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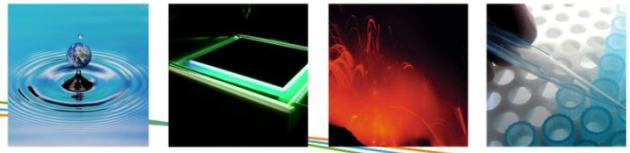

REAPower

COOPERATION

INES seminar on salinity gradient power

Energy generation and desalination : The REAPower project

Joost Helsen

Brussels, June 20th, 2012

Topics in the presentation of today

Energy generation and desalination : The REAPower project

- REAPower objectives
- SGP-RE battery principle and advantage
- Theoretical effect of SGP-RE battery parameters, indications from
  - simple resistances in series point of view
  - Lacey model based calculations
- Hybrid concept and relation with REAPower
- REAPower consortium
- REAPower workplan explained
- Acknowledgments

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REAPower objectives

- REAPower targets an innovative concept based on the reverse electrodialysis technology. This technology consists of the extraction of the “osmotic energy” from two salt solutions showing a large difference in salt concentration, what is called salinity gradient power (SGP).

- The objective of REAPower is to prove the concept of electricity production through SGP-RE using **brine** and **sea (/brackish) water** and to develop the necessary materials, components and processes.

- Time frame : 4 years ; October 2010 – October 2014

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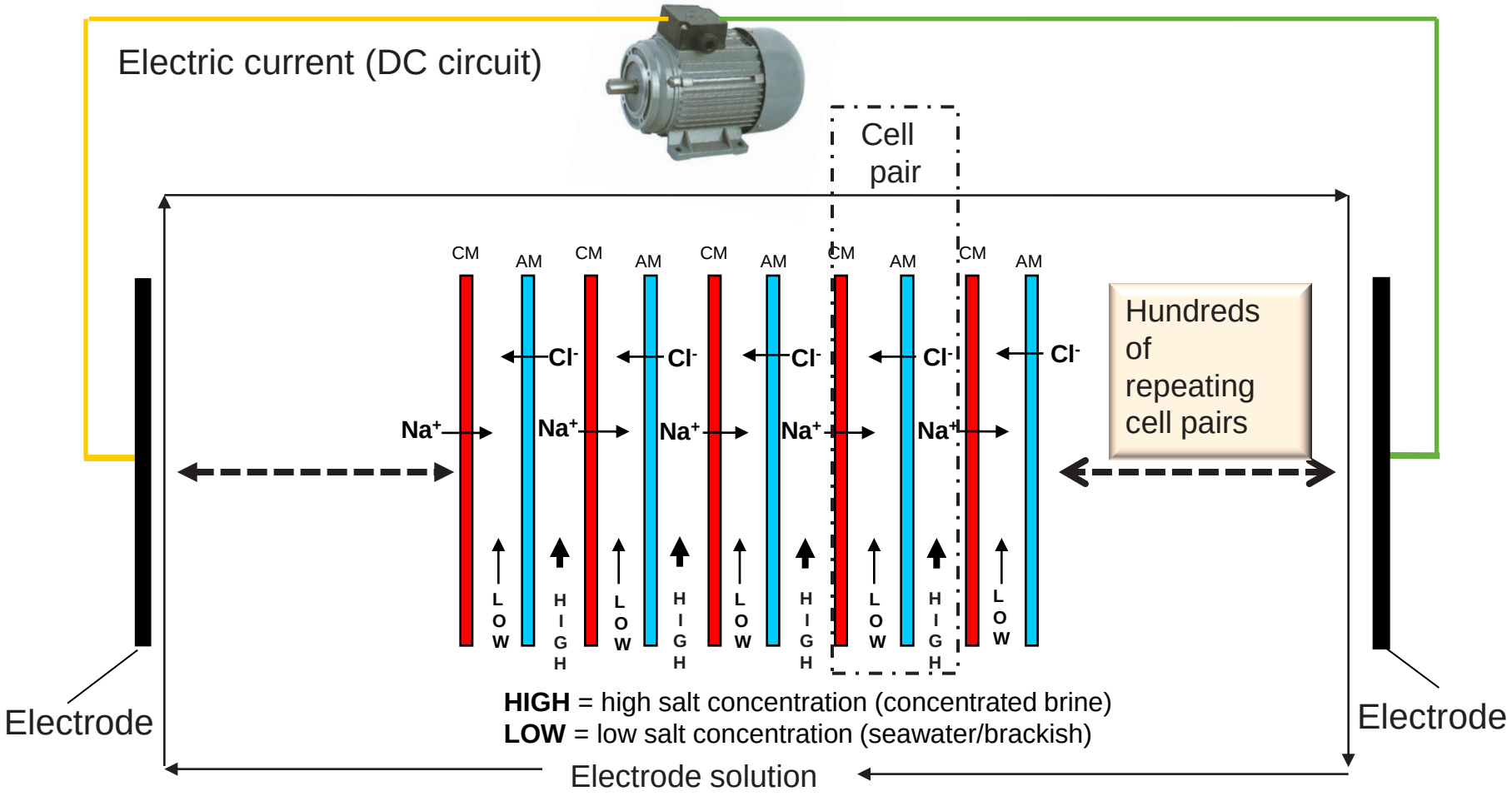
REAPower SGP-RE battery



Electrode solution redox-reactions at the electrodes induce the transport of electrons in the DC circuit

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REAPower advantage

The use of

- highly conductive seawater (e.g. 35 kg/m³) in the LOW compartment
- even more conductive concentrated brine (e.g. 300 kg/m³) in the HIGH compartment

creates a low resistance in both the HIGH and LOW battery compartments

As a result:

opportunity to target a low total internal resistance within the SGP-RE battery cell-pairs through the introduction of thinner membranes

Lower, internal battery resistance should significantly promote a higher power density of the SGP-RE battery.

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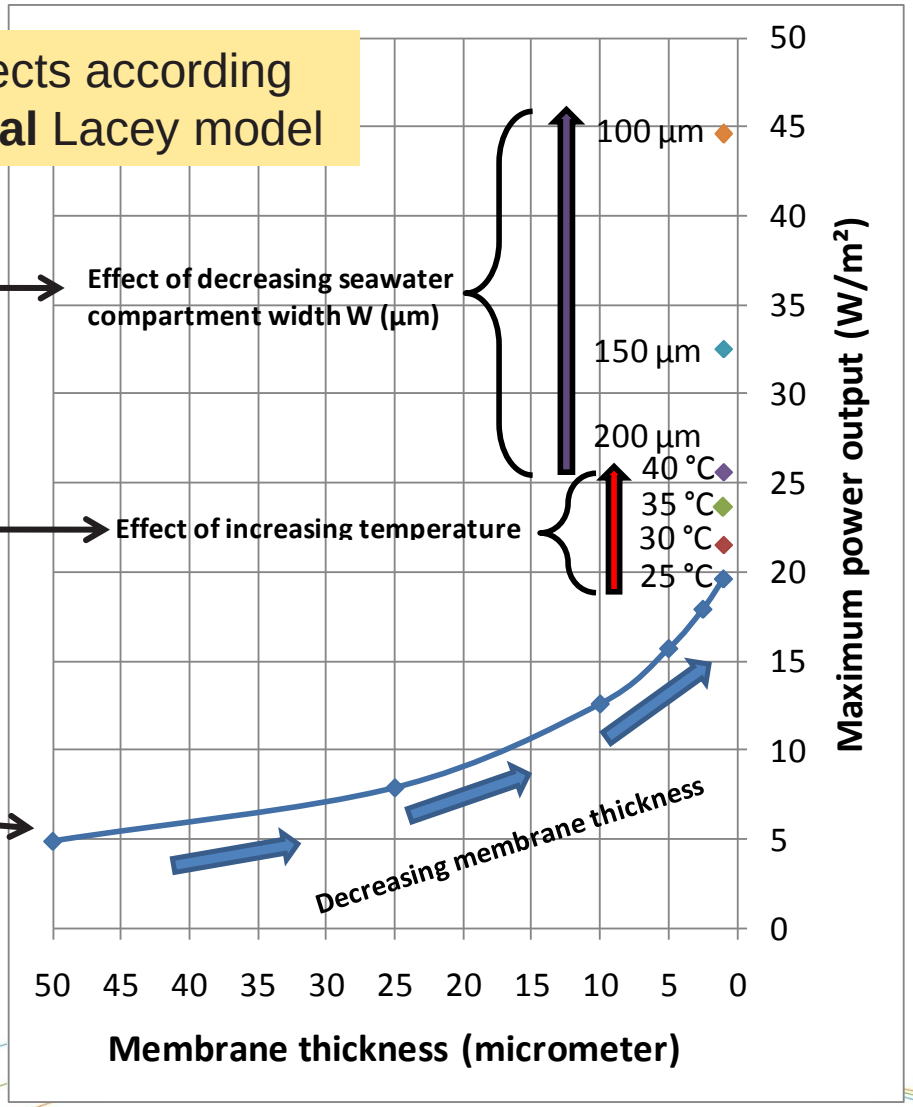
REAPower : theoretical effect of parameters

Parameter effects according to the **theoretical** Lacey model

3) Additional effect of lowering the compartment width

2) Additional temperature effect of thinner membranes

1) Effect of thinner membranes



E. Brauns, Desalination 237 (2009) 378–391

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REAPower : lowering the internal battery resistance

To give a rough idea and in theory, when assuming :

- simplified series of resistances
- AM and CM : specific membrane resistance of 100 Ω.cm
- seawater : 20 Ω.cm (*about 50 times lower than fresh water !*)
- brine : 2.5 Ω.cm

Theoretical indication of the internal cell pair resistance optimization window

CM membrane		LOW compartment		AM membrane		HIGH compartment		Total resistance	
(µm)	(Ω.cm²)	(µm)	(Ω.cm²)	(µm)	(Ω.cm²)	(µm)	(Ω.cm²)	(Ω.cm²)	(%)
100	1	200	0.4	**100**	1	200	0.05	***2.45***	***100***
20	0.2	200	0.4	**20**	0.2	200	0.05	0.85	35
10	0.1	200	0.4	**10**	0.1	200	0.05	0.65	26
100	1	**100**	0.2	**100**	1	200	0.05	2.25	92
50	0.5	**100**	0.2	**50**	0.5	200	0.05	1.25	51
20	0.2	**100**	0.2	**20**	0.2	200	0.05	0.65	26
10	0.1	**100**	0.2	**10**	0.1	200	0.05	0.45	18

