UNIVERSITÀ DEGLI STUDI DI PALERMO

REAPower

The REAPower project: power production by Reverse Electrodialysis with seawater and brines

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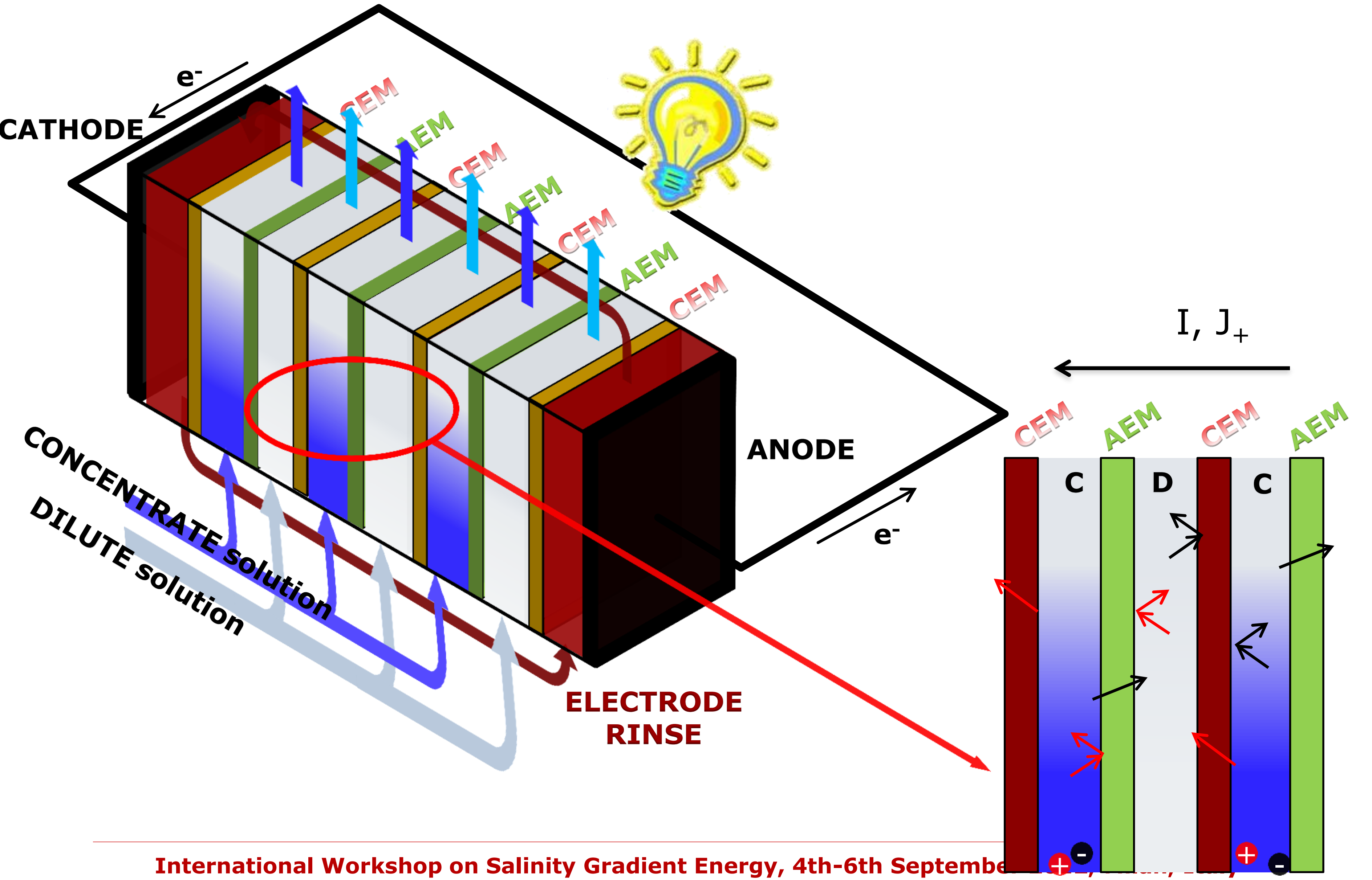
The REAPower project

Main facts

- Project acronym: ***Reverse Electrodialysis for Alternative Power production***
- Cooperative project financed through the FP7 programme
- *Starting date:* 1 October 2010
- *Closing date:* 30 September 2014

The Reverse Electrodialysis technology



The REAPower project

The idea . . .

To produce energy from salinity gradients generated by ultra-concentrated brines and sea- or brackish-water

Technological benefits for the SGP-RE process

New potentials for the exploitation of brines

Technological basic concepts . . .

i) Seawater (≈30-35 g/lt) in the LOW conc. compartment and concentrated brine (≈ 300 g/lt) in the HIGH conc. compartment dramatically reduce the electrical resistance in both battery compartments

ii) As a result: an ultra-low overall internal resistance within the SGP-RE battery cell-pairs can be achieved . . . with the introduction of thinner membranes

iii) Thus, the ultra-low internal resistance will significantly promote a higher power density of the SGP-RE battery.

The REAPower project

The objectives . . .

i) Define and optimise materials and components tailored to the requirements of the technology;

ii) Optimise the design of the SGP-RE cell pairs and stack using computer modelling tools;

iii) Validate the model and assess the developed materials, components and design by laboratory stack tests;

iv) Evaluate and improve the system performance through tests on a prototype fed with real brine;

