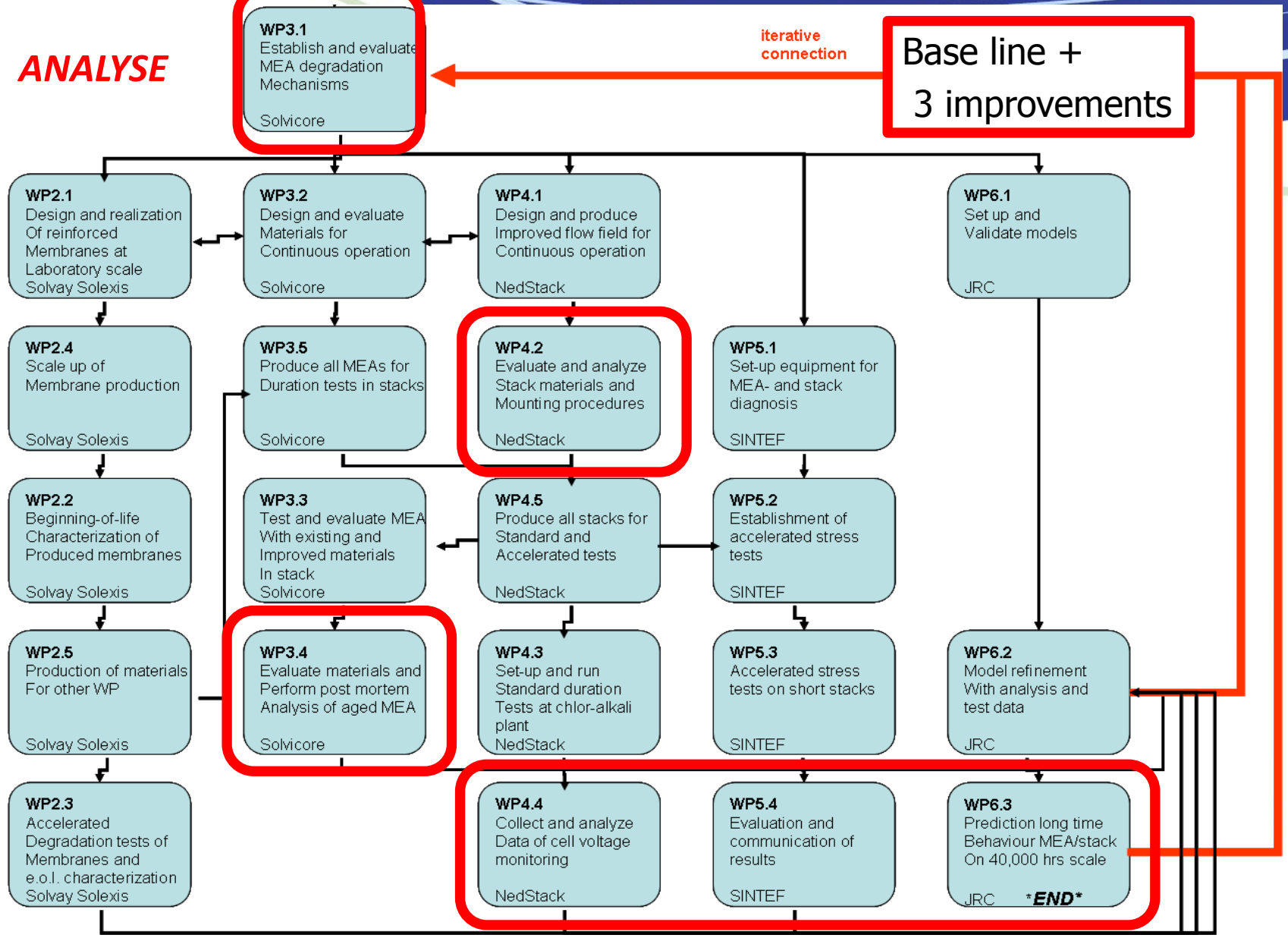
1. Project achievements: approach

Membrane | MEA | Stack



1. Project achievements: approach

Membrane | MEA | Stack



1. Project achievements: Expected progress to state of art

- Reinforced membrane (Solvay Solexis)
- Chemically stabilised membrane (Solvay Solexis)

- Improved catalyst layer (Solvicore)
- Improved GDE (GDL+catalyst layer) (Solvicore)
- More stable MEA rim / gas seal (Solvicore/Nedstack)

- Improved flow field(s, if appropriate) (Nedstack)
- Optimized set operating conditions (RH, T, λ) (Nedstack)

- Dedicated AST's for single stressor evaluation (SINTEF)

- Model quantifying degradation (μV/hr) based on physical parameters that characterise degradation phenomena (JRC)