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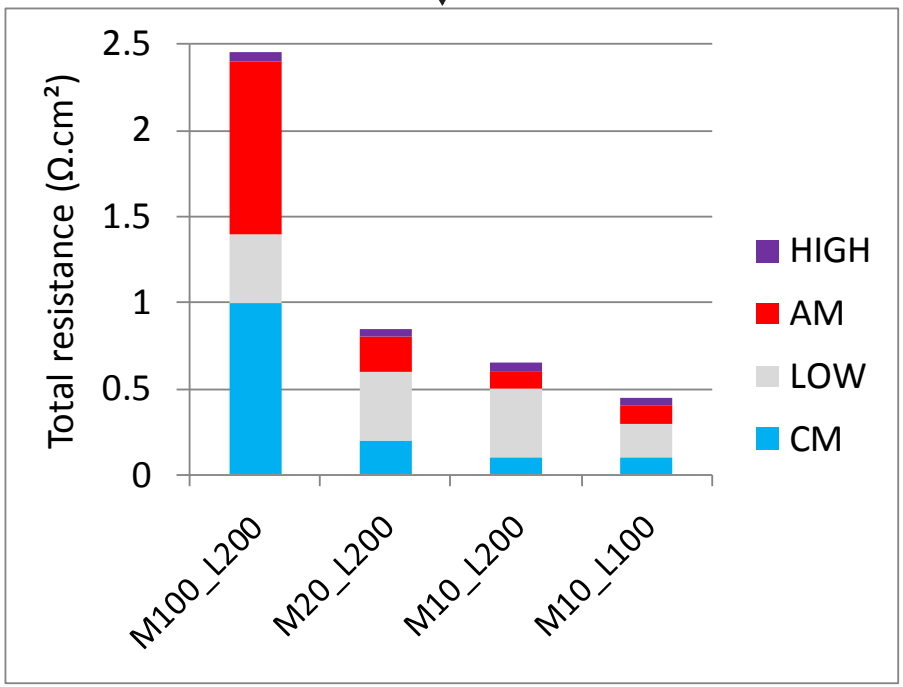
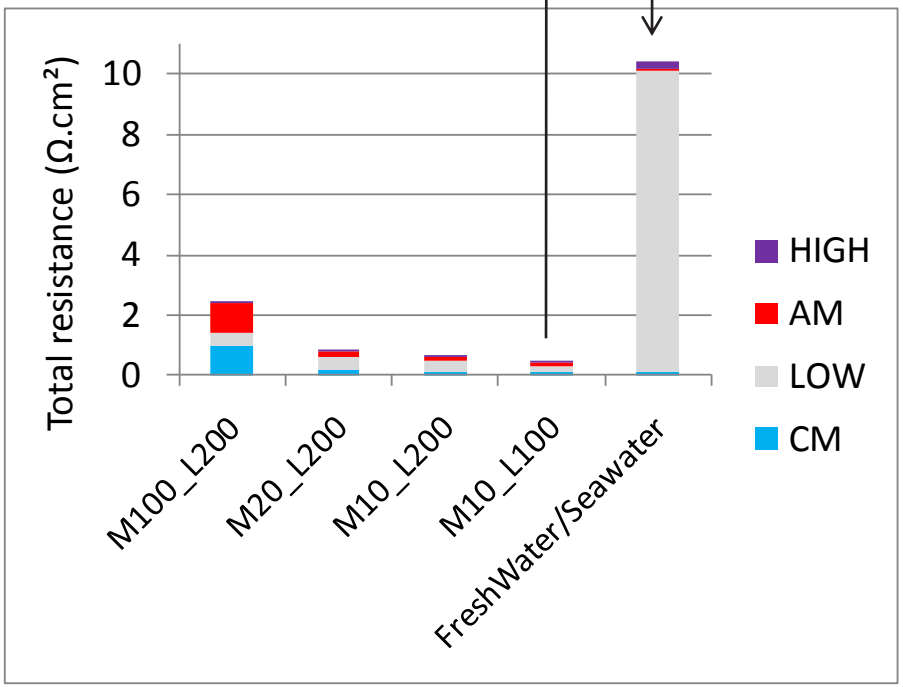
REAPower : lowering the internal battery resistance

Brine and seawater



The effect of putting fresh water in the LOW compartment and seawater in the HIGH compartment in the case M10_L100



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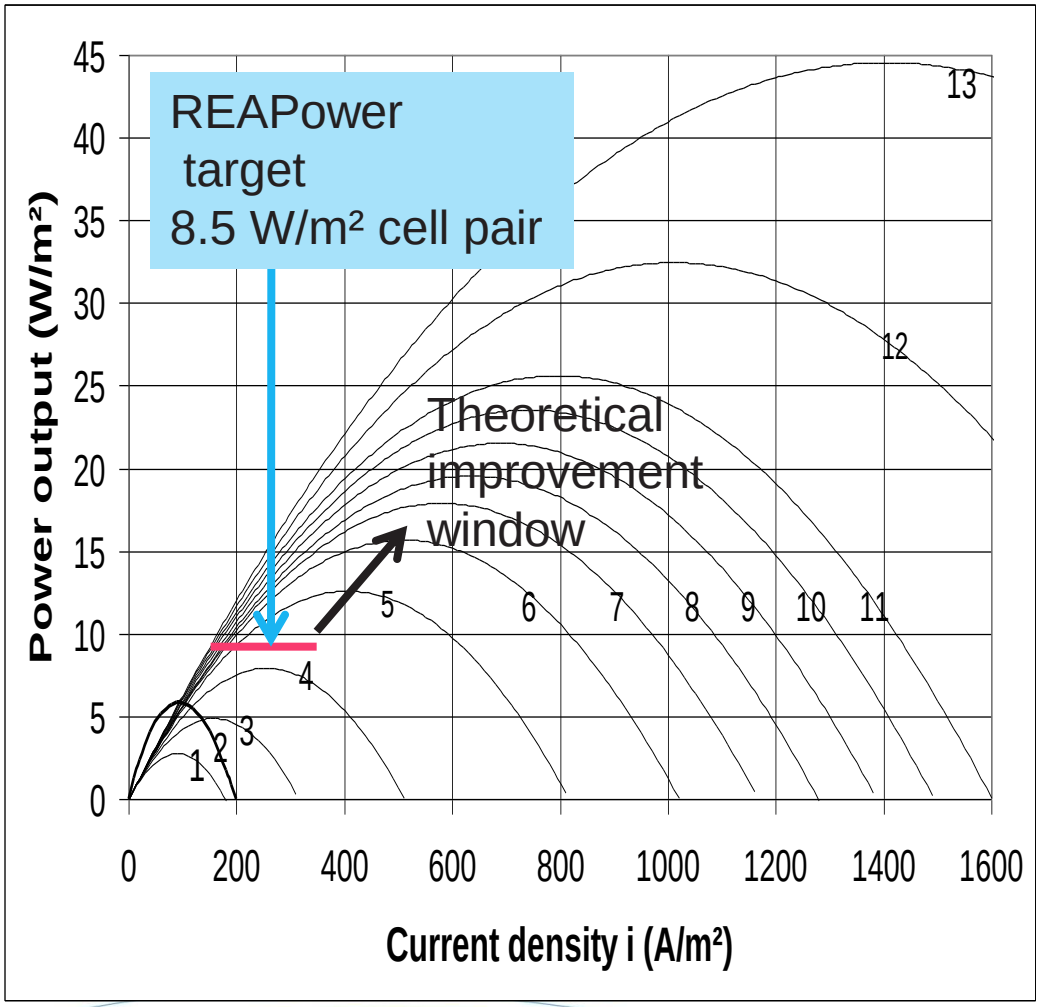
Power output indications from Lacey model

CURVE	Membrane thickness (µm)	LOW compartment thickness (µm)	Temp. (°C)	Max Power Output (W/m²)
1	100	200	25	2.8
2		(Lacey)		6
3	50	200	25	4.9
4	25	200	25	7.9
5	10	200	25	12.6
6	5	200	25	15.7



E. Brauns, Desalination 237 (2009) 378–391

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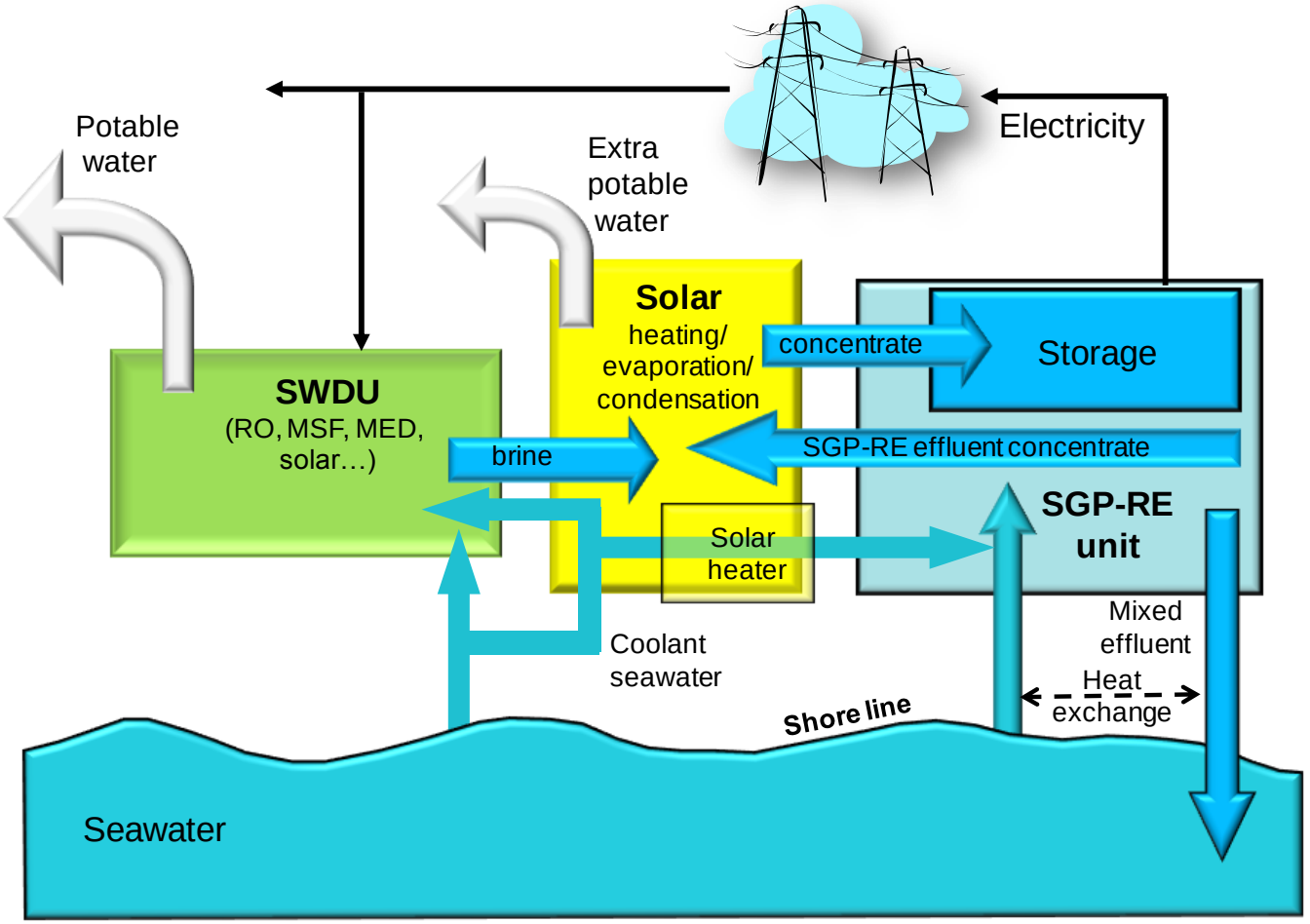
Hybrid system to produce energy and fresh water