v) Analyse the “economics” and assess the perspectives

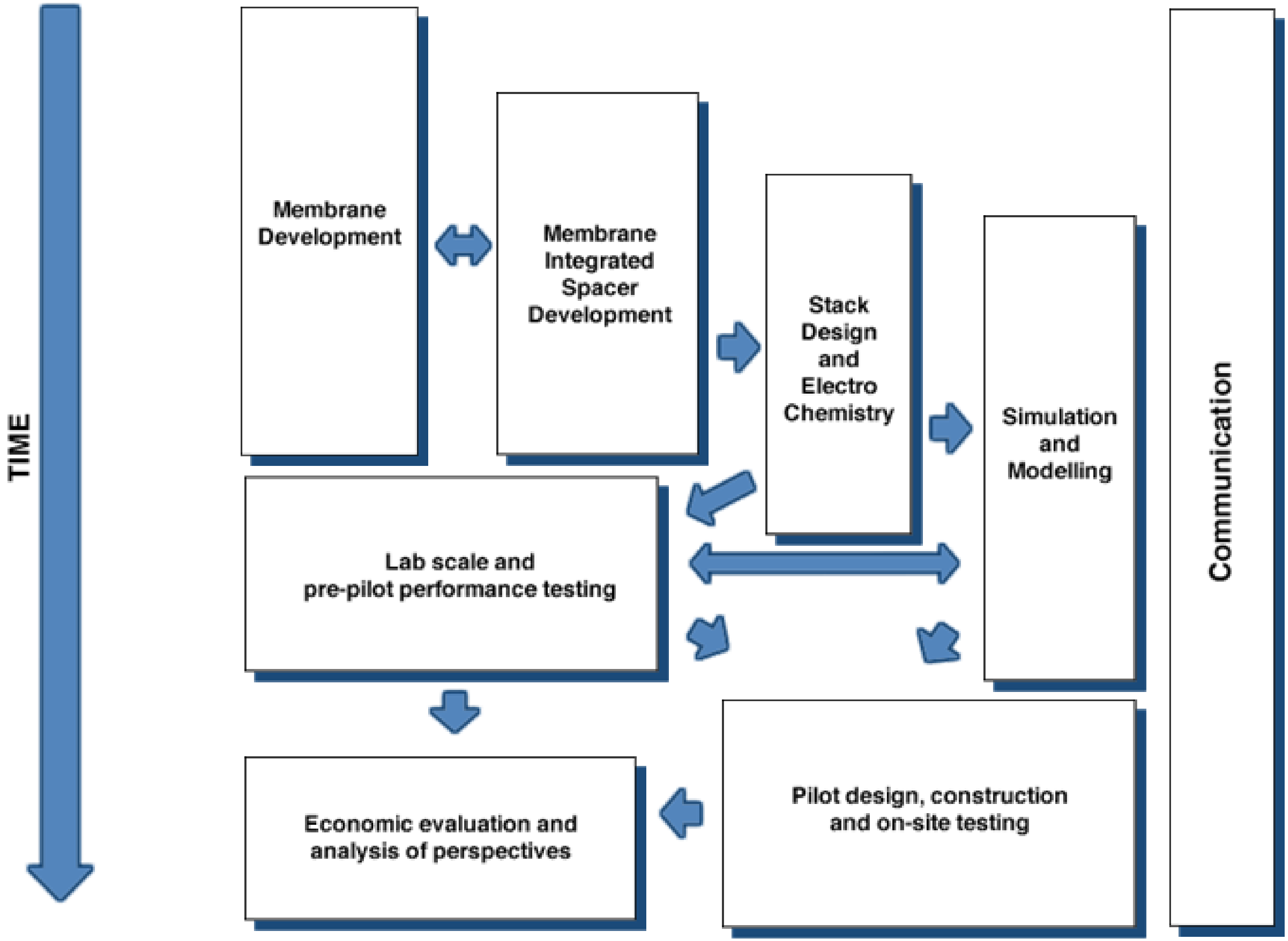
vi) Define the next R&D steps

The REAPower project

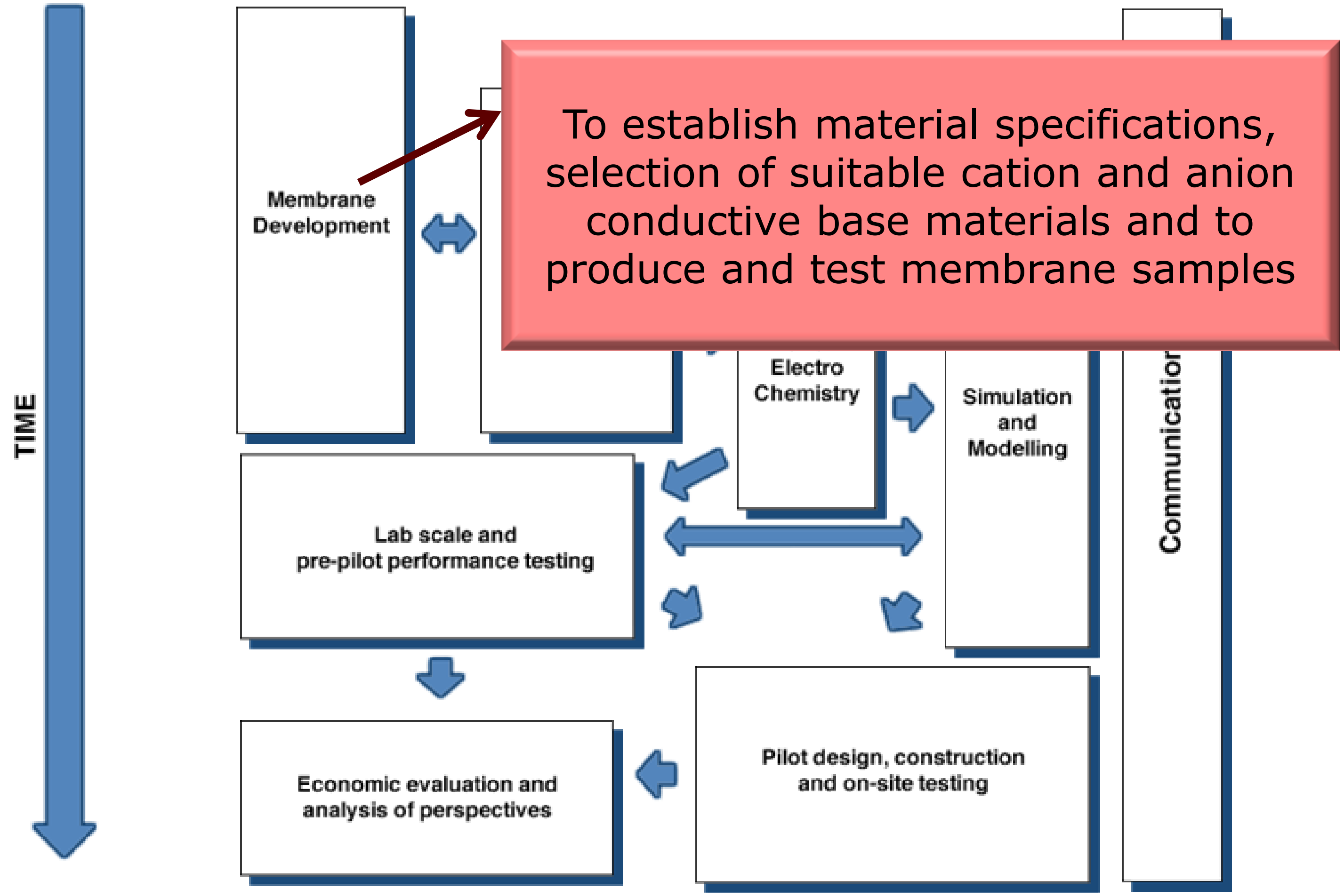
Technological barriers . . .

Barrier		Solution
Effect of salinity on permselectivity	Solution strategy →	Improve IEMs formulation/preparation
High fouling and scaling potentials	Solution strategy →	Adequate pre-treatments for seawater and brine
Still low power density	Solution strategy →	Thin IEMs & Membrane Integrated Spacer
Limited quantity of brine	Solution strategy →	Increase "fuel efficiency" and regeneration strategies

