ElectroMembrane Stacks

Platform Technology for Resource Recovery

Simon Grasman
CTO of REDstack BV

REDstack has developed the ElectroMembrane Stack Technology for the world’s first operating Blue Energy pilot plant

- The Afsluitdijk is a dam of 32 km
- It forms a crucial part of Dutch water management infrastructure
- REDstack has to comply with many strict environmental and safety regulations

Platform Technology For Resource Recovery

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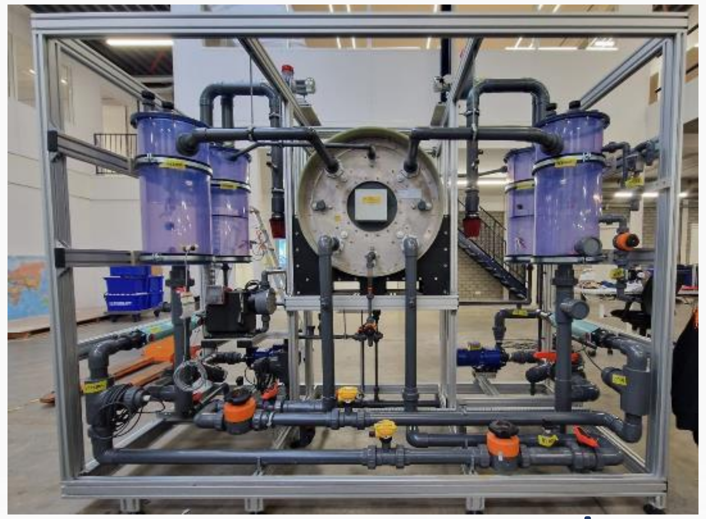
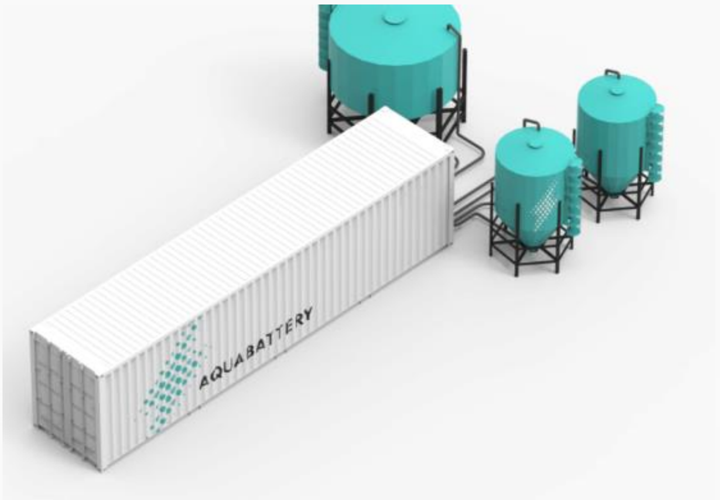
Water recovery



Nitrogen removal

Carbon capture

Energy recovery



Environmental batteries

Lithium recovery

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Technology: ElectroDialysis

- Desalination of a saline feed water, by applying an electrical current.
- Using ion-exchange membranes.

- Conversion of an electrical potential into a chemical potential.
- Driving the negative charged ions towards the anode and positive carged ions towards the cathode.
- Producing a concentrated reject and desalinated product

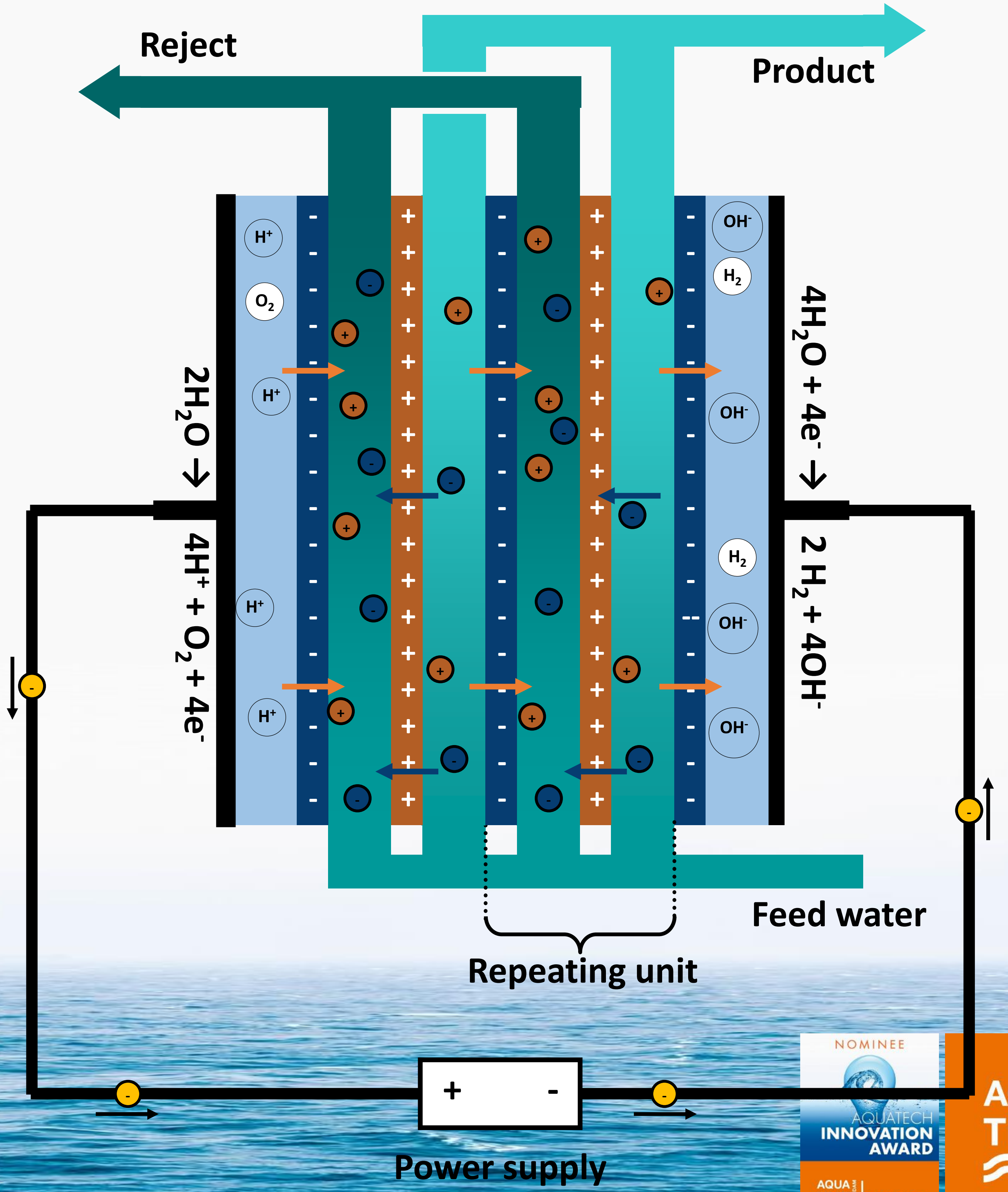
$$\mu_i = \mu_i^0 + \vartheta_i \, \Delta p + RT \, ln(x_i) + |z_i| \, F \, \Delta\varphi$$

Free energy under standard conditions

Pressure difference

Chemical potential

Electrical potential difference



Technology: Reverse ElectroDialysis

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- Energy recovery from a difference in salinity between two feed sollutions.
- Using ion-exchange membranes.