E. Brauns, Desalination and Water Treatment, 13 (2010) 53–62

E. Brauns, WO/2007/009196 [PCT/BE2006/000078]

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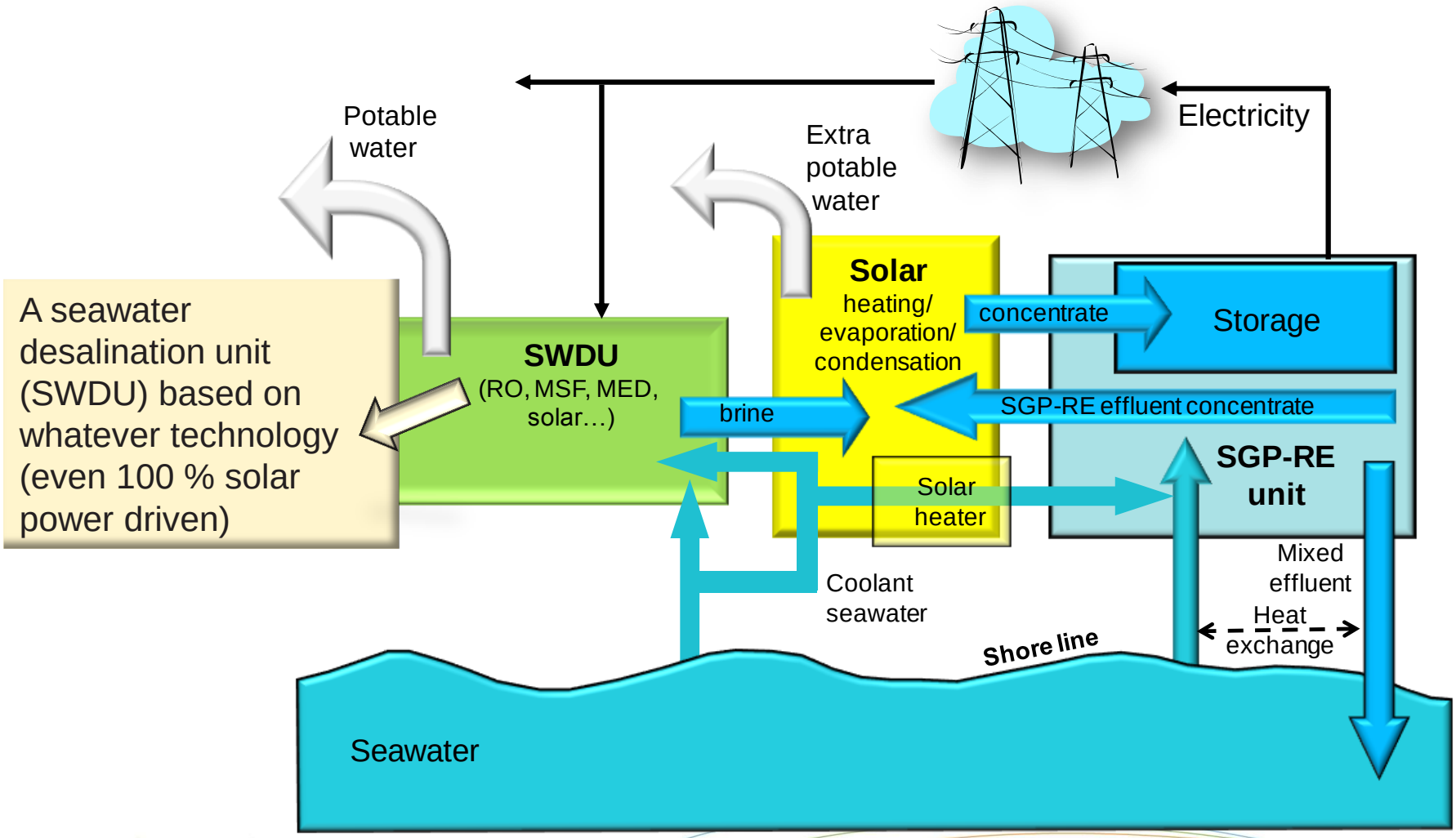
Hybrid system to produce energy and fresh water



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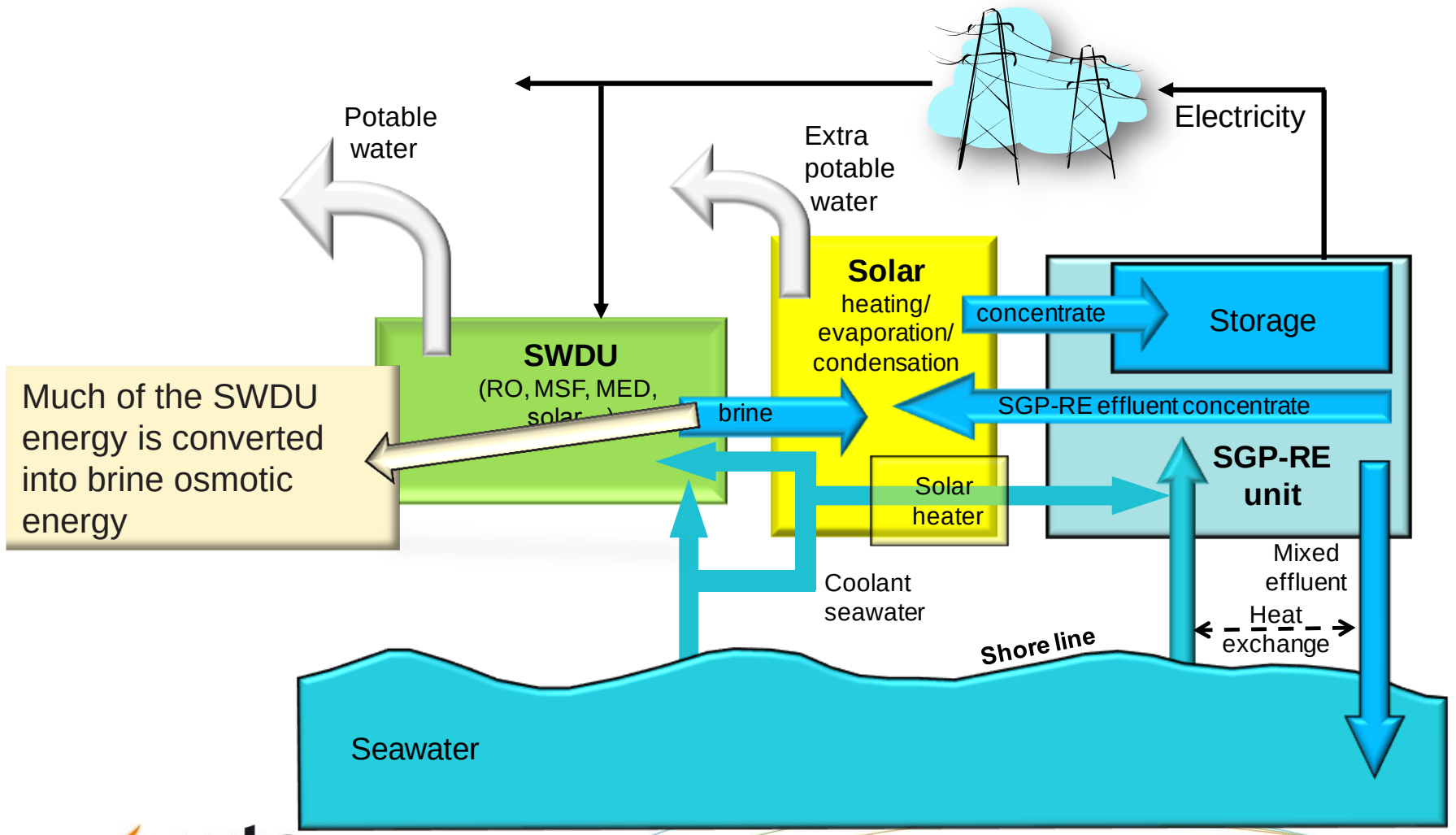
Hybrid system to produce energy and fresh water