Project workplan

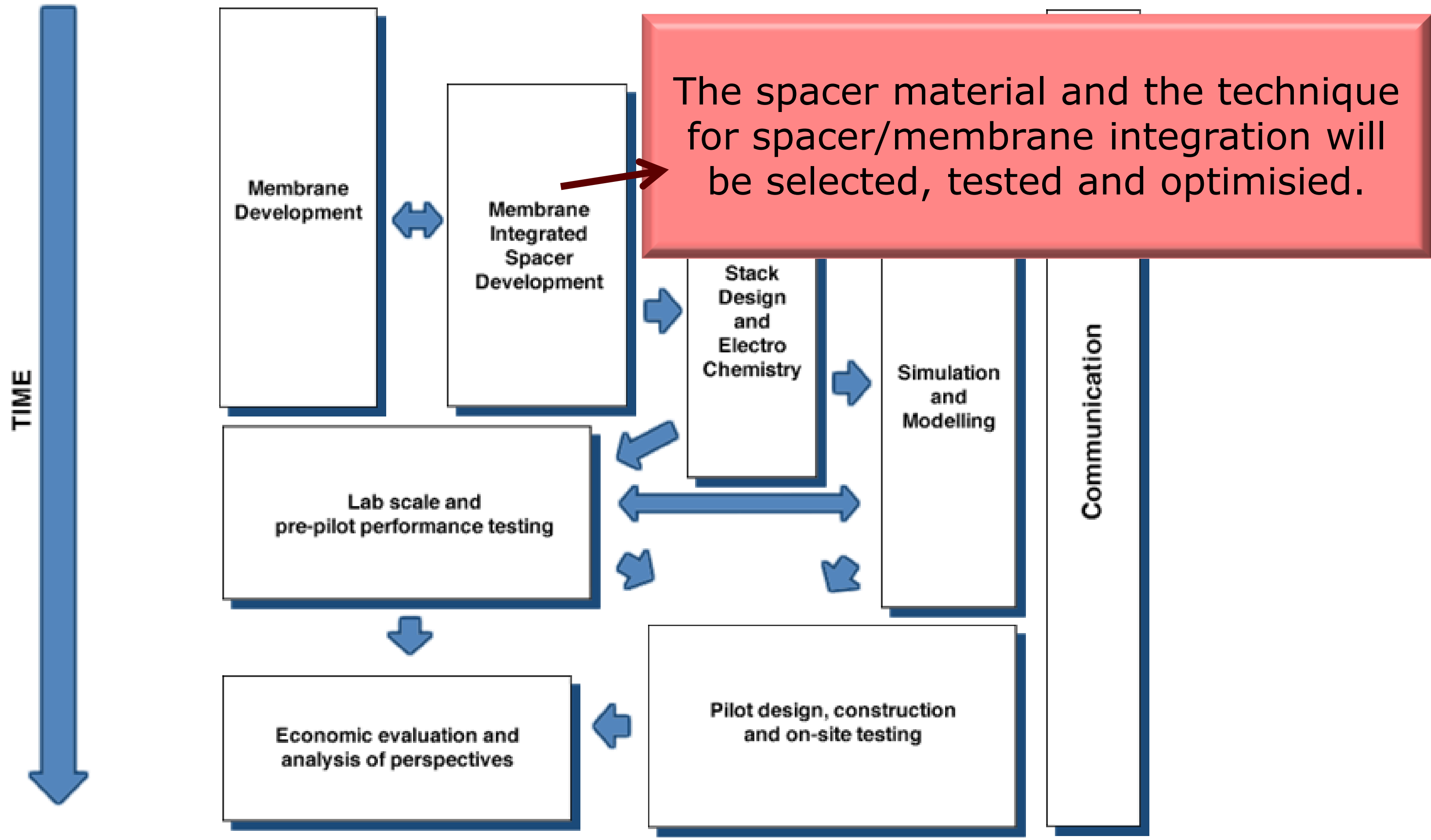


WP2. Membrane Development

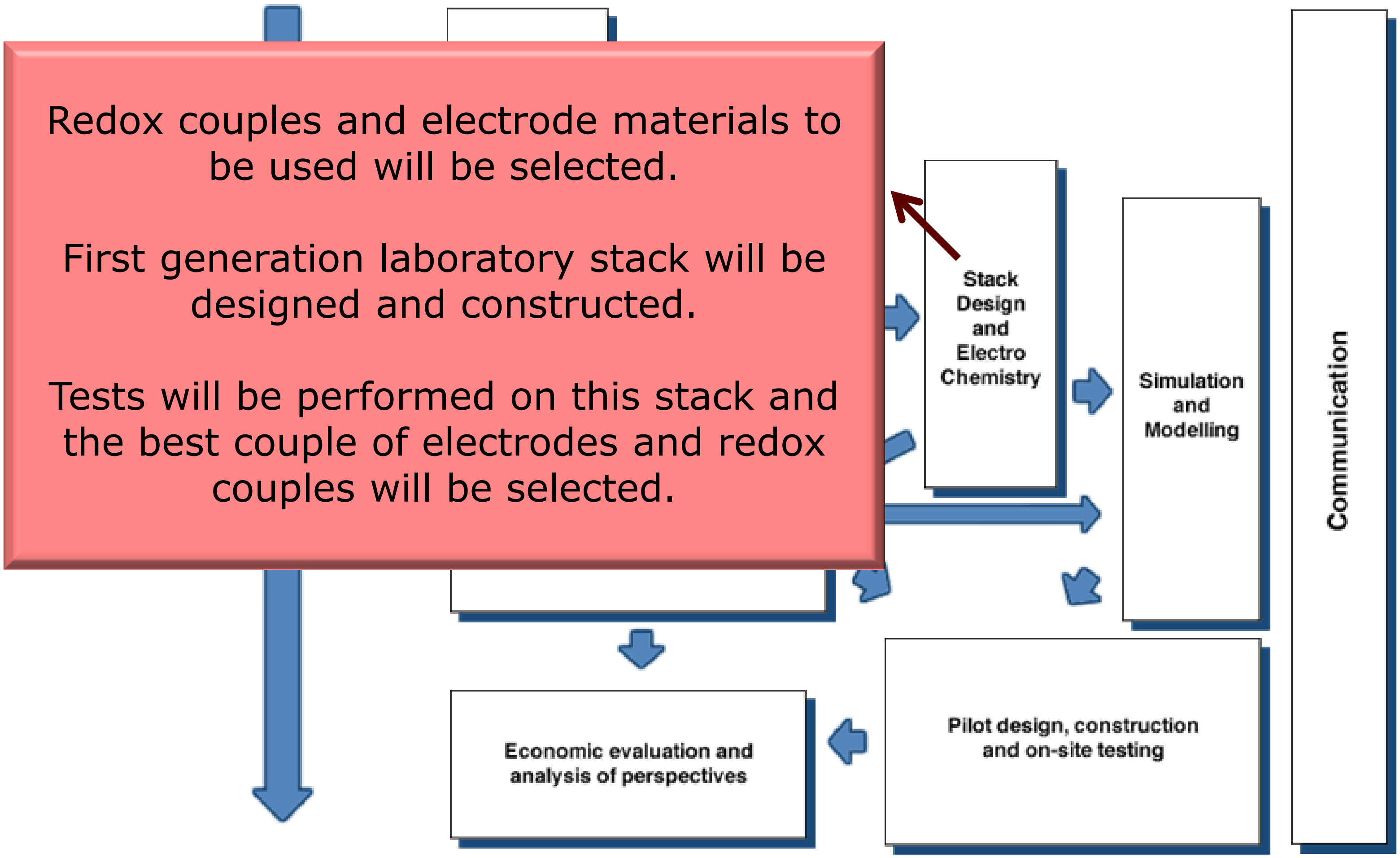


To establish material specifications, selection of suitable cation and anion conductive base materials and to produce and test membrane samples

WP3. Membrane Integrated Spacer Development



WP4. Electrochemical engineering/stack design



Redox couples and electrode materials to be used will be selected.