- Conversion of chemical potential into an electrical potential.
- Driving force for current.
- Ionic current inside stack and electrical current in external circuit.

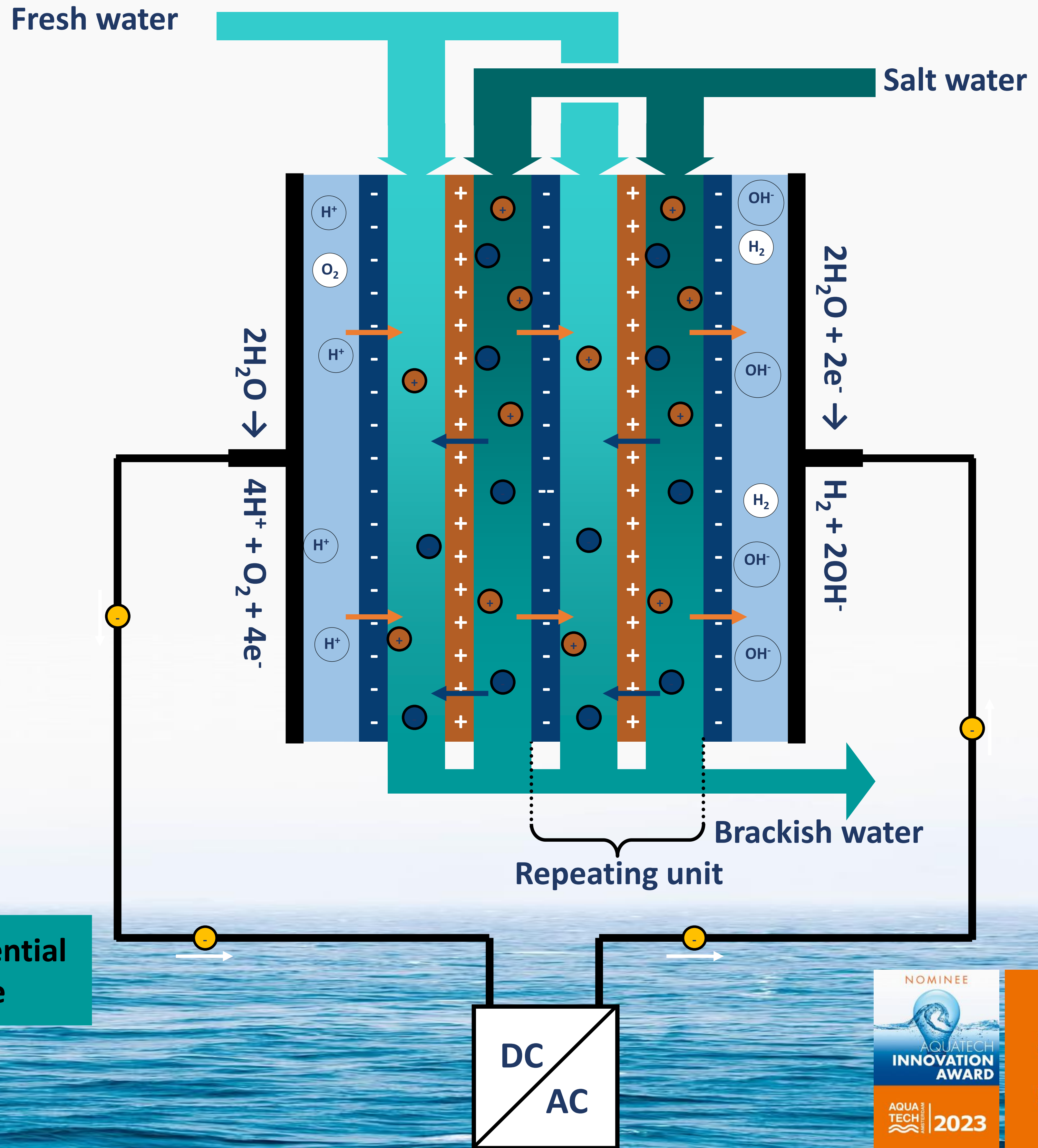
$$\mu_i = \mu_i^0 + \vartheta_i \, \Delta p + RT \, ln(x_i) + |z_i| \, F \, \Delta\varphi$$

Free energy under standard conditions

Pressure difference

Chemical potential

Electrical potential difference



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Technology: ElectroDialysis with Bipolar Membranes