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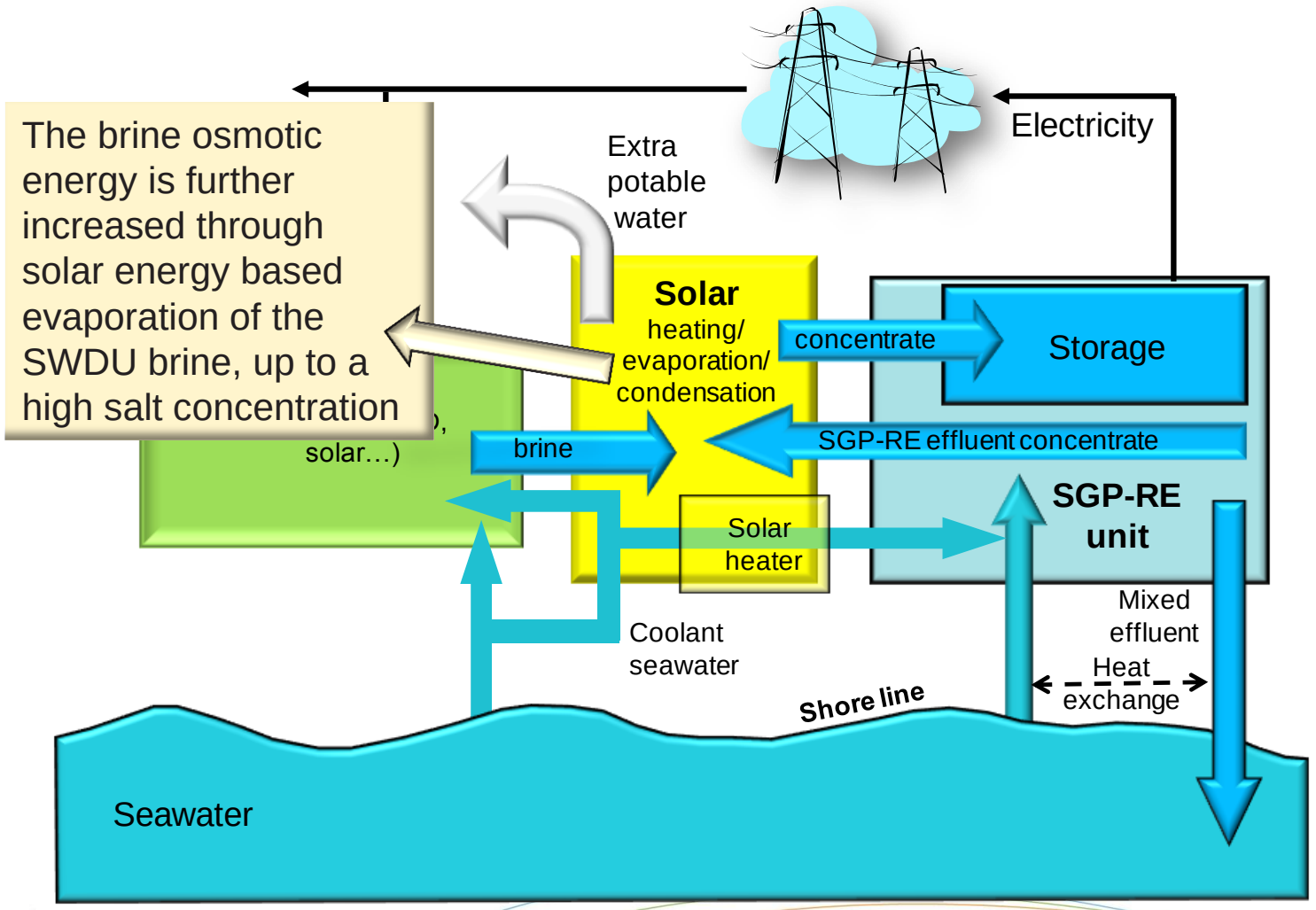
Hybrid system to produce energy and fresh water



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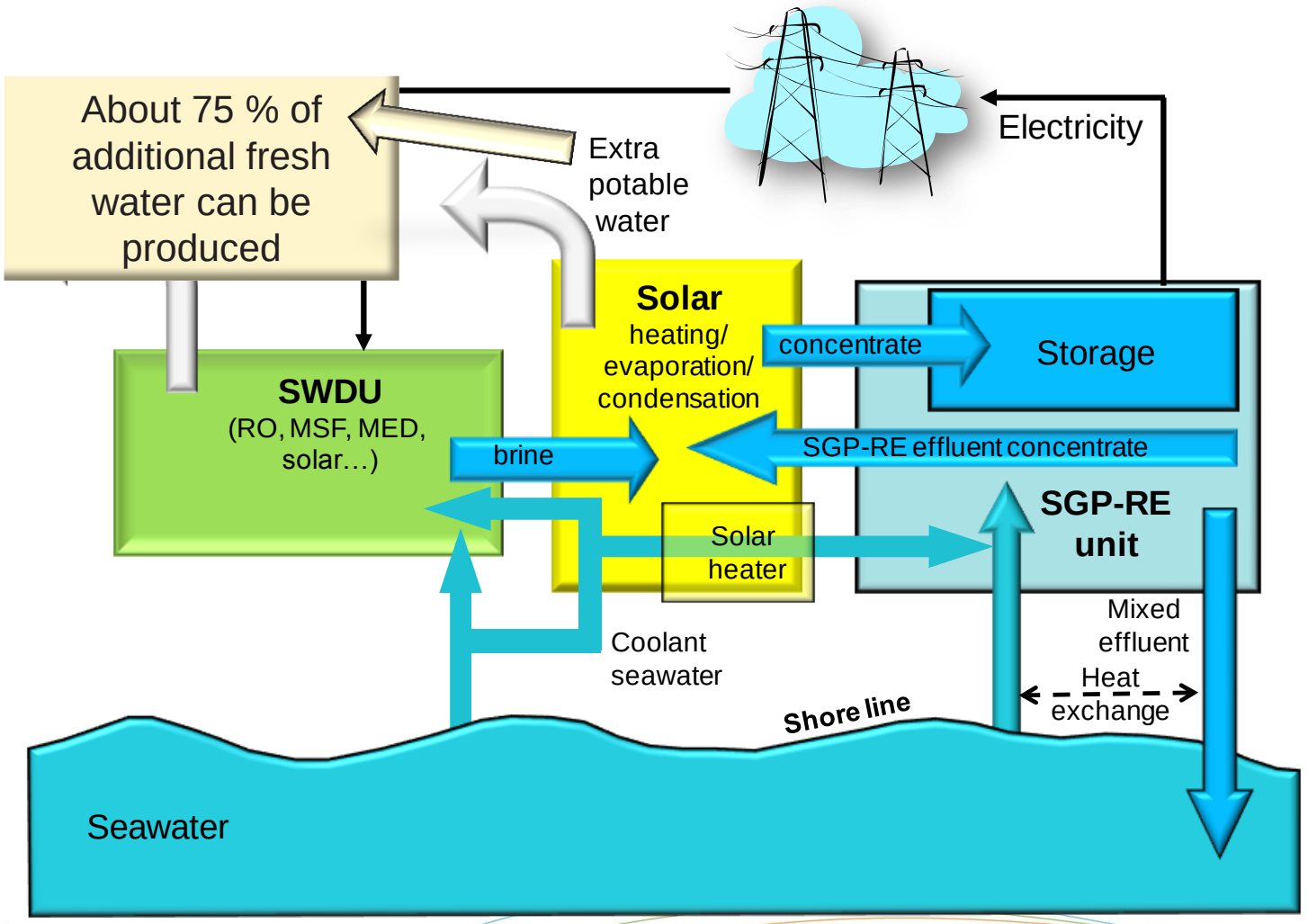
Hybrid system to produce energy and fresh water



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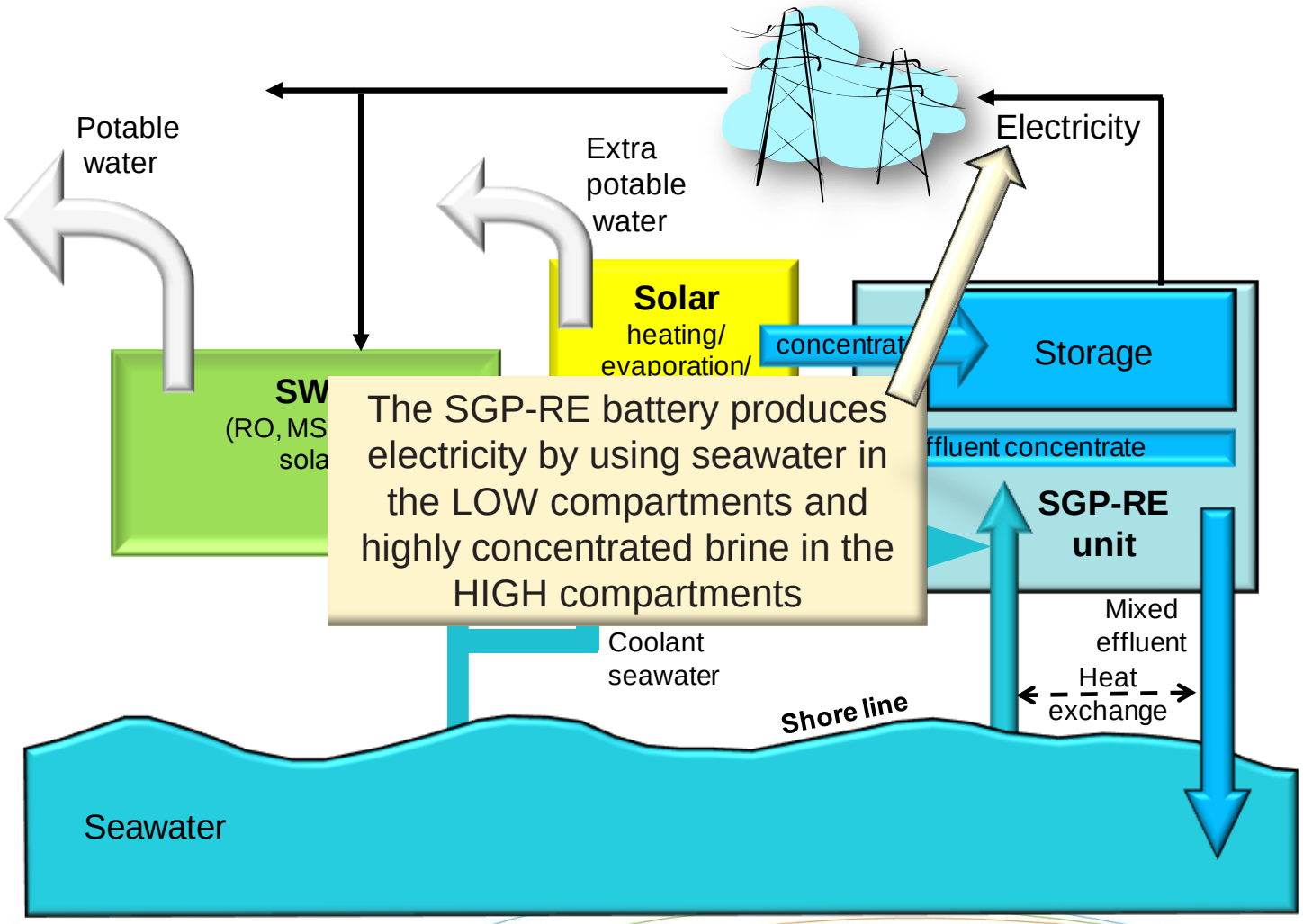
Hybrid system to produce energy and fresh water