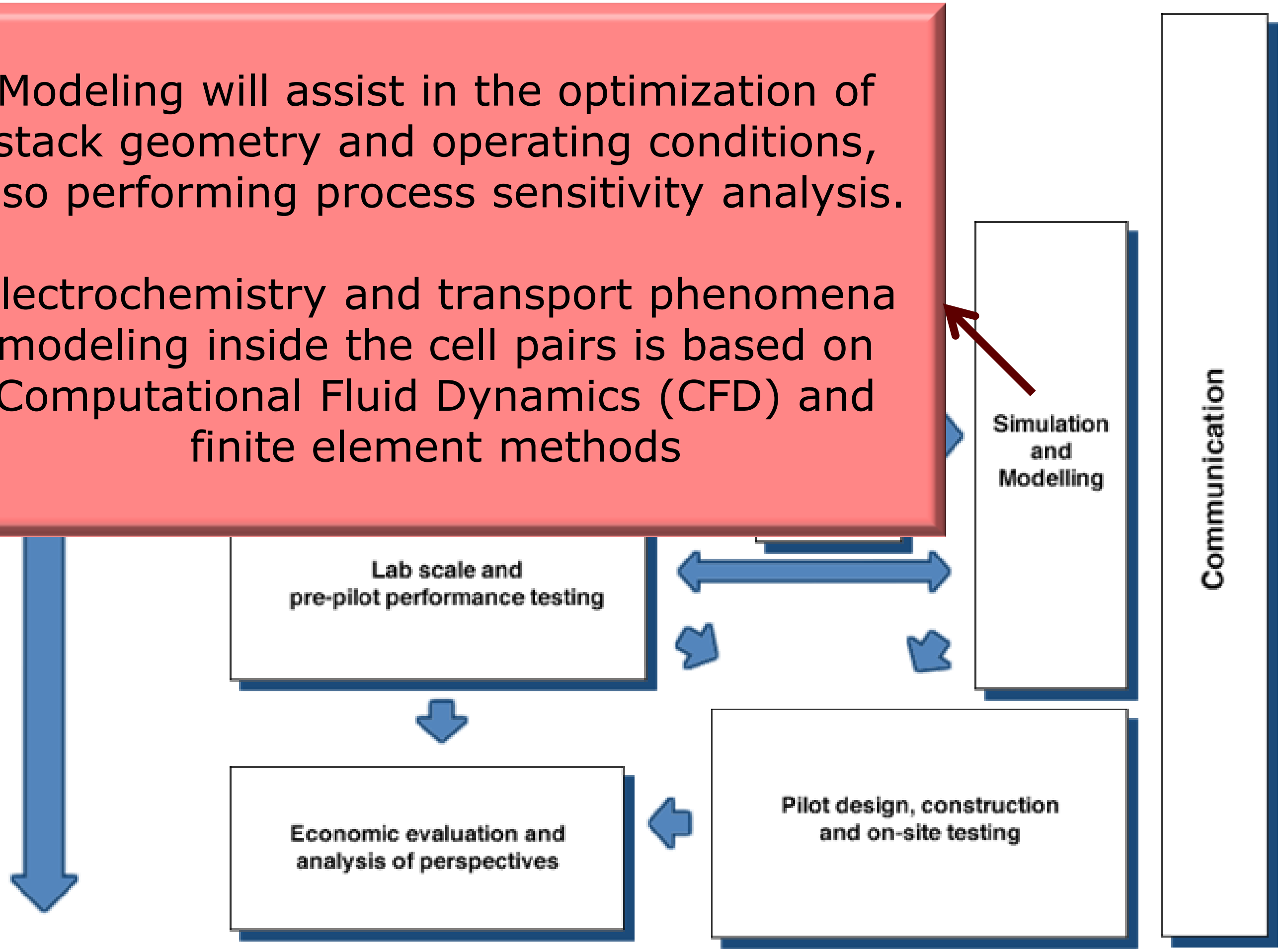
First generation laboratory stack will be designed and constructed.

Tests will be performed on this stack and the best couple of electrodes and redox couples will be selected.

WP5. Process simulation

Modeling will assist in the optimization of stack geometry and operating conditions, also performing process sensitivity analysis.

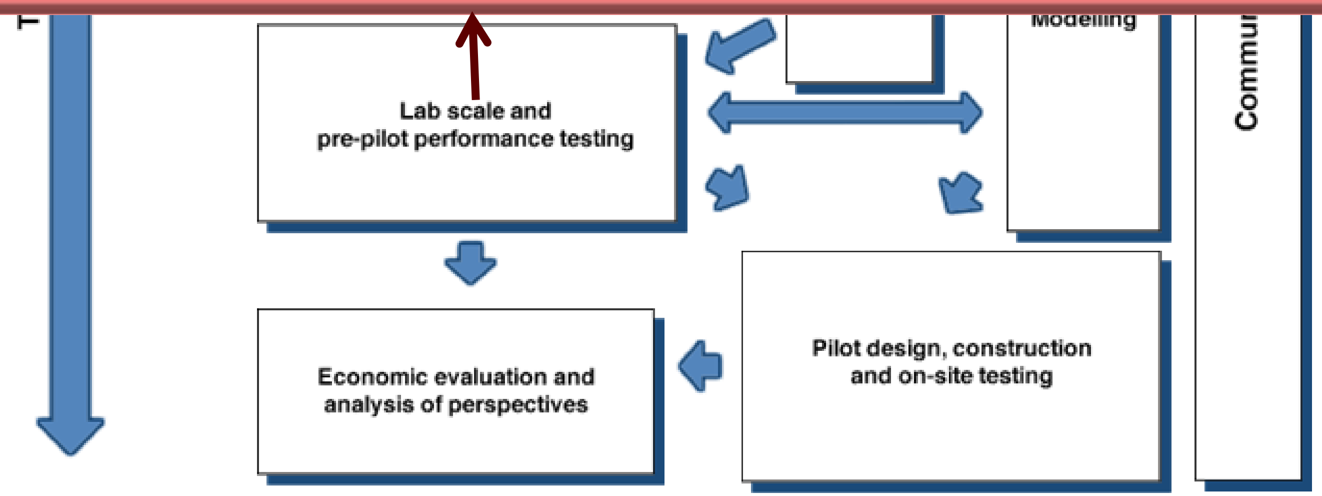
Electrochemistry and transport phenomena modeling inside the cell pairs is based on Computational Fluid Dynamics (CFD) and finite element methods