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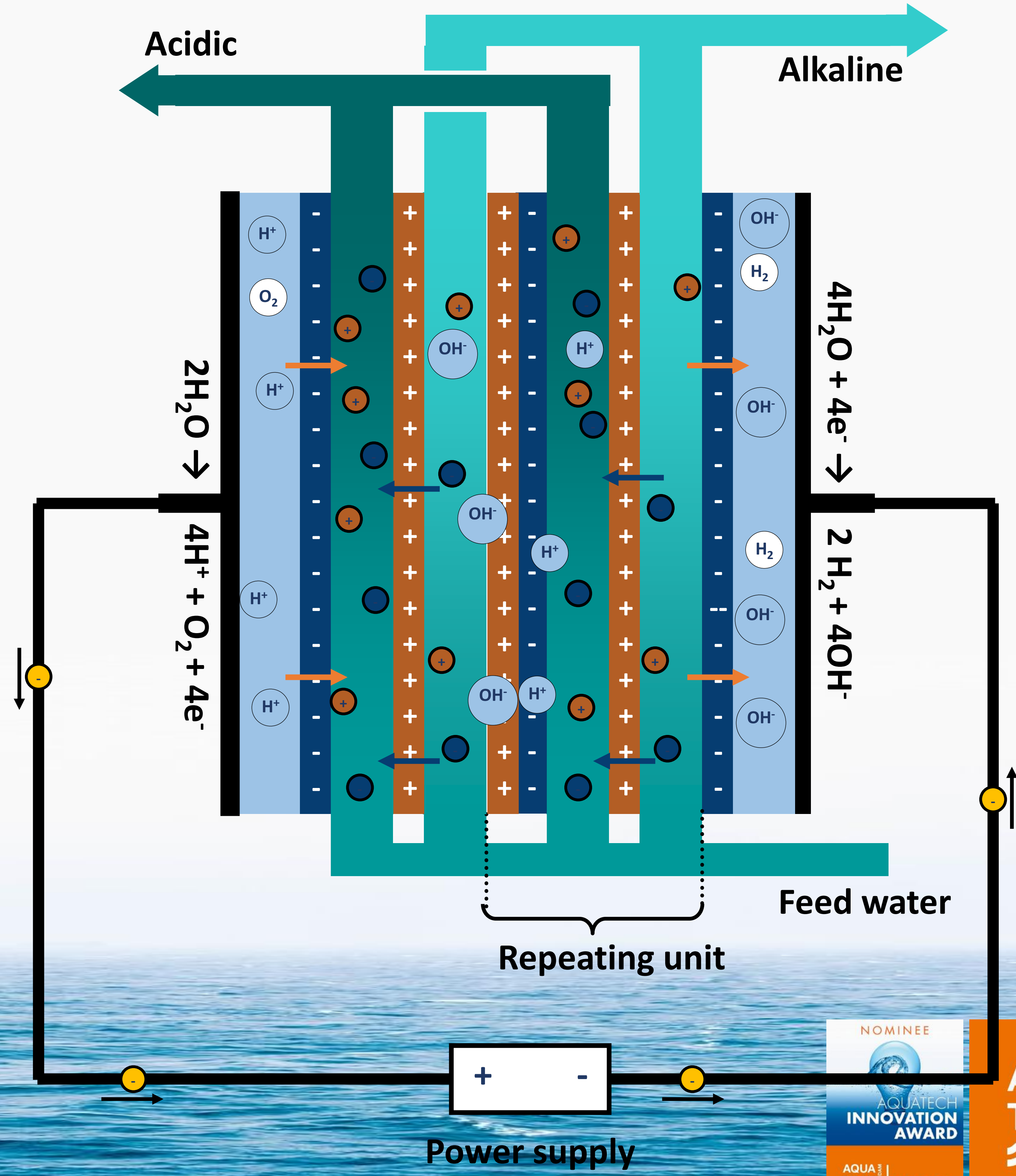
- Special case of Electrodialysis.
- Using bipolar membranes.
- Splitting water into H^+ and OH^-

- Conversion of an electrical potential into a chemical potential.
- Splitting water at the interface of the AEM and CEM layer of a bipolar membrane.
- Producing an Acidic and Alkaline stream



$$\mu_i = \mu_i^0 + \vartheta_i \, \Delta p + RT \, ln(x_i) + |z_i| \, F \, \Delta\varphi$$

Free energy under standard conditions

Pressure difference

Chemical potential

Electrical potential difference

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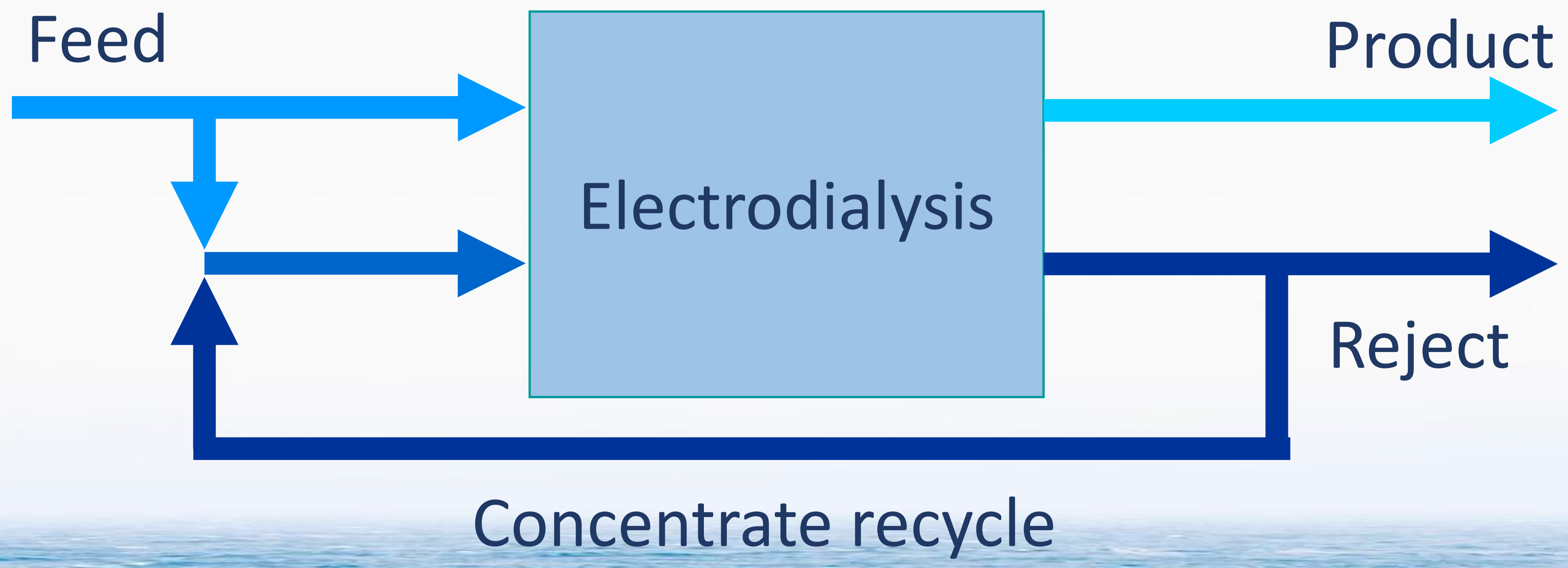
Application: Water Recovery

Possible applications:

- Water recovery in industries.
- Desalination & reuse of water for irrigation.
- Desalination of brackish (ground) water.

Process:



Case Study: Industriewater Eerbeek

REDSTACK
www.redstack.nl

Advanced wastewater treatment to upgrade process water for the paper industry.