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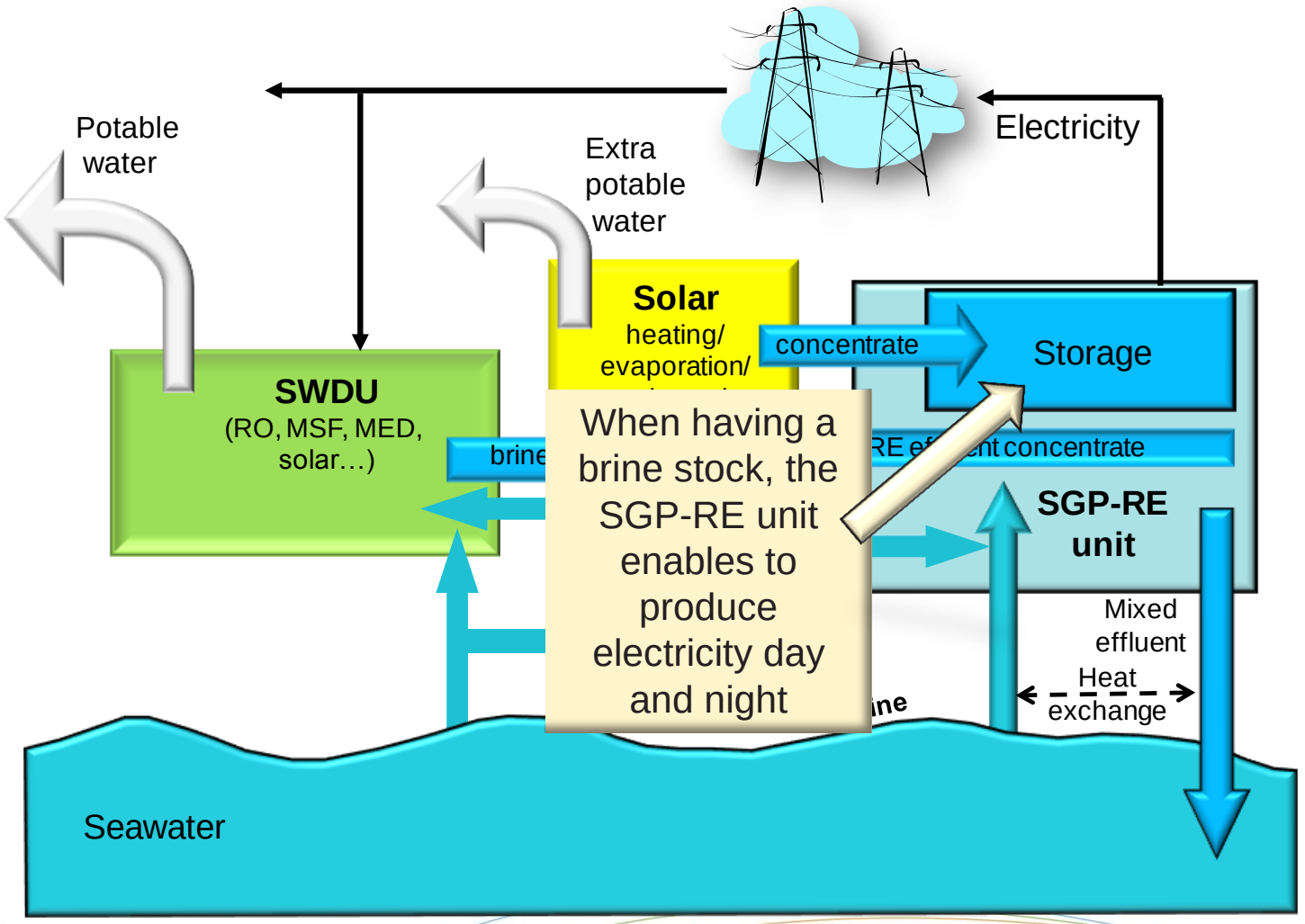
Hybrid system to produce energy and fresh water



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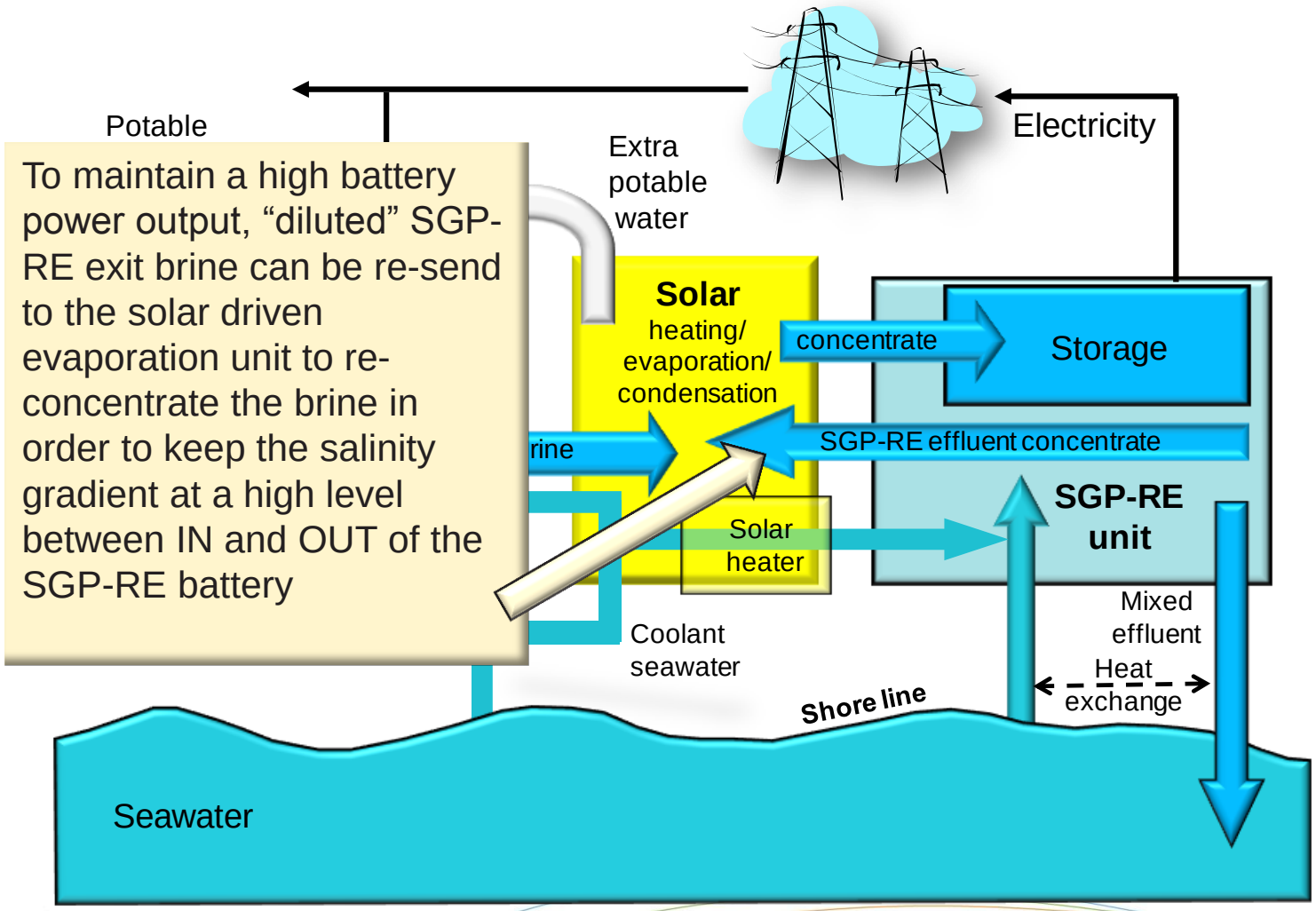
Hybrid system to produce energy and fresh water



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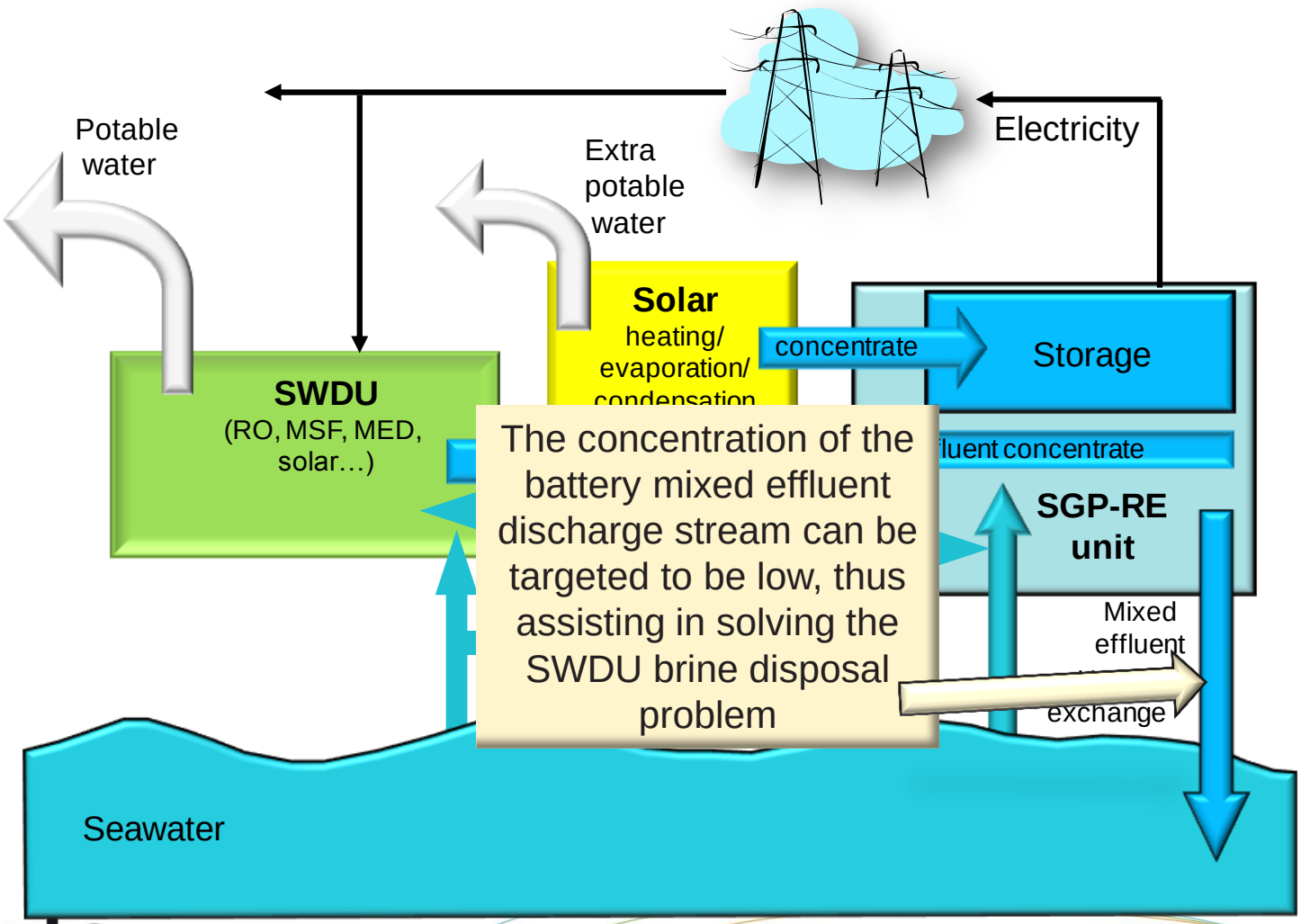
Hybrid system to produce energy and fresh water