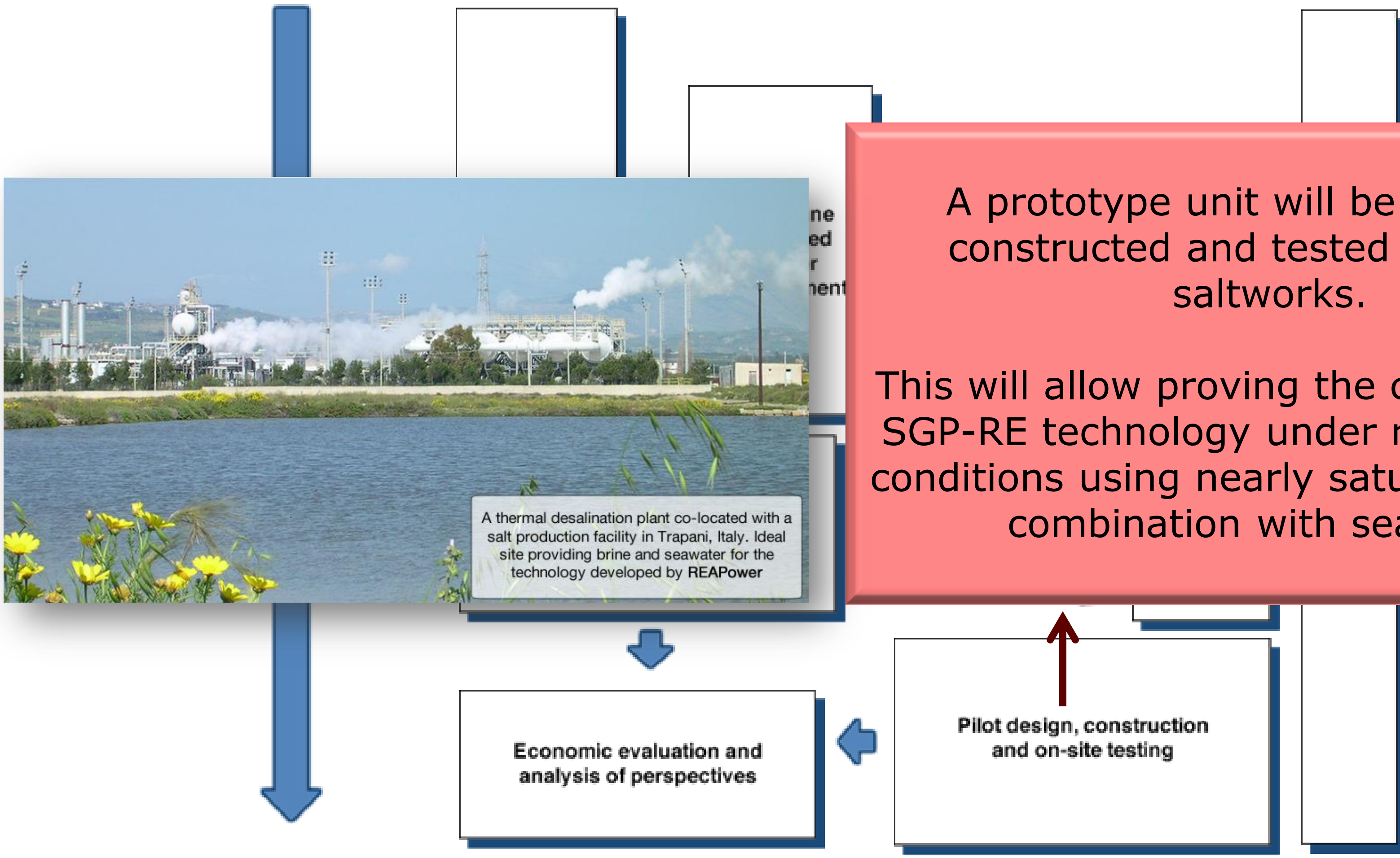
WP6. Lab-scale performance testing

Extensive testing of the laboratory stack in order to evaluate the effect of the hydraulic conditions and to study the effect of the real feed composition on the process.

The combination of this technology with a membrane distillation concept and the pre-treatment requirements of different brine inputs will be assessed.



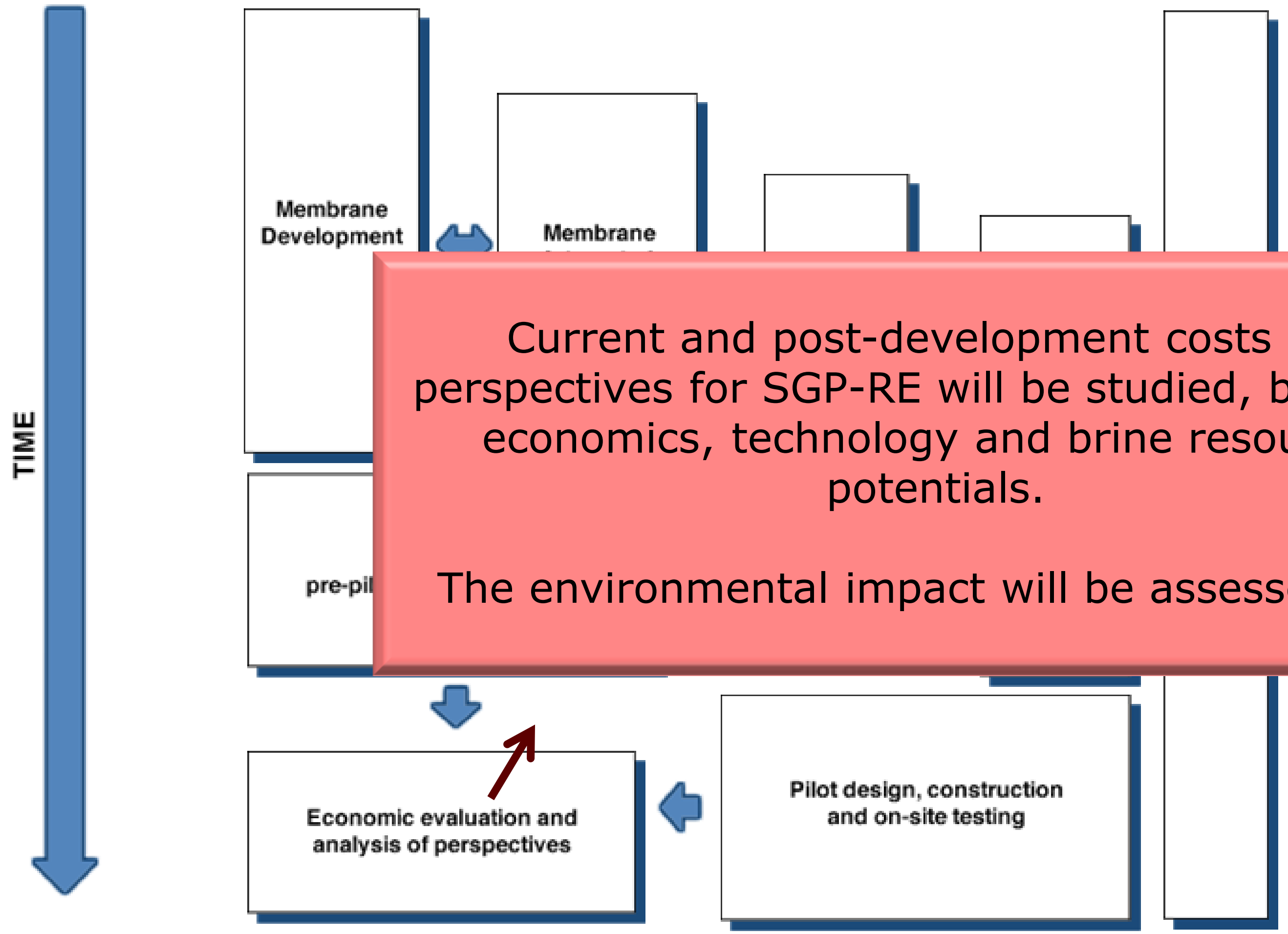
WP7. Design, construction, testing of the prototype



A prototype unit will be designed, constructed and tested in Trapani saltworks.

This will allow proving the concept of the SGP-RE technology under real operating conditions using nearly saturated brine in combination with seawater.

WP8. Economic evaluation/analysis of perspectives



Current and post-development costs and perspectives for SGP-RE will be studied, based on economics, technology and brine resources potentials.

The environmental impact will be assessed too.

Which brines for the SGP-RE process?

Environmental issues related to brine discharge have become more and more crucial in a number of different situations such as:

- Desalination plants
- Mining activities
- Salt industry

Solutions so far proposed can be:

- Novel and low-impact brine disposal strategies to be implemented;
- Re-use and exploitation of brines as a non-conventional source of minerals and energy.

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Achievements and perspectives

IEMs performance enhancements

Increased permselectivity

Permselectivity values have achieved values of **almost 90%** in some samples developed, with a decrease to values **above 50%** when **in contact with** almost saturated **brine**

Reduced membrane resistance

Membrane specific resistance has been reduced to values in the range **1-4 Ω•cm^2** aiming at a **5-folds reduction** in the next months

Achievements and perspectives

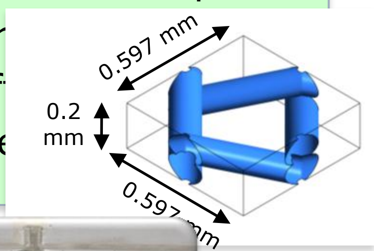
Membrane Integrated Spacer and fluid dynamic optimisation

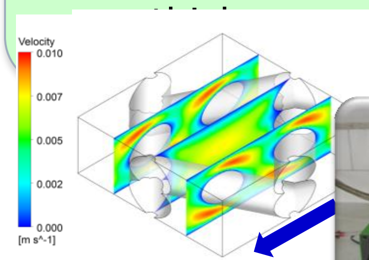
Membrane Integrated Spacer

Tests are being performed for the preparation of **Membrane Integrated Spacers**, aiming at membrane thickness in the range **10-20 μm**

Choice of spacer thickness and geometry

CFD simulations have been adopted along with exper characterisation of dif and ge