1. Project achievements: Results first 6 months

- Systematic lower decay rate in laboratory duration test than in field test: → searching the cause
- Reinforced membrane produced for base line MEA**: 370 parts**
- Delayed base line testing due to problems of membrane integration in the MEA:
  → solution found + base line data generation in progress:
  MEA production scalability is strong criterium for MEA prototype selection
- Preliminary field test results of base line improvement generated
- New test rig installed for field testing of 12 stacks simultaneously
- Standard analysis BOL/EOL protocol for conditioning/testing (iV/EIS/CV/H_2 cross over)
- Base line seal material degradation test methods screening completed
- AST protocol inventory completed: selection/design to reproduce field test stress factors in progress
- Data analysis method development in progress: how to deal with reversible decay/recovery and irreversible decay for decay rate determination?
- Model setup completed: physical parameter collection in progress

2. Alignment to MAIP

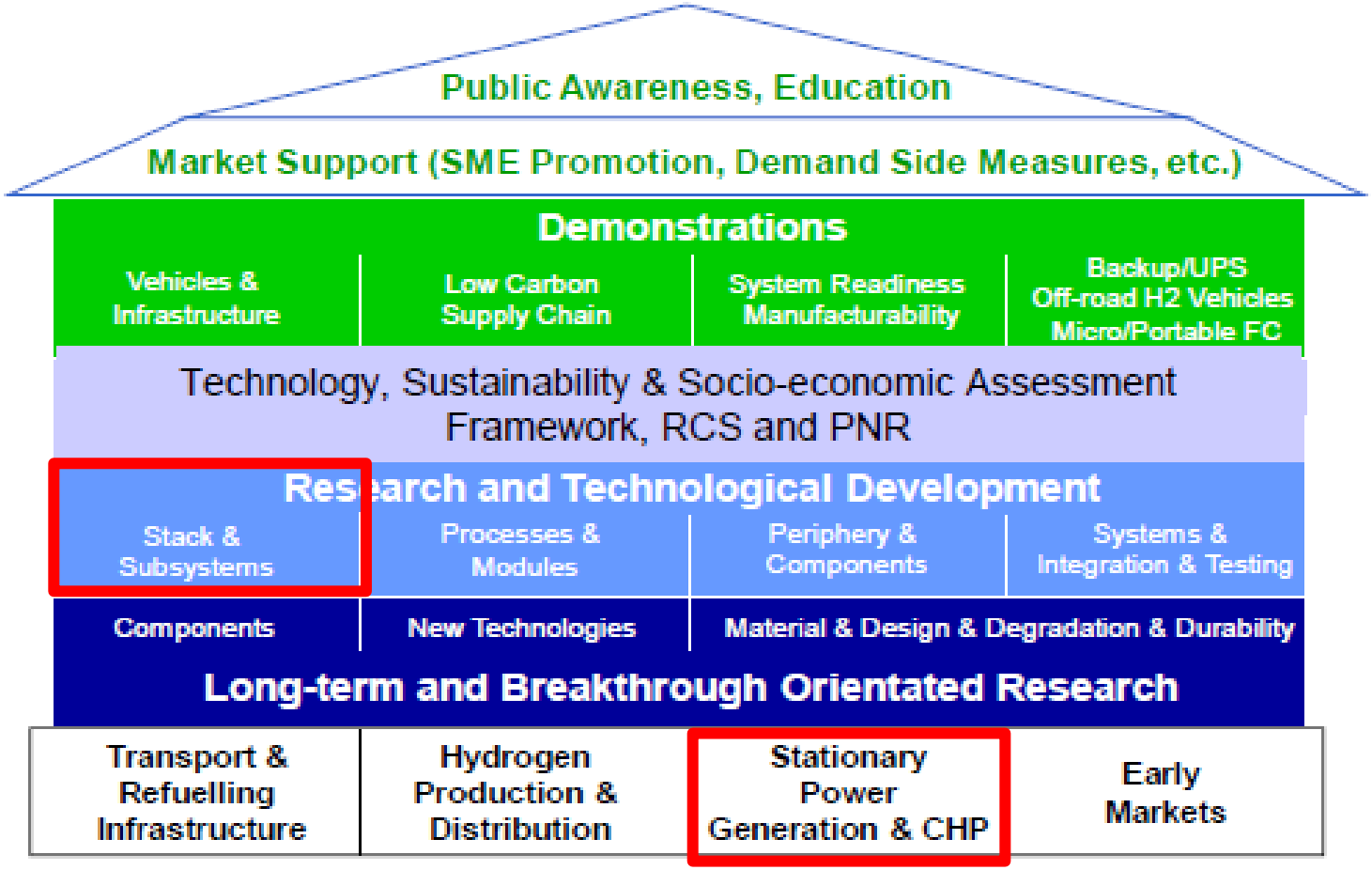
Stationary Power Generation & Combined Heat & Power

"Long-term and breakthrough orientated research will concentrate on **degradation and lifetime fundamentals related to materials and typical operation environments for all power ranges**. The aim will be to deliver new or improved materials as well as reliable control and diagnostics tools both at a component and at system level."