The concentration of the battery mixed effluent discharge stream can be targeted to be low, thus assisting in solving the SWDU brine disposal problem

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REAPower consortium

Participant	Country	Logo
Wirtschaft und Infrastruktur GmbH & Co Planungs-KG (WIP) - more info -	DE	
Vlaamse instelling voor technologisch onderzoek N.V (VITO) - more info -	BE	
Università Degli Studi Di Palermo (UNIPA) - more info -	IT	
Fujifilm Manufacturing Europe B.V. (FUJI) - more info -	NL	
Next Technology TECNOTESSILE Società Nazionale di Ricerca r.l. (NTT) - more info -	IT	
KEMA NEDERLAND BV (KEMA) - more info -	NL	
Università della Calabria (DICEM-UNICAL) - more info -	IT	
The University of Manchester (UNIMAN) - more info -	UK	
REDstack B.V. - more info -	NL	
Kraton Polymers, LLC (KRATON) - more info -	US	
SolarSpring GmbH - more info -	DE	

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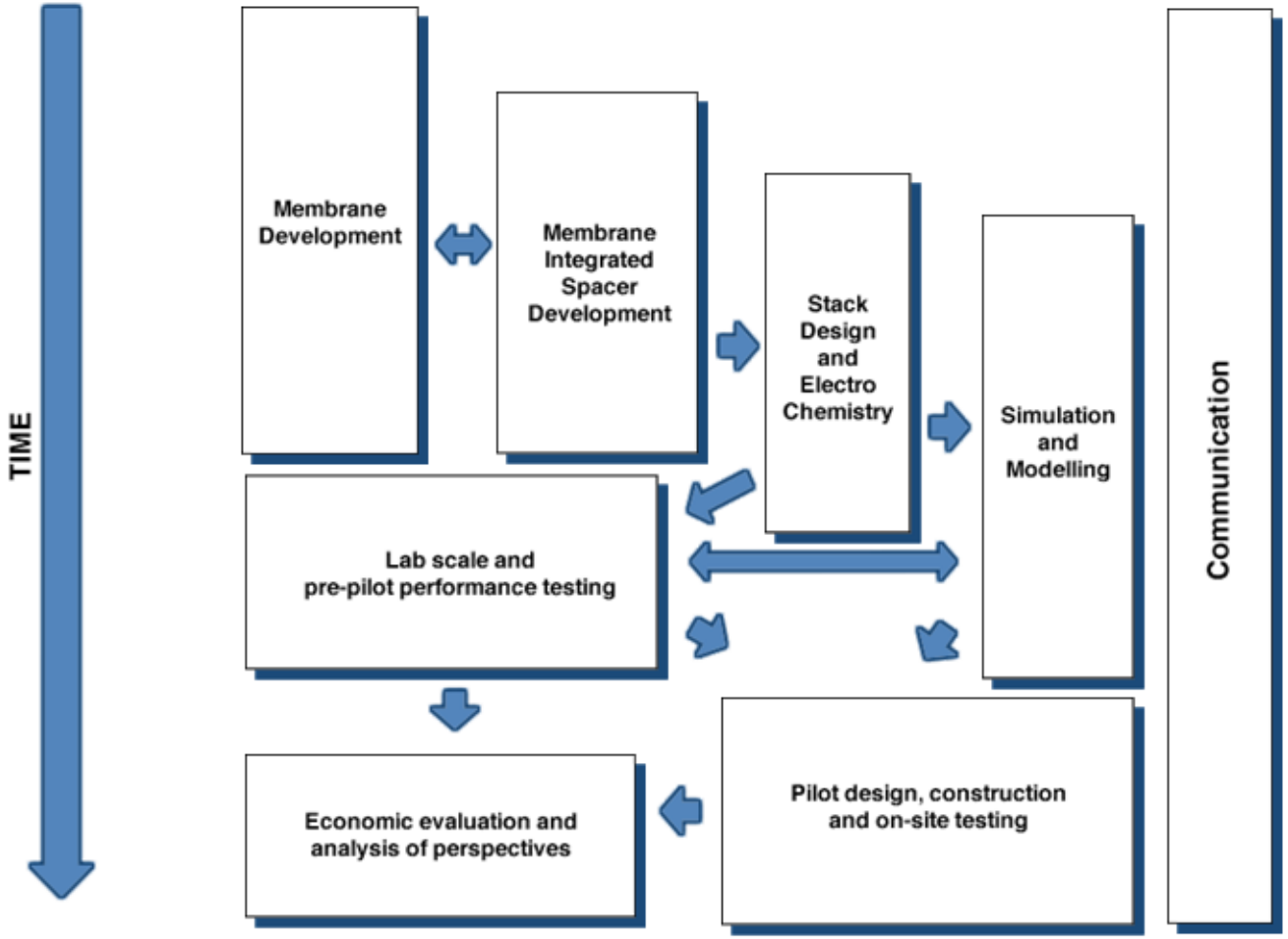
REAPower workplan - status



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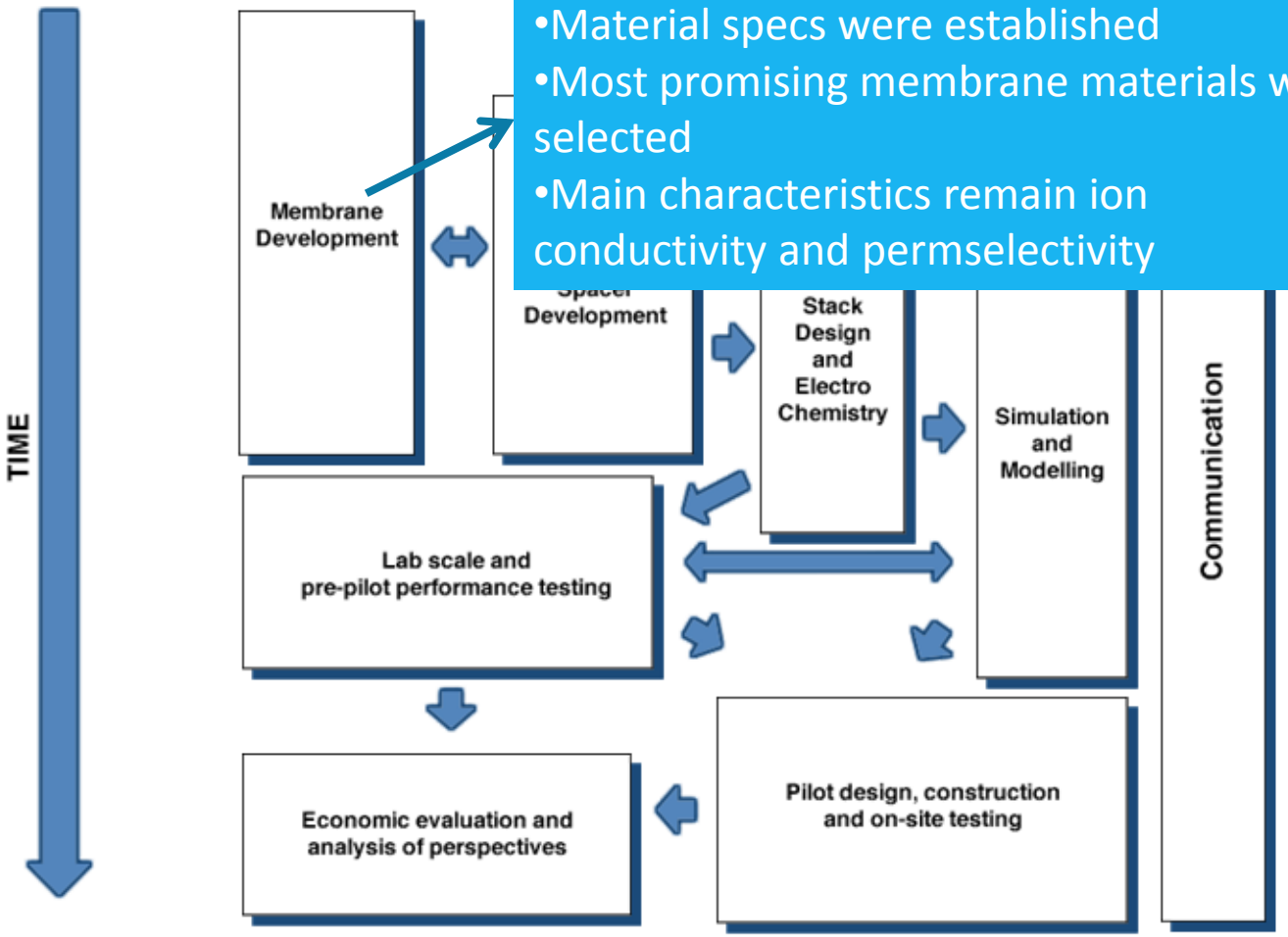
Membrane Development