Achievements and perspectives

Redox couples and stack design

Redox couples selection

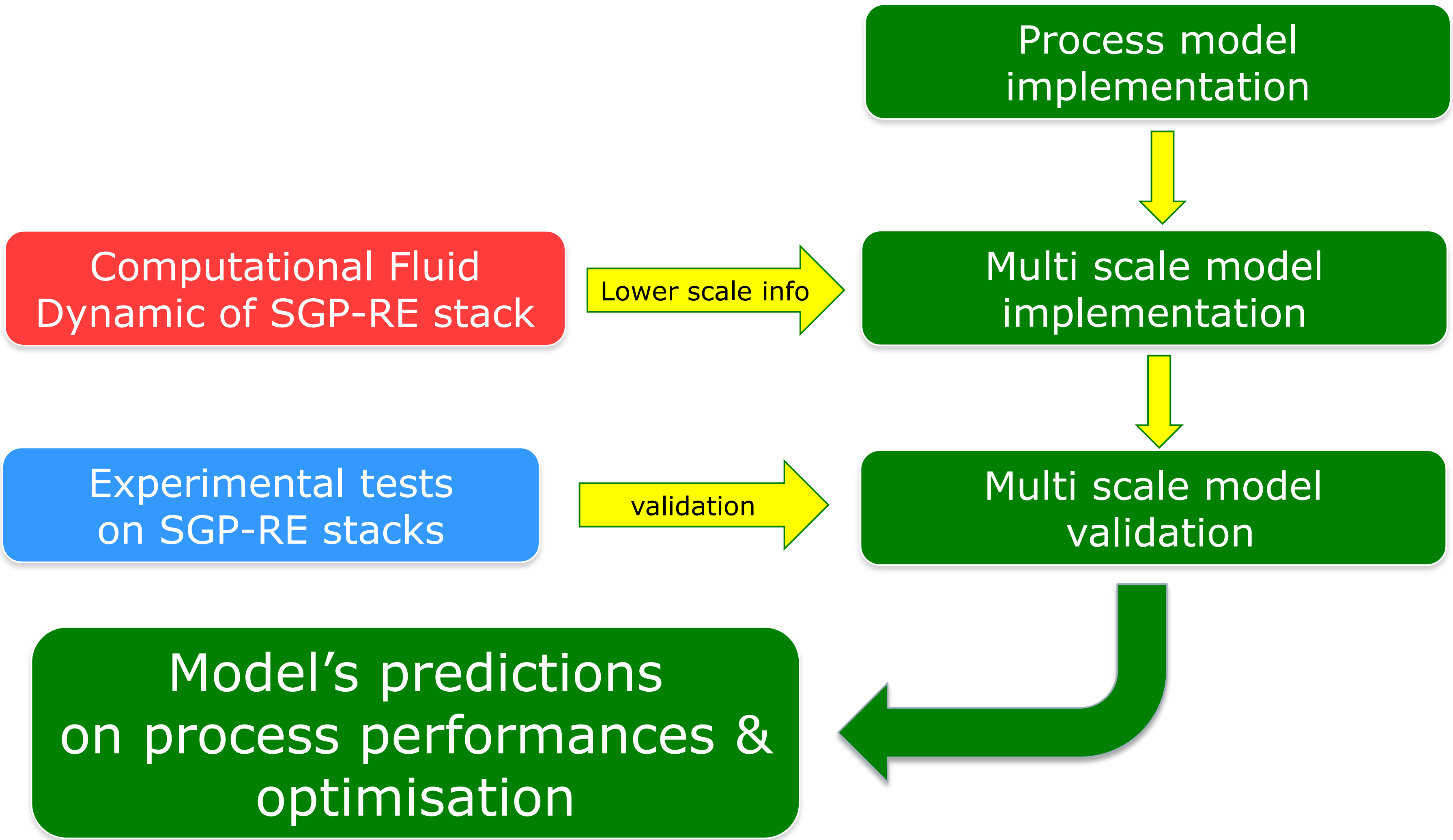
Several redox couples have been tested under different conditions, finding the most promising for the SGP-RE prototype: $FeCl_3/FeCl_2$; Water/Na_2SO_4; $[Fe(CN)_6]^{3-}/[Fe(CN)_6]^{4-}$

2 stack generations already designed and tested

Two different stack geometries have been already designed, constructed and tested and are now available for the consortium