"Research and technological development will be directed towards **developing components and sub-systems (including BoP)** as well as **novel architectures for cell and stacks** leading to step change **improvements** over existing technology in terms of **performance, endurance, robustness, durability** and cost for all three technologies." *(PEMFC, MFC, SOFC)*

2. Alignment to MAIP

STAYERS in the Multi Annual Implementation Plan Structure



2. Alignment to AIP2009: theme 3.2

Materials development for cells, stacks and balance of plant

Theme 3.2 project objectives	STAYERS objectives match?
Development and design of materials to improve performance of both cells and stack and BoP components. Mechanical, thermal and electro-chemical stability should be considered and lifetime and degradation issues relevant to production cost for single cells and stacks.	**Yes**, improved electrode and rim MEA, improved separator plate flowfield and operating conditions
Investigation on failure mechanisms (such as Chromium poisoning, redox resistance in SOFCs, fuel tolerance, **robust low resistance membranes in PEMFCs**, and durable metals for interconnects of MCFCs).	**Yes**, reinforced, thin, low resistance membrane, AST investigation dominant failure mechanisms
New and improved material production techniques to reduce cost, emissions and improve yields, quality and performance in industry relevant cells, or BoP materials in FC-units.	**Yes**, Scale up membrane production process, MEA prototypes designed for large volume production
Development of inspection techniques that can be used in manufacturing of materials and cells to identify known defects or anomalies related to materials.	**Yes**, membrane/MEA suppliers developed procedures to evaluate BOL/EOL + quality control

2. Alignment to AIP2009: theme 3.1

Fundamentals of fuel cell degradation for stationary power applications

Theme 3.1 project focus on	**STAYERS objectives match?**
Developing **full understanding of failure mechanisms**, **degradation and deterioration phenomena** and how these relate to stationary operating conditions, materials and processing.	**Yes**, post mortem analysis MEAs, separator plates, membranes; combined lab, AST and field testing
Steady state operation, abnormal operational states, thermal and/or current cycling, vibration and shock proofing, sensitivity to typical gas impurities, loss of water supply, power cycles, etc.	**Yes**, field testing at 70 kW power plant
Material research to relate basic materials/performance understanding relevant to current industrial cell/stack component, proof of concept.	**Yes**, each prototype is a large volume produced MEA / stack
Accelerated testing techniques, **statistical analysis and building up a sensitivity matrix to allow predictive lifetime estimates**.	**Yes**, multiple cell/stack degradation statistics in field test, dedicated ASTs, modeling aided sensitivity matrix build up
Durability/failure mechanisms common to other applications and interface with other relevant actions in the field.	**Yes**, failure mode analysis back up power customer returned fuel cells

3. Cross-cutting issues

- STAYERS contributions to :
  - Training and Education
    - Not main goal of project
  - Safety, Regulations, Codes and Standards
    - Not main goal of project
    - AST protocol design complementary to exisiting standards
    - Field test stop/start/operate protocols respect safety regulations on chemical industry site
  - Dissemination & public awareness
    - Project achievements will be disseminated by science papers, international workshops, press releases, and via the (to be launched) internet site
    - 2nd International Workshop on Degradation Issues on Fuel Cells, Thessaloniki, sept. 2011

4. Enhancing cooperation and future perspectives: too early for STAYERS

- **<u>Too early for STAYERS to address below items:</u>**
- *Technology Transfer / Collaborations*
  - *the degree to which the project interacts, interfaces, or coordinates with other institutions and projects (especially regional/national/international projects and/or organizations)*
    - ***Cooperation with other FCH JU projects on PEMFC degradation (e.g. KEEPEMALIVE)***
    - ***2nd International Workshop on Degradation Issues on Fuel Cells, Thessaloniki, sept. 2011***
- *Project Future Perspectives*
  - *Proposed future research approach and relevance*
    - *the degree to which the project has effectively planned its future, considered contingencies, built in optional paths or off ramps, etc*
  - *Need/opportunities for increasing cooperation at EU, Member States or Regional level, and/or for building alliances between industry, government, research centers, SMEs, etc.*
  - *Need/opportunities for international collaboration*
  - *Possible contribution to the future FCH JU Programme*

THANK YOU FOR YOUR ATTENTION