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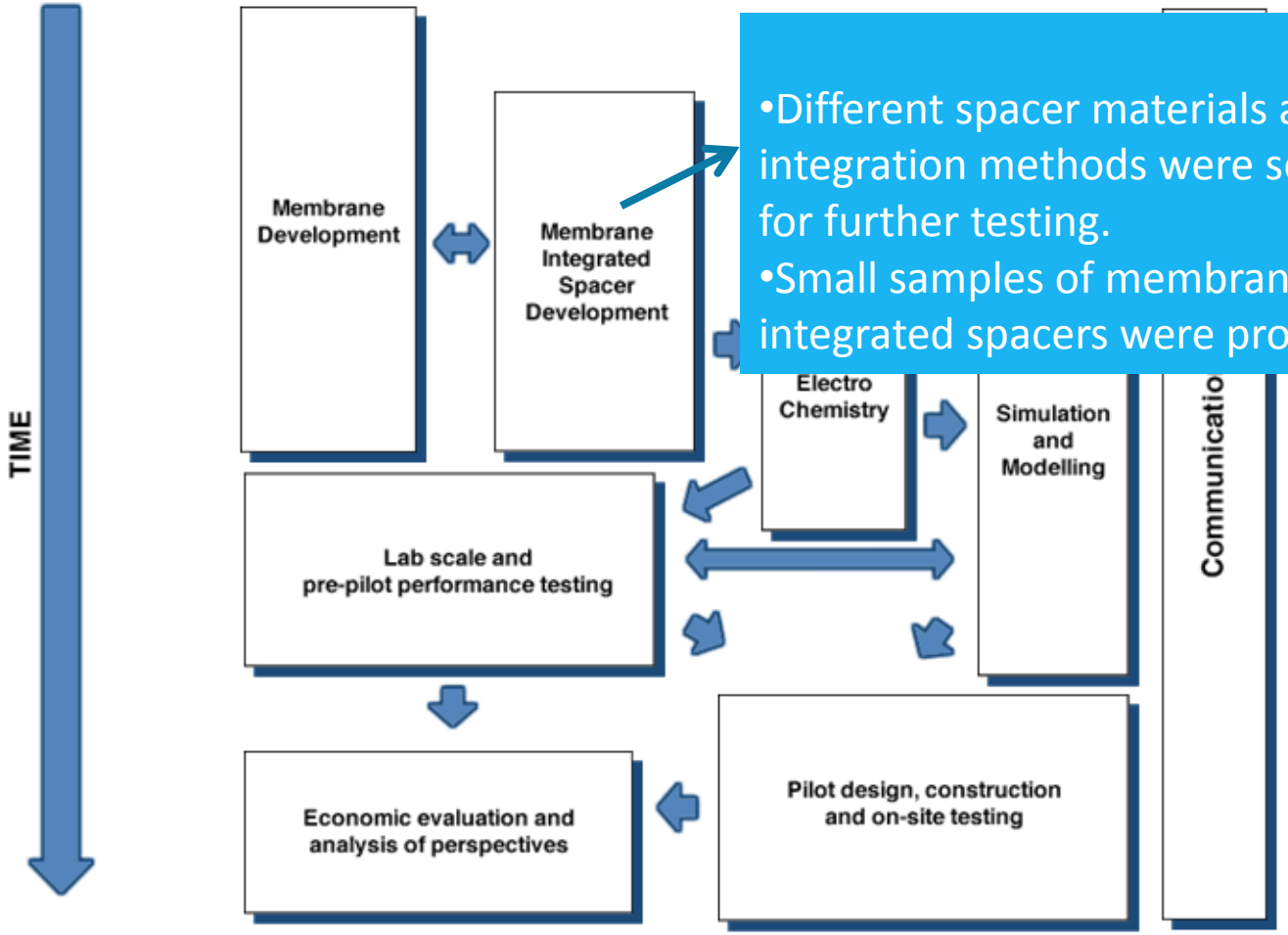
Membrane Integrated Spacer Development



- Different spacer materials and integration methods were selected for further testing.
- Small samples of membrane integrated spacers were produced

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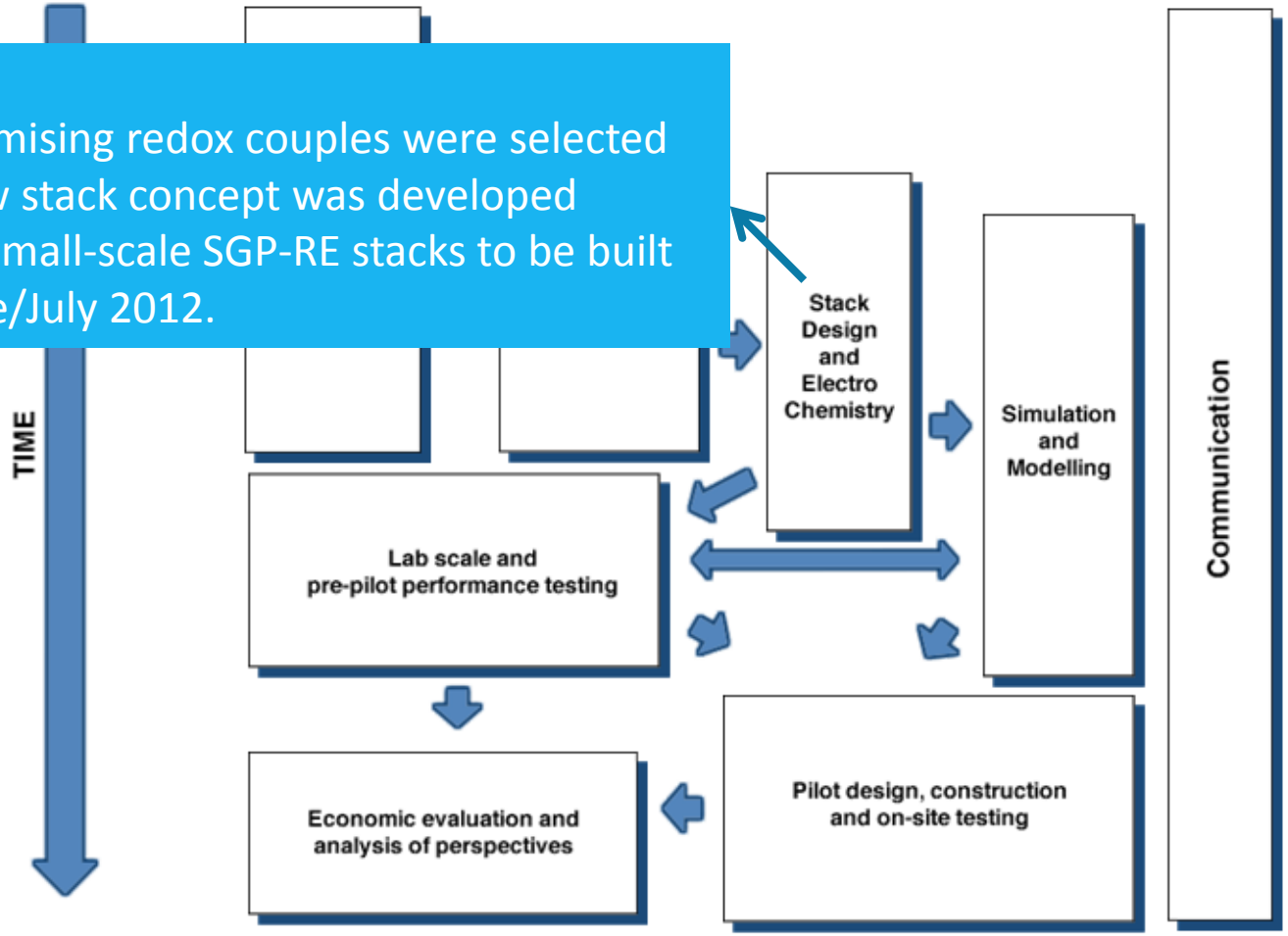
Electrochemical engineering / stack design

- 3 promising redox couples were selected
- A new stack concept was developed
- First small-scale SGP-RE stacks to be built in June/July 2012.



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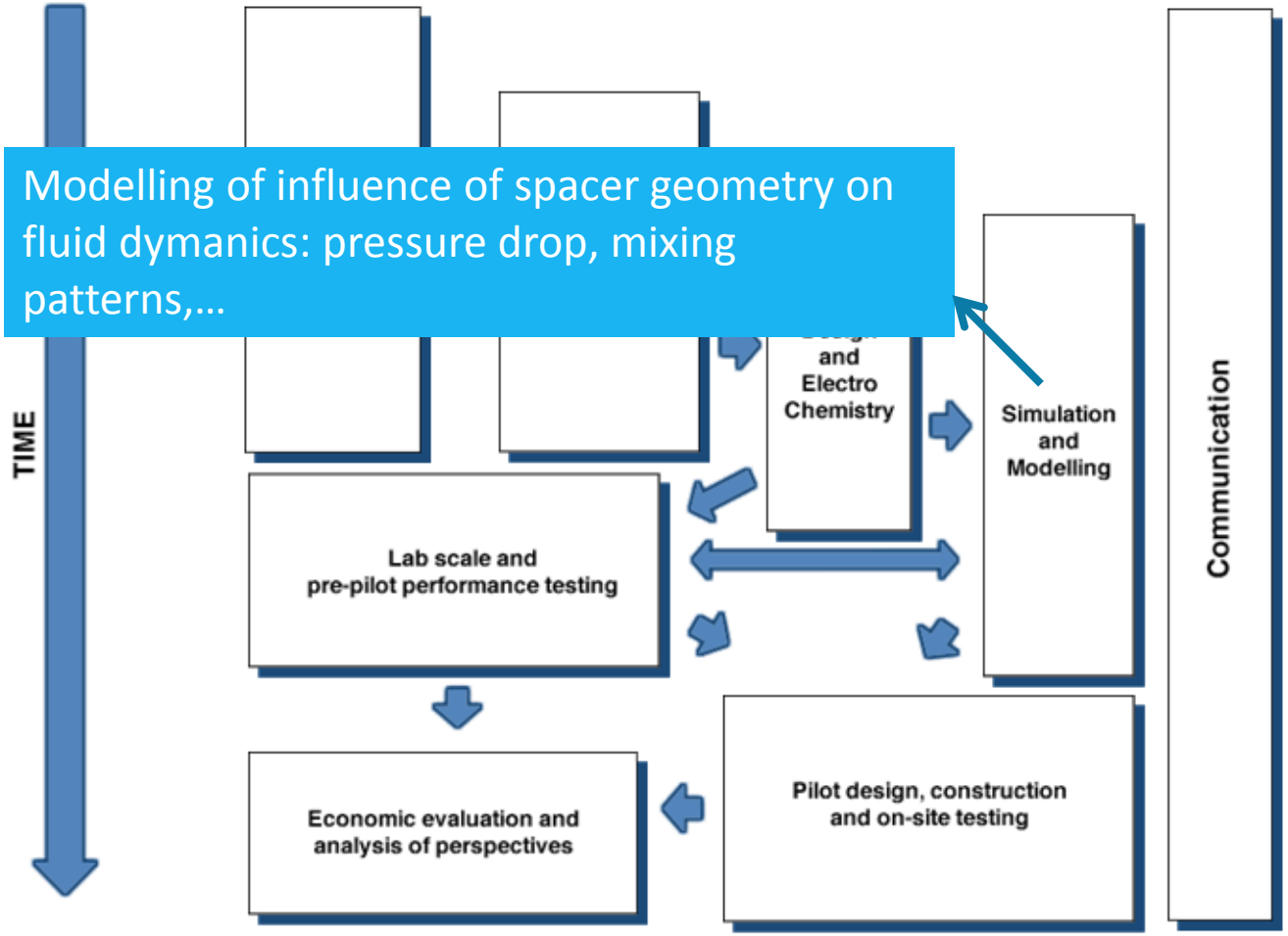
Process simulation