Goal:

- Circular water system for paper production
- To replace the existing ground water extraction
- Saving 3,600,000 m^3 of ground water annually

www.waterrotonde.nl

Industrie water Eerbeek

nijhuis

nx filtration

PURE WATER GROUP

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Case Study: FT Equipment and Irrigation

REDSTACK
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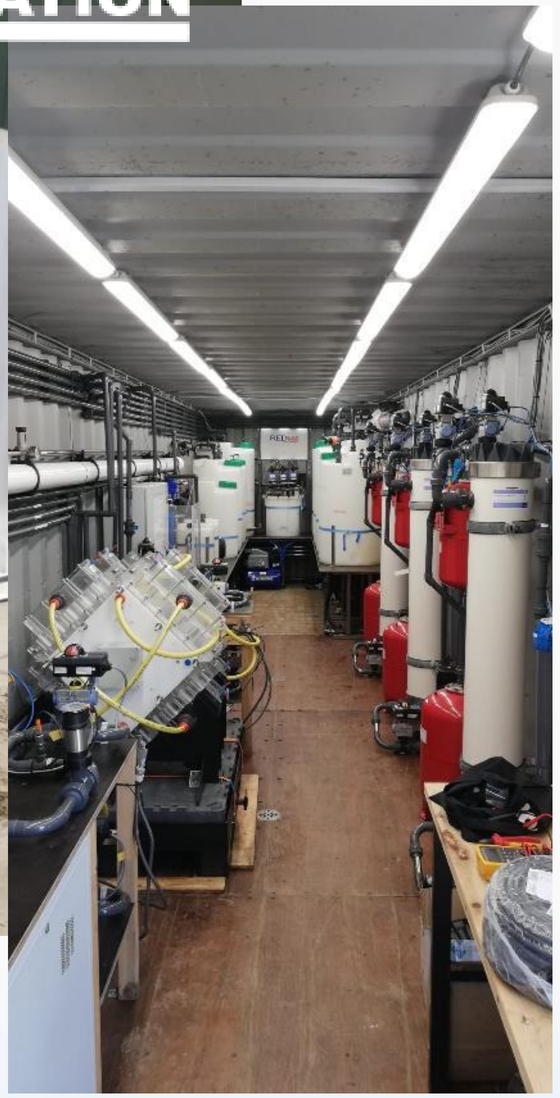
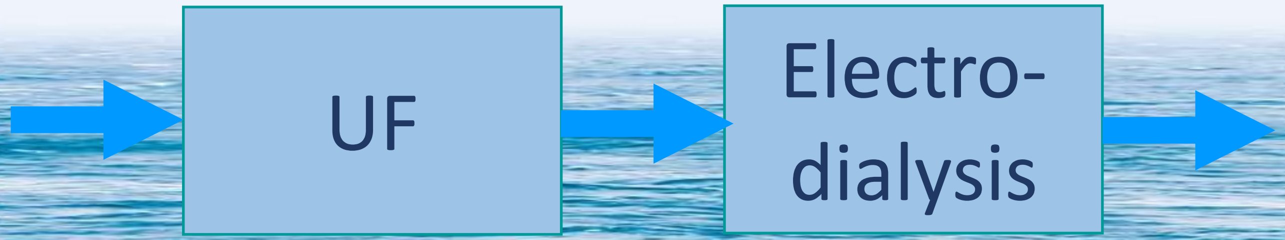
Desalination of brackish surface water for irrigation.

Goal:

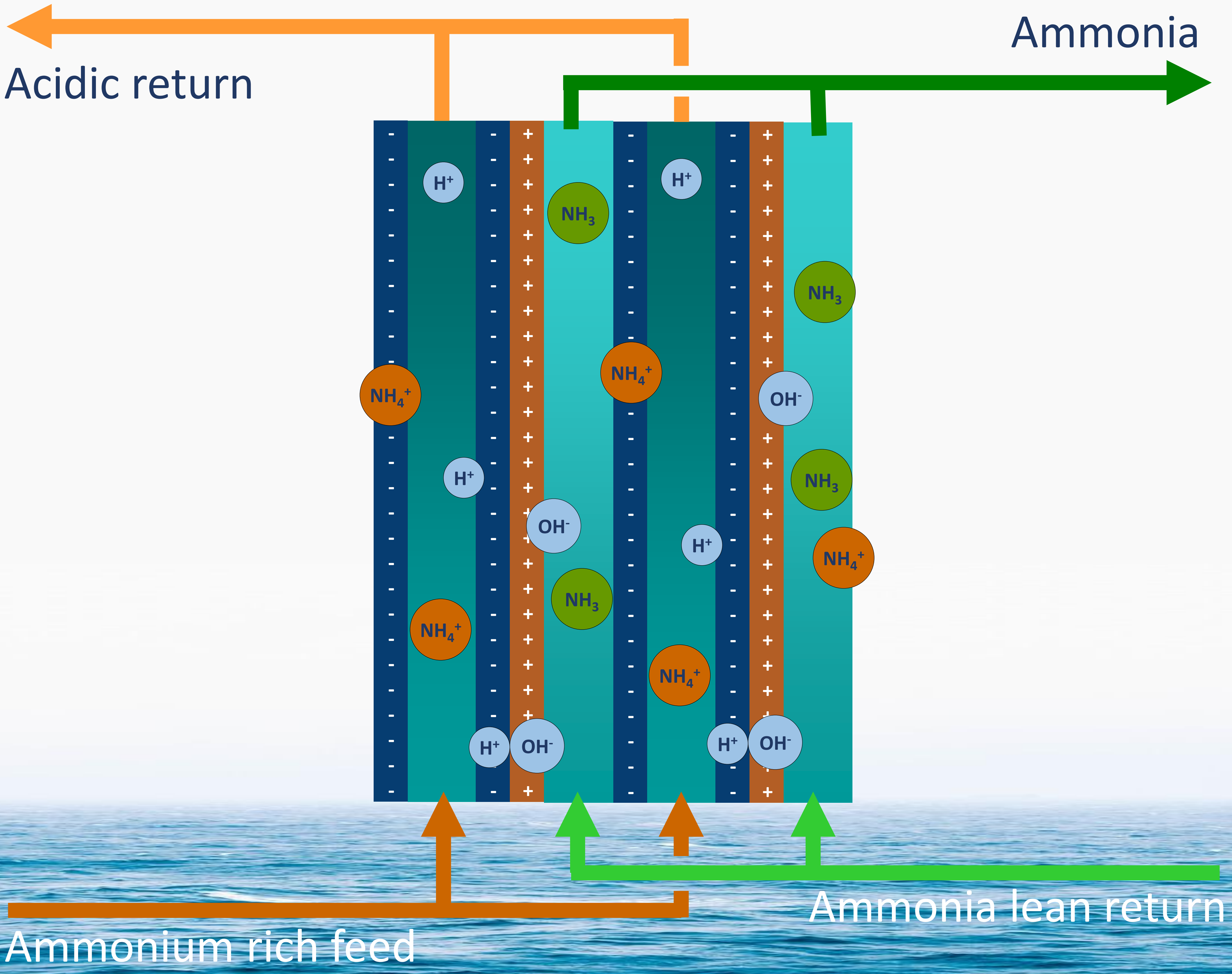
- Direct treatment of brackish water from ditches.
- Ensure sufficient water availability for agriculture.
- Avoiding the use of tap water or the transport of large volumes of water for irrigation during periods of drought.