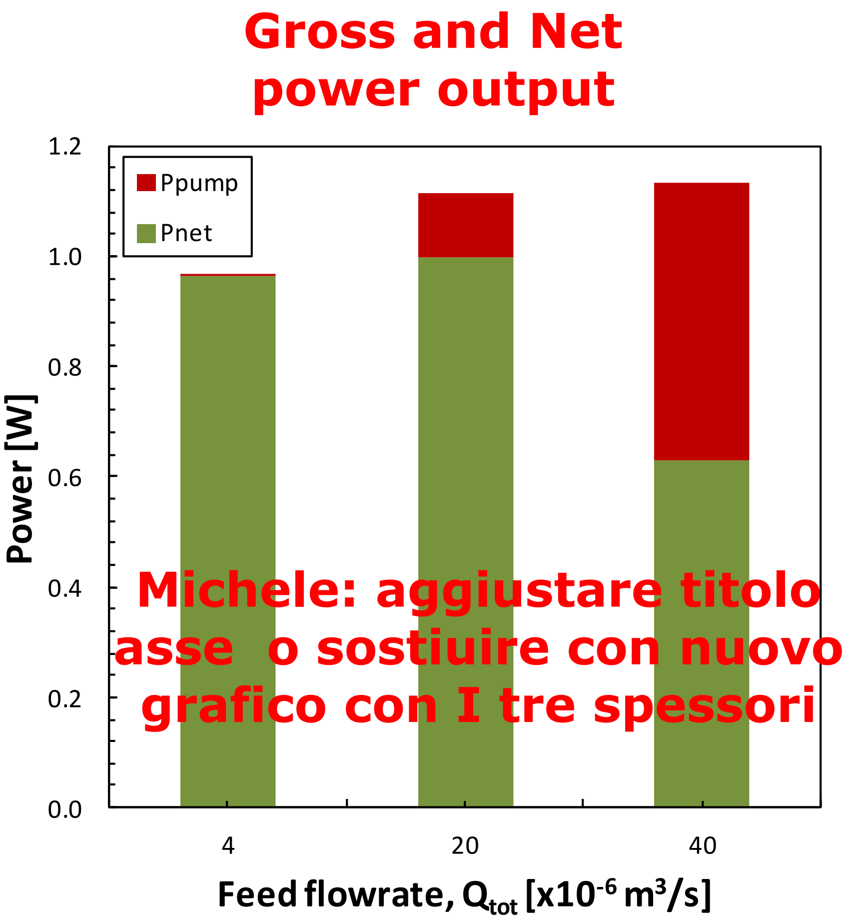
Achievements and perspectives

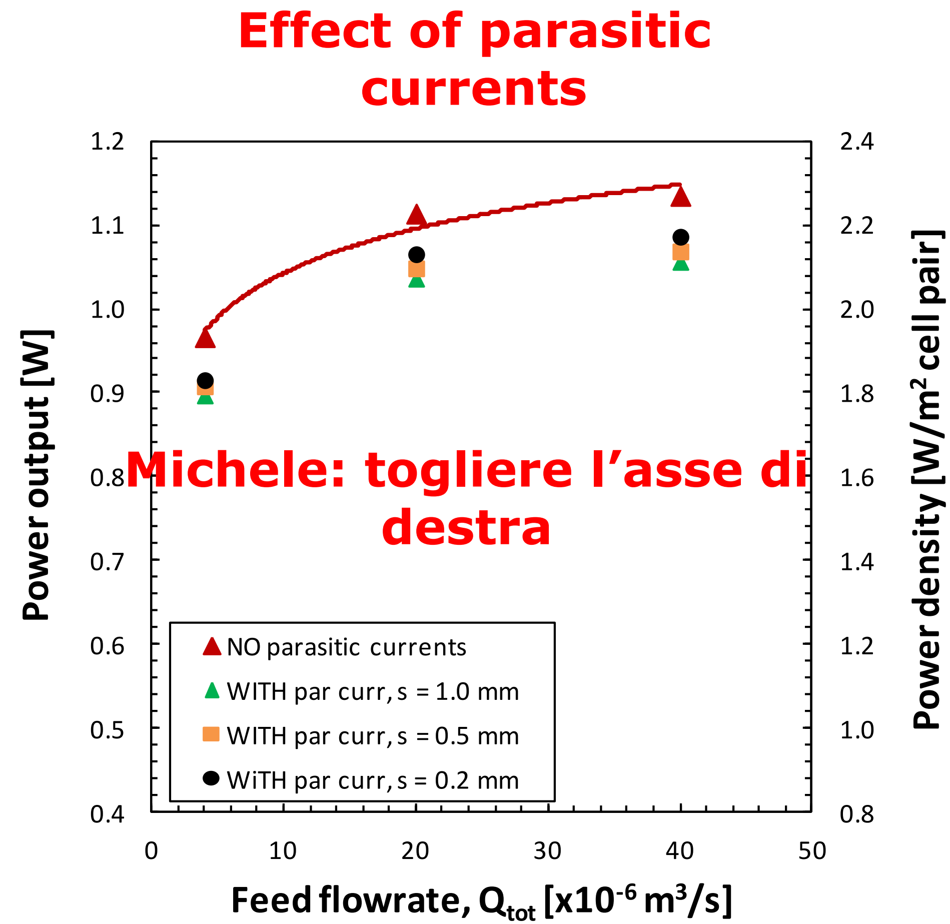
Multi-scale model implementation



Achievements and perspectives

Power density output: effect of stack geometry

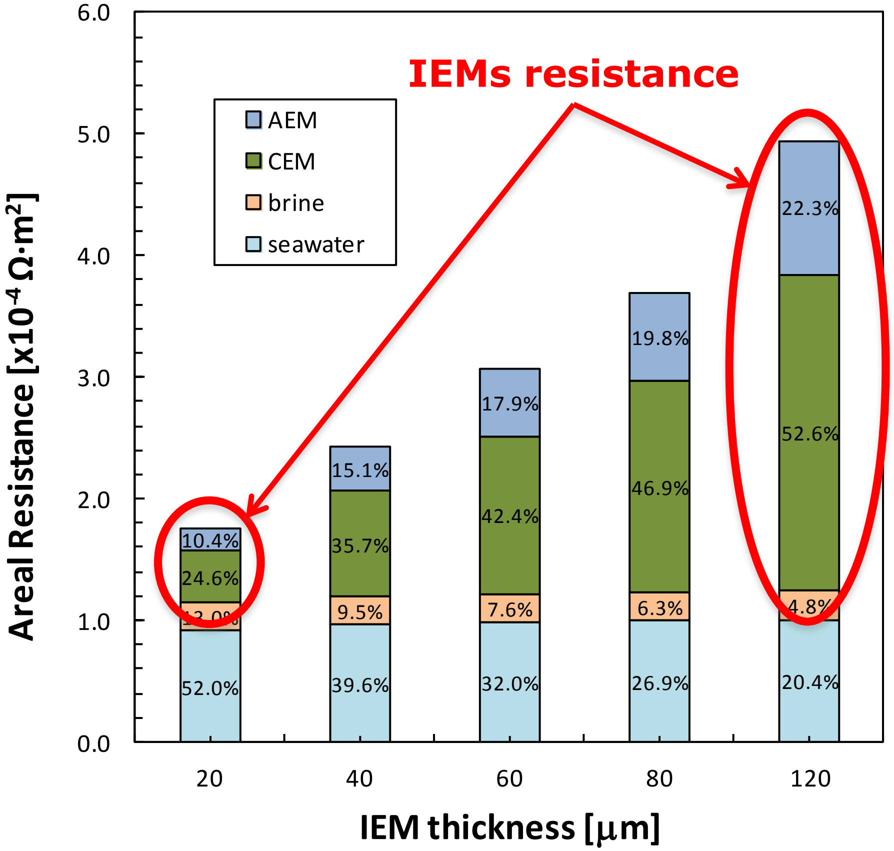


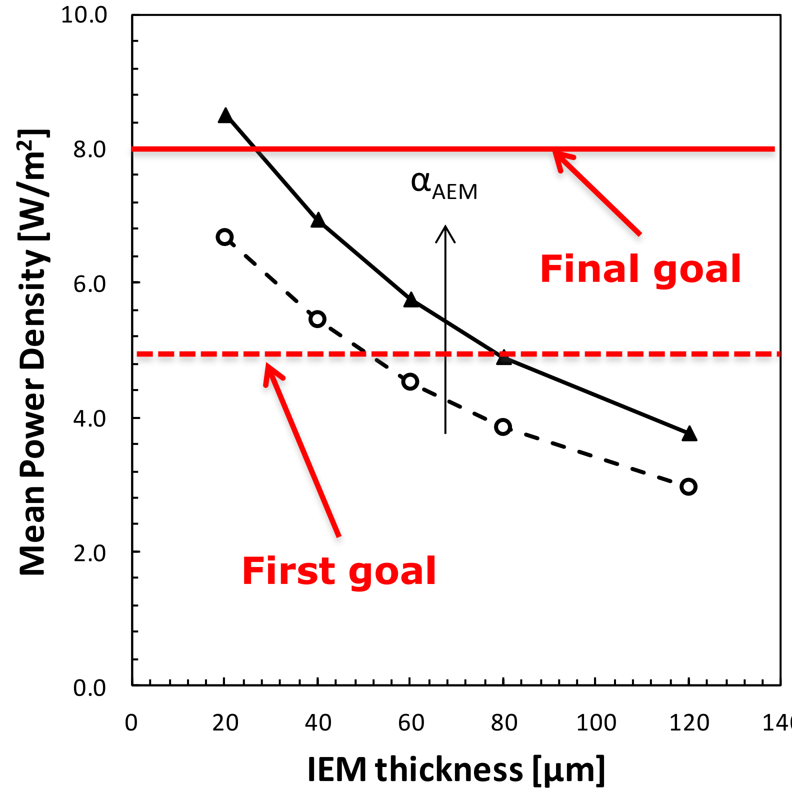


Simulation of a **50-cells stack** with **200 μm** spacers; rectangular distributor/collector with thickness s= 0.2 – 0.5 – 1.0 mm; external load is assumed equal to stack resistance