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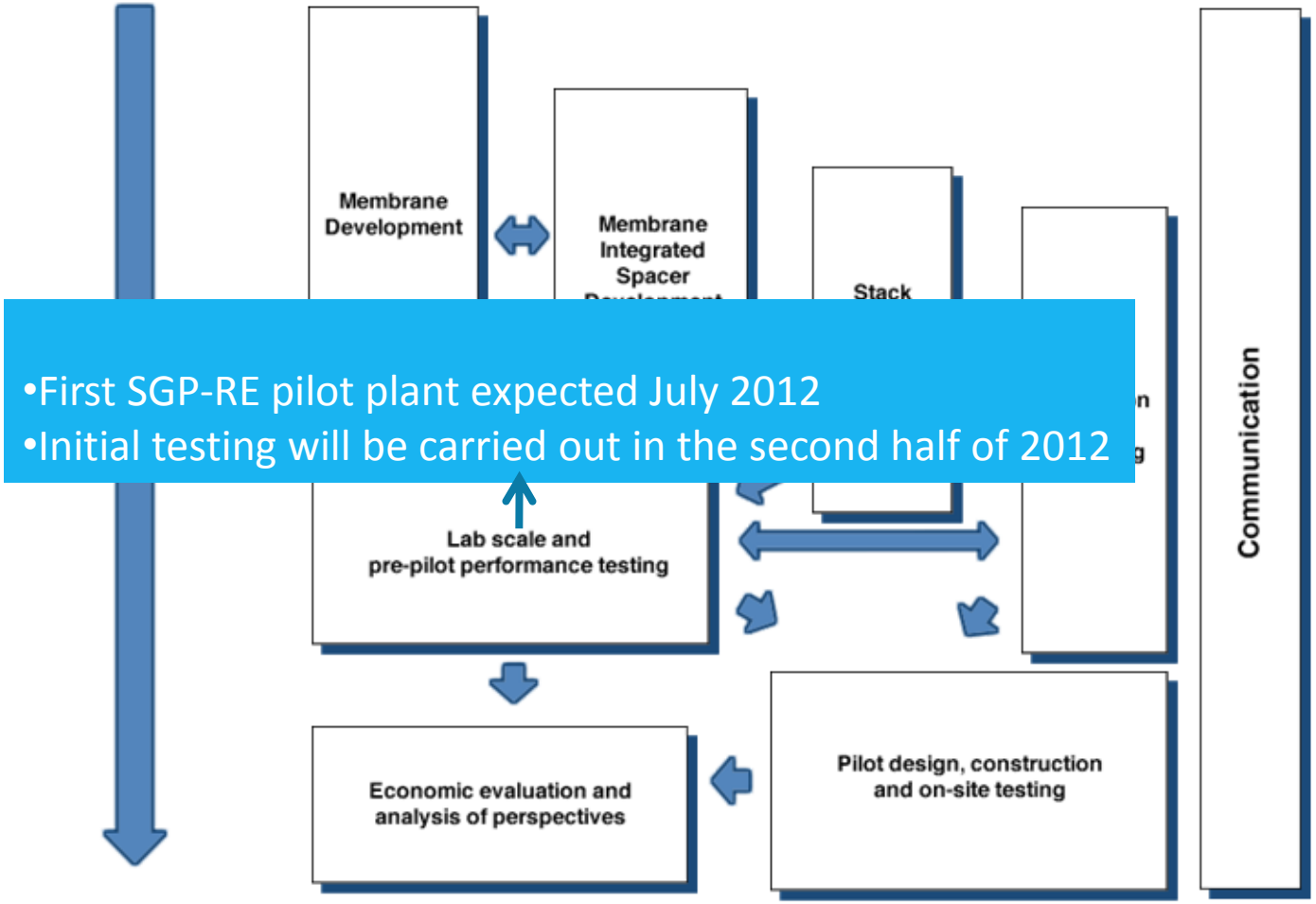
Lab-scale performance testing



- First SGP-RE pilot plant expected July 2012
- Initial testing will be carried out in the second half of 2012

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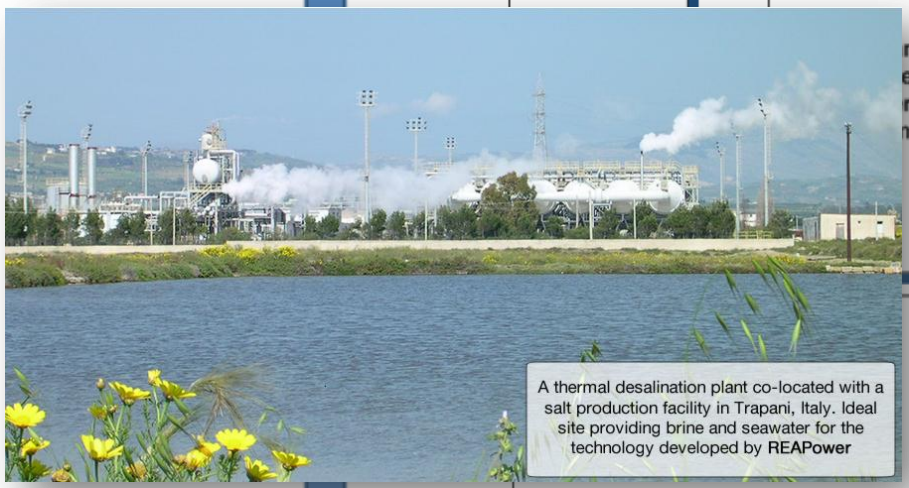
Design, construction, testing of prototype installation



A prototype unit of the developed technology will be designed, constructed and tested in the saline pond salt factory 2013-2014.

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

Pilot design, construction and on-site testing

Economic evaluation and analysis of perspectives

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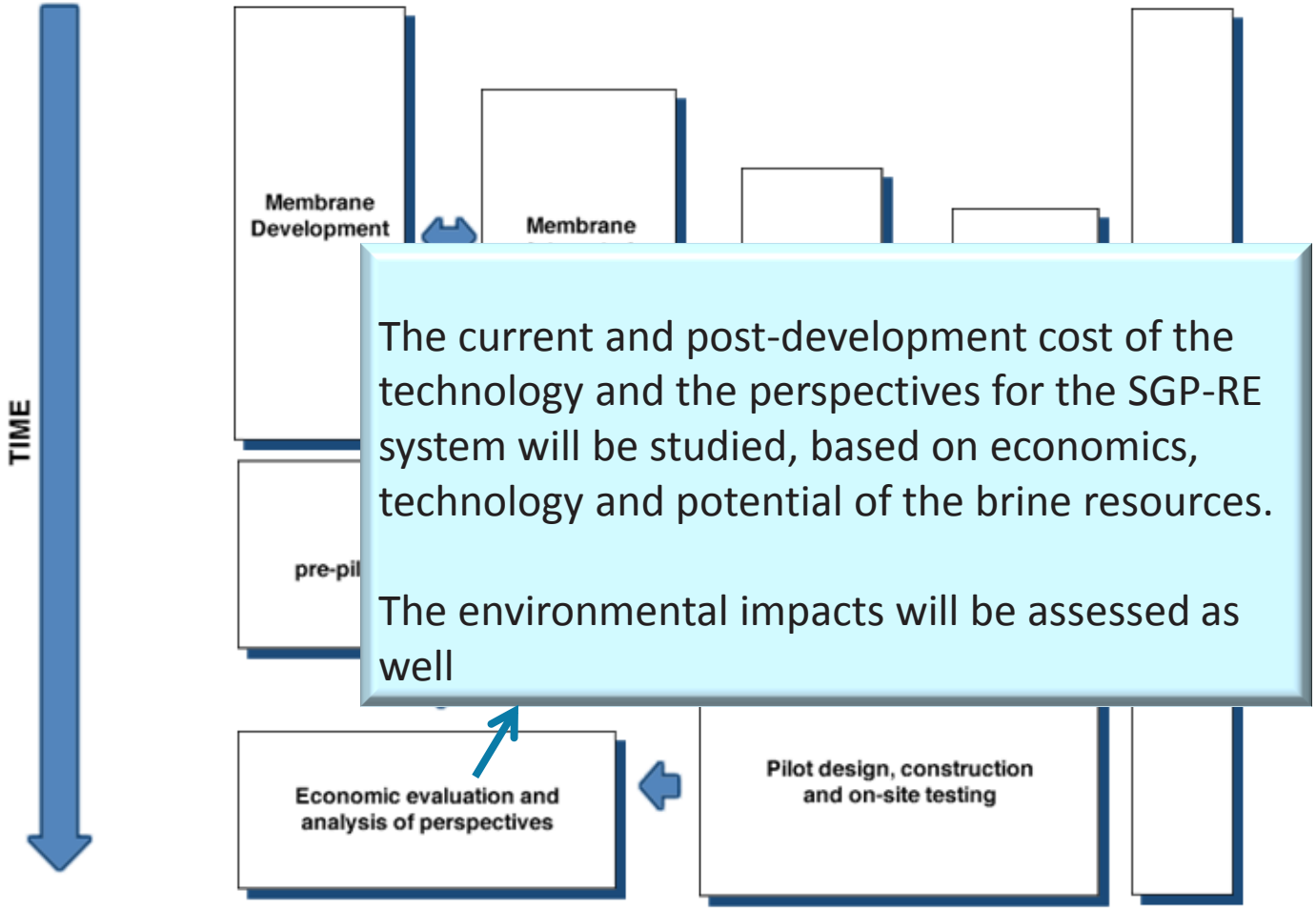
Economic evaluation / analysis of perspectives



The current and post-development cost of the technology and the perspectives for the SGP-RE system will be studied, based on economics, technology and potential of the brine resources.

The environmental impacts will be assessed as well

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Main challenges for the coming years

- Development of thinner membranes in an integrated membrane-spacer design
- feed pre-filtration at low cost
- Fouling/scaling issues?
- prove technology on lab-scale and scale up to fieldtest pilots

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REAPower

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Thank you for your attention

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