Application: Nitrogen Removal

Process:



Possible applications:

- Treatment of ammonium rich solutions from air scrubbers.
- Direct treatment of ammonium rich streams

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Case Study: NoChemNAR

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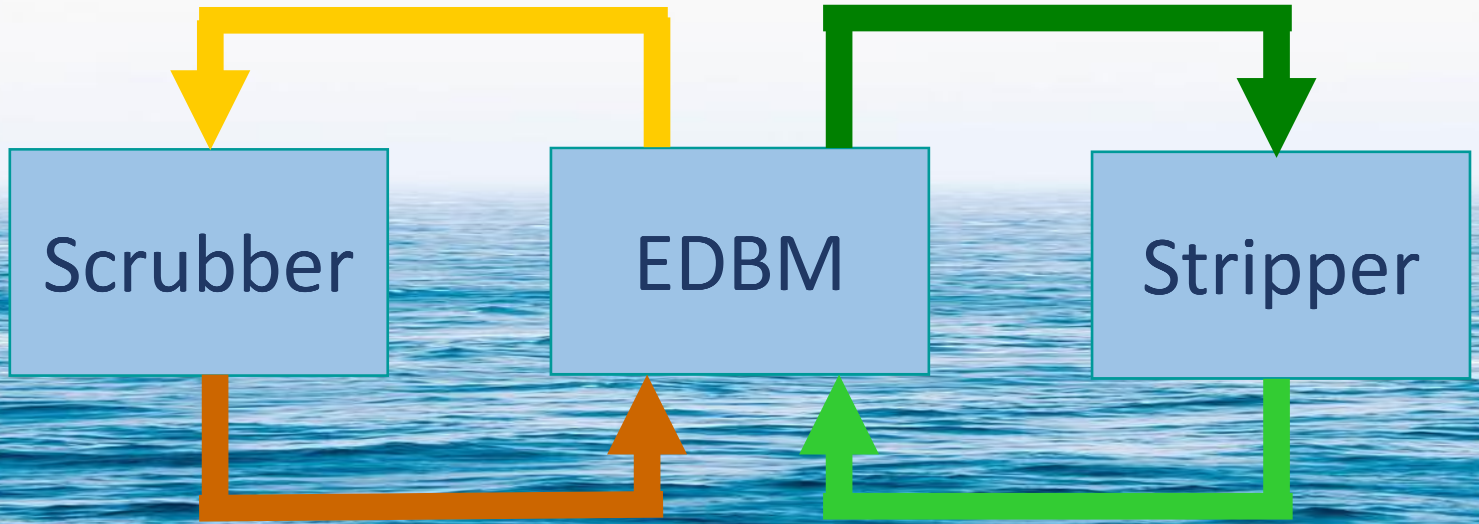
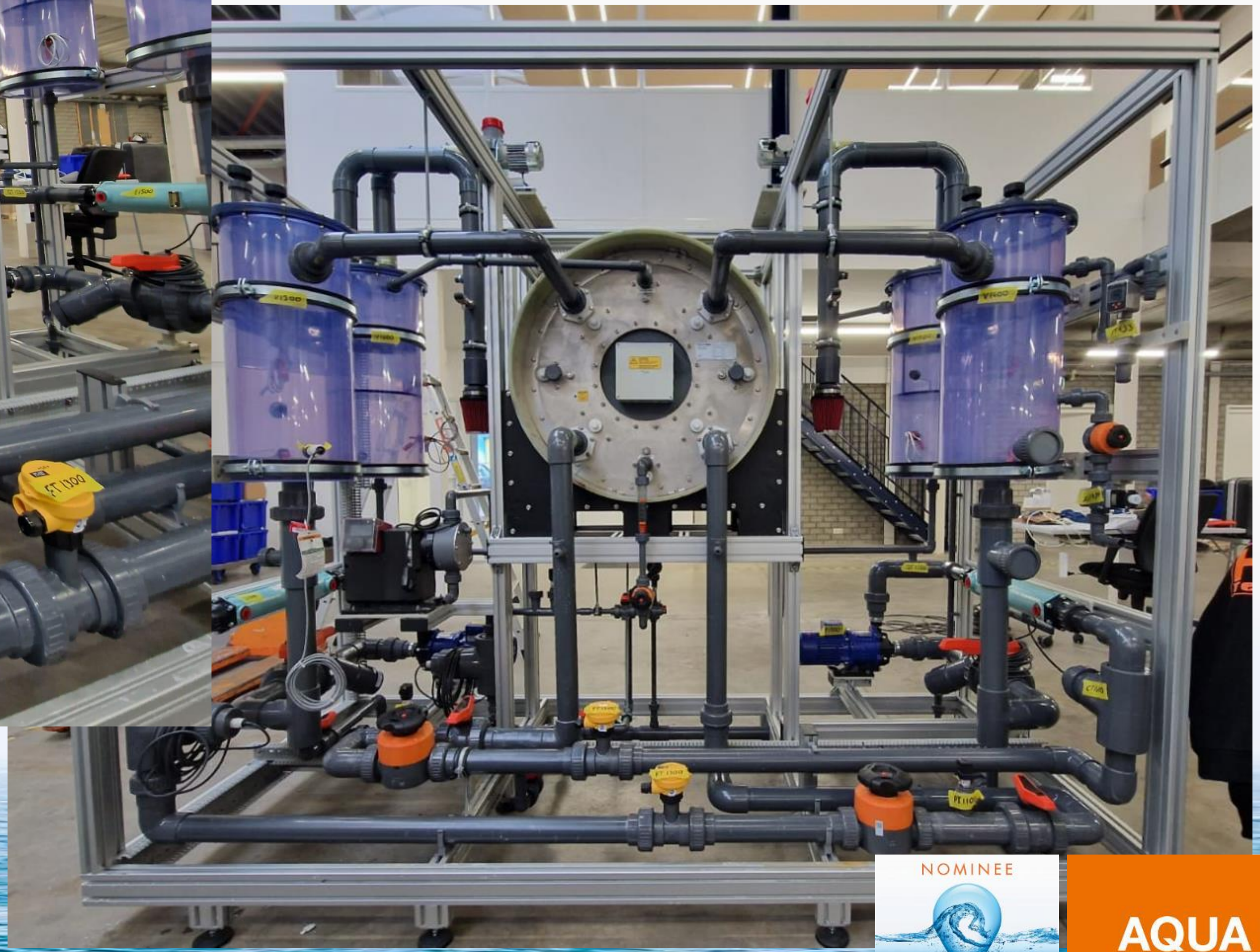
Recovery of nitrogen from digester at WWT-plant.