Achievements and perspectives

Power density output: effect of IEMs properties

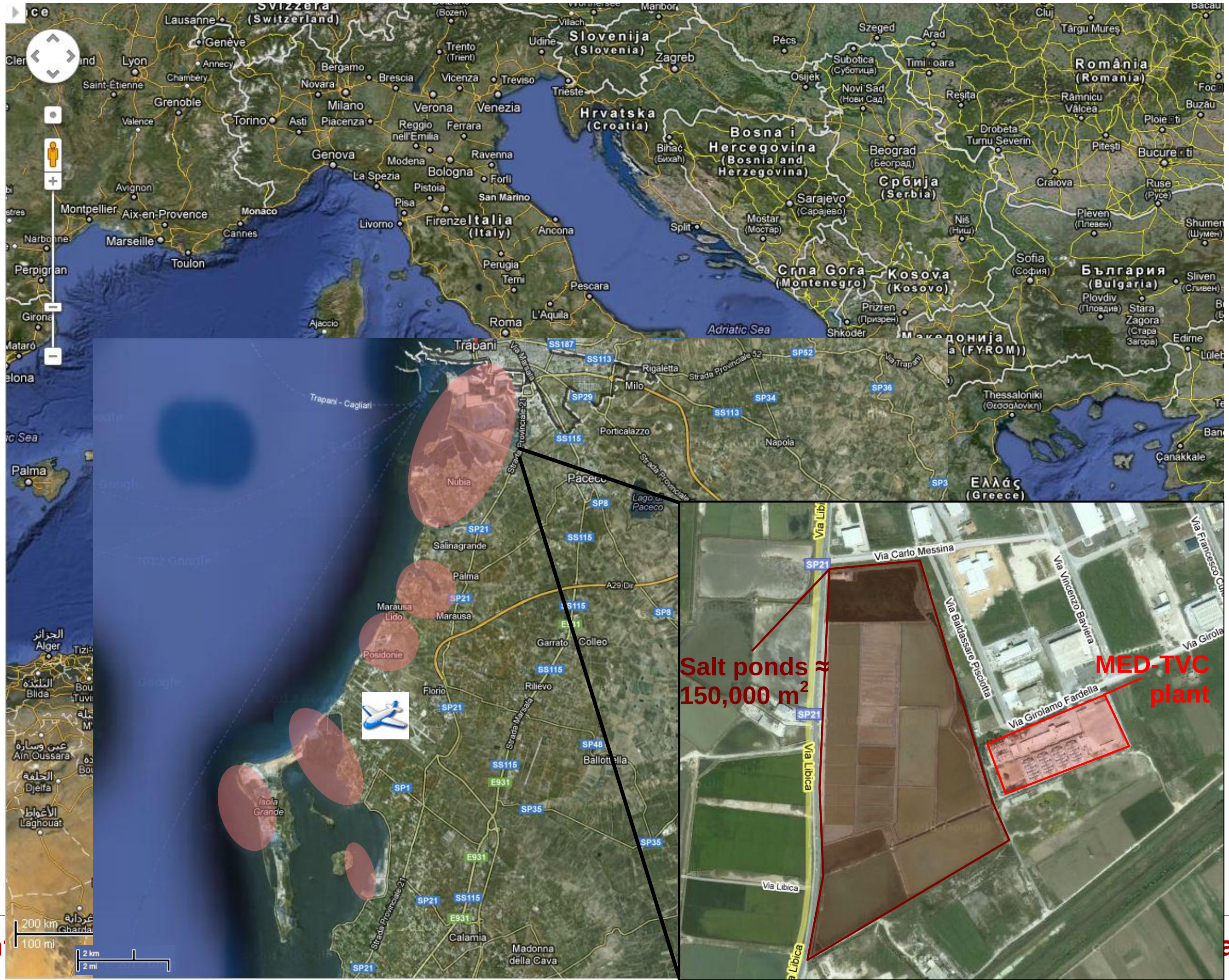




Simulation of a 1000 cells stack assuming a linear decreasing of IEMs resistance with IEMs thickness. α_{AEM} = 0.65, α_{CEM} = 0.90. Spacer thickness of seawater/brine compartments δ = *200 μm*.

Achievements and perspectives

Prototype installation site:
the singular framework of Trapani saltworks



Achievements and perspectives

Prototype installation site: The MED-TVC plant

4 MED-TVC units with total nominal production: **36000 m³/d**

MED units with **12 effects** and a Vapor Ejector for the **Thermal Vapor Compression**;

Brine available:

-**80,000 m³/d;**

-**35-38° C;**

-**52-55 gr/lt**

Prototype installation site

Prototype installation site: Ettore-Infersa saltworks

Direct access to both saturated brine and seawater from open channels

Installation place within an old, restructured WINDMILL

Achievements and perspectives

Prototype installation: plant specifications

Site features

- Seawater availability: unlimited;
- Brine availability: 10-15 m^3/h (much larger with feed-recycle);
- Brine concentration: variable between 250 and 320 gr/lt.

Prototype features

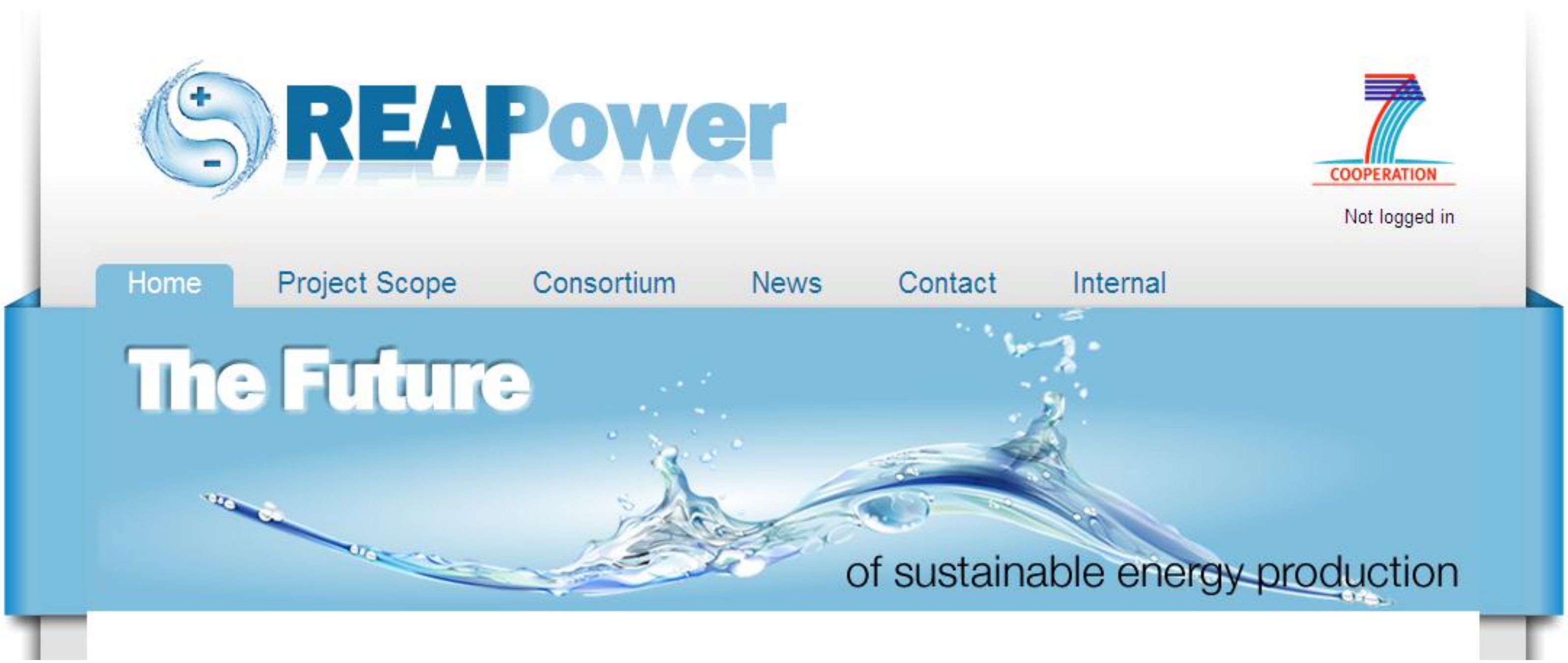
-Total cell pair surface: ≈ 60 m^2;

-Expected power density: > 5 W/m^2;

-Expected power output: > 300W

REAPower website

http://www.reapower.eu/



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Thanks for your kind attention

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