Goal:

- Recovery of ammonia from the ammonium rich solution coming from the scrubber.
- Return of the acidic (ammonium lean) solution to the scrubber.





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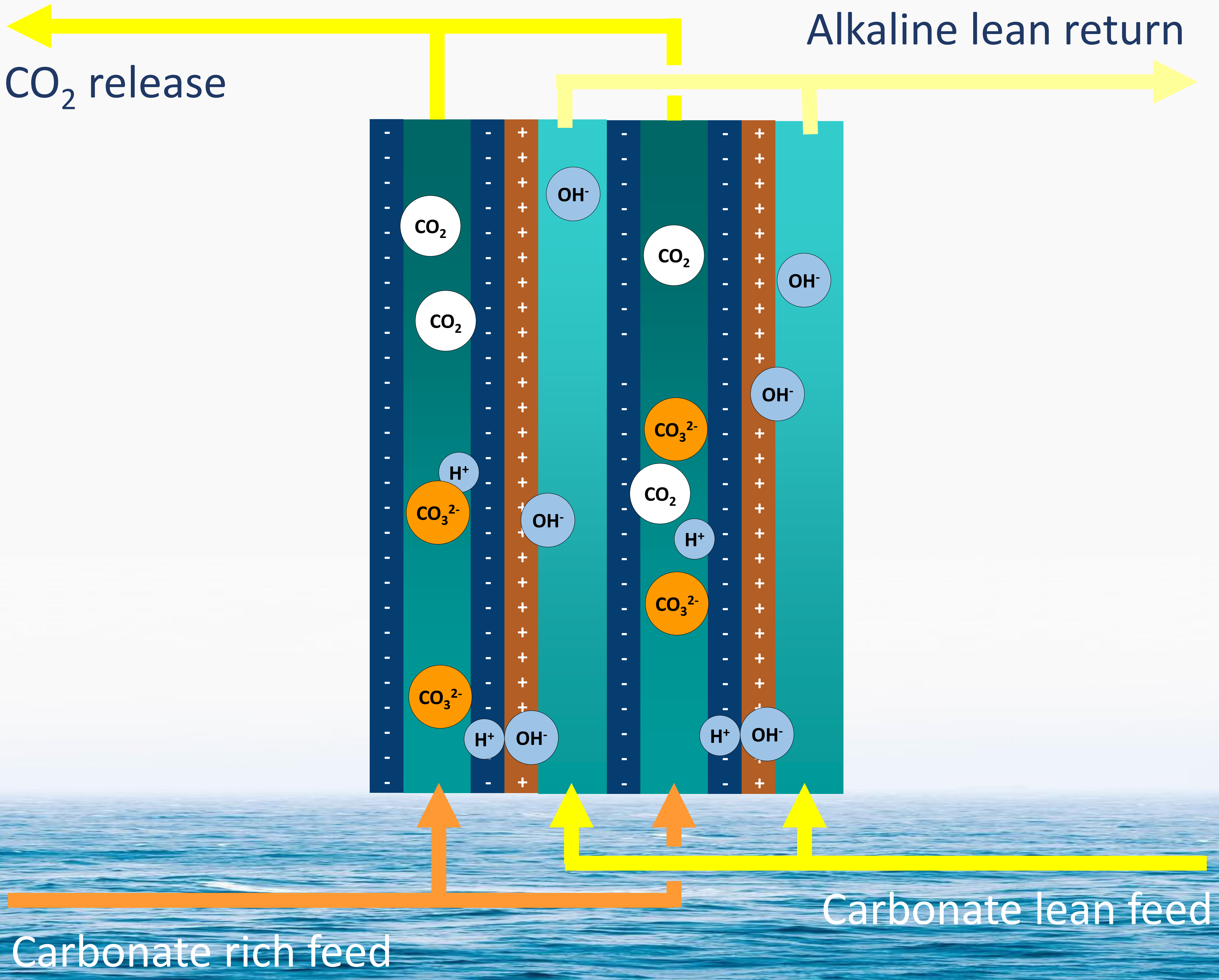
Application: Carbon Capture

Process:



Possible applications:

- CO_2 recovery form flue gass
- Direct air capture
- Oceanic CO_2 recovery

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Case Study: Concencus

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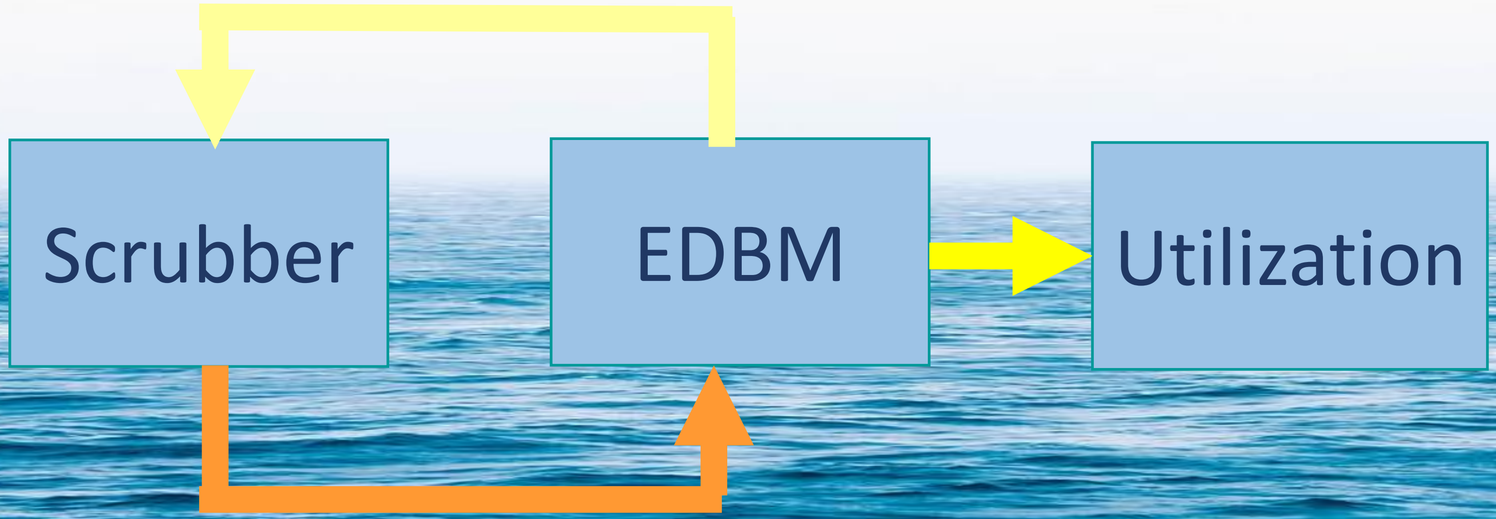
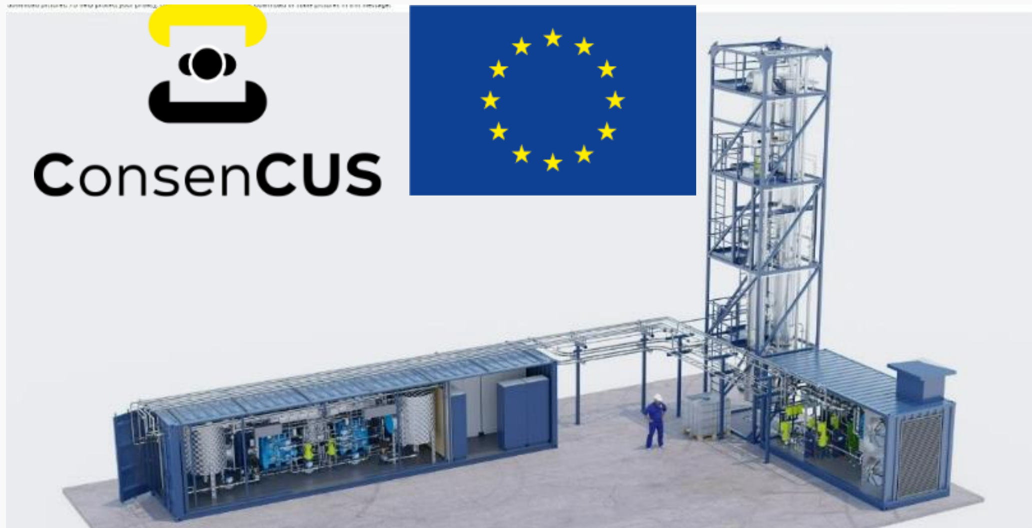
CO_2 capture from flue gas and utilization at three different locations in Europe. Starting at Aalborg Portland

Goal:

- Regeneration of the captured CO2 in the EDBM.
- Feed the CO2 to the utilization module to produce formic acid.
- Return the lean alkaline stream to the scrubber.





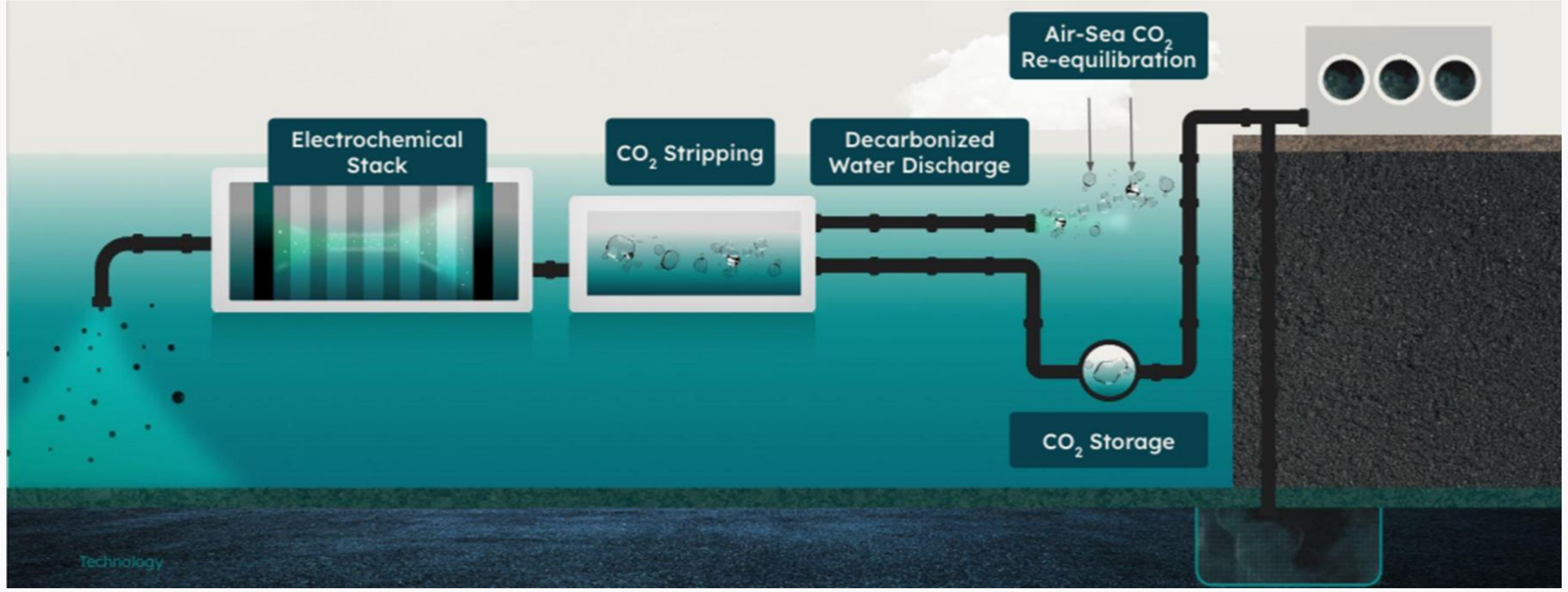
This project has received funding from the European Union’s Horizon 2020 research and Innovation programme under grant agreement N° 101022484.

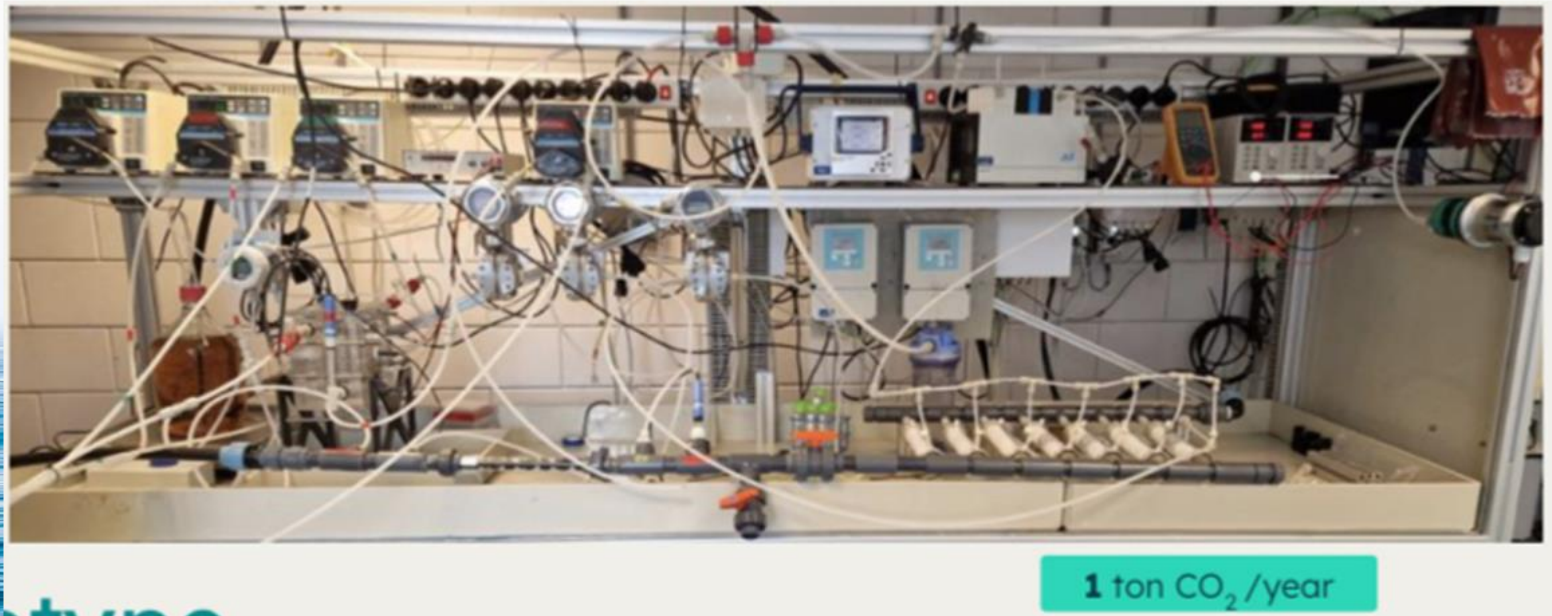
Case Study: SeaO2

Direct ocean capture of CO_2. Prototype in operation and preparing for pilot scale.

Goal:

- Capture CO2 from seawater, for CCS or CCU.
- To fight climate change and ocean acidification.
- Return the lean alkaline stream to the scrubber.





Prototype at the **Afsluitdijk**

Pilot plant under construction, due 2024

Application: Energy Recovery

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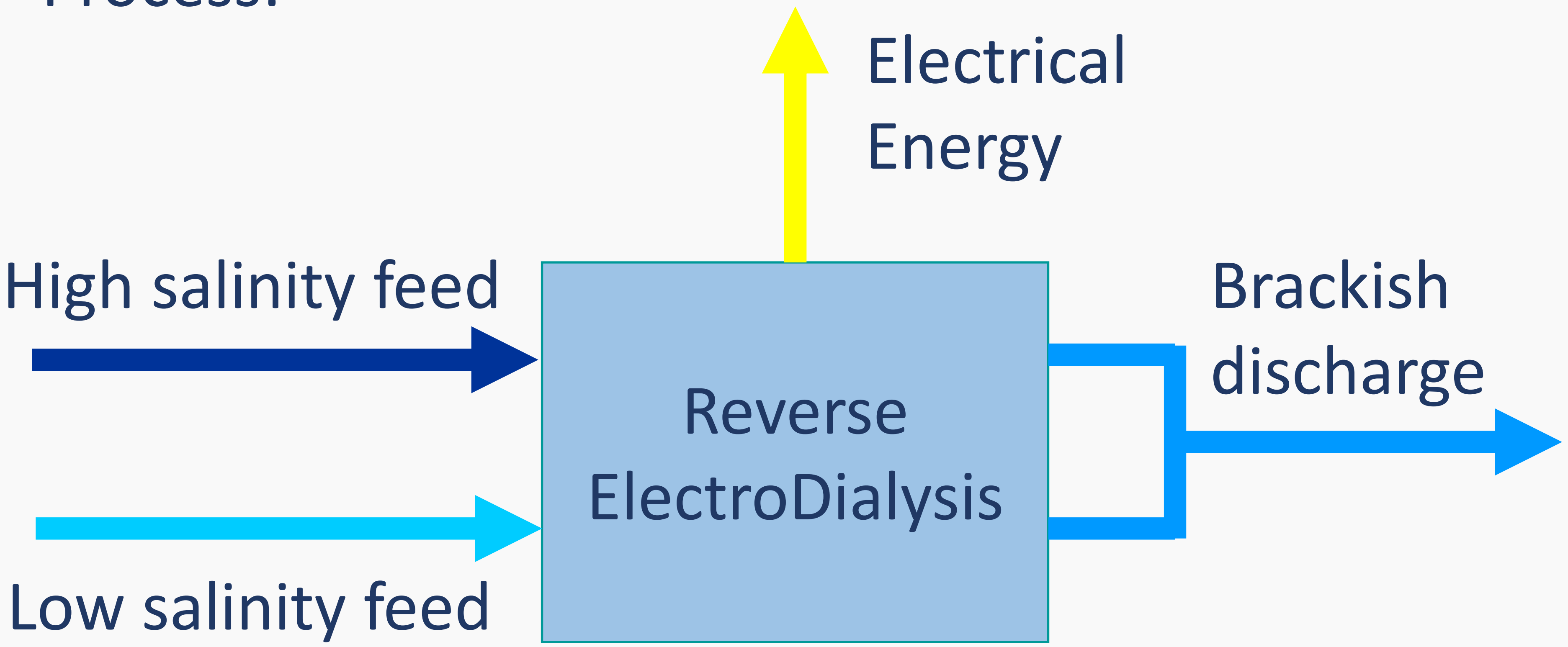
Possible applications:

- Energy production from seawater and fresh water
- Energy recovery from desalination brines
- Energy recovery in industries

Process:



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Case Study: HyReward

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Energy recovery from the salinity difference between SWRO brine and treated wastewater.

Goal:

- Recovery of energy in desalination.
- Increased overall water recovery.
- Reduced salinity of discharged brine.

HyReward

The LIFE HyReward Project has received funding from the LIFE+ Programme of the European Commission. LIFE HyReward LIFE20 CCA/ES/001783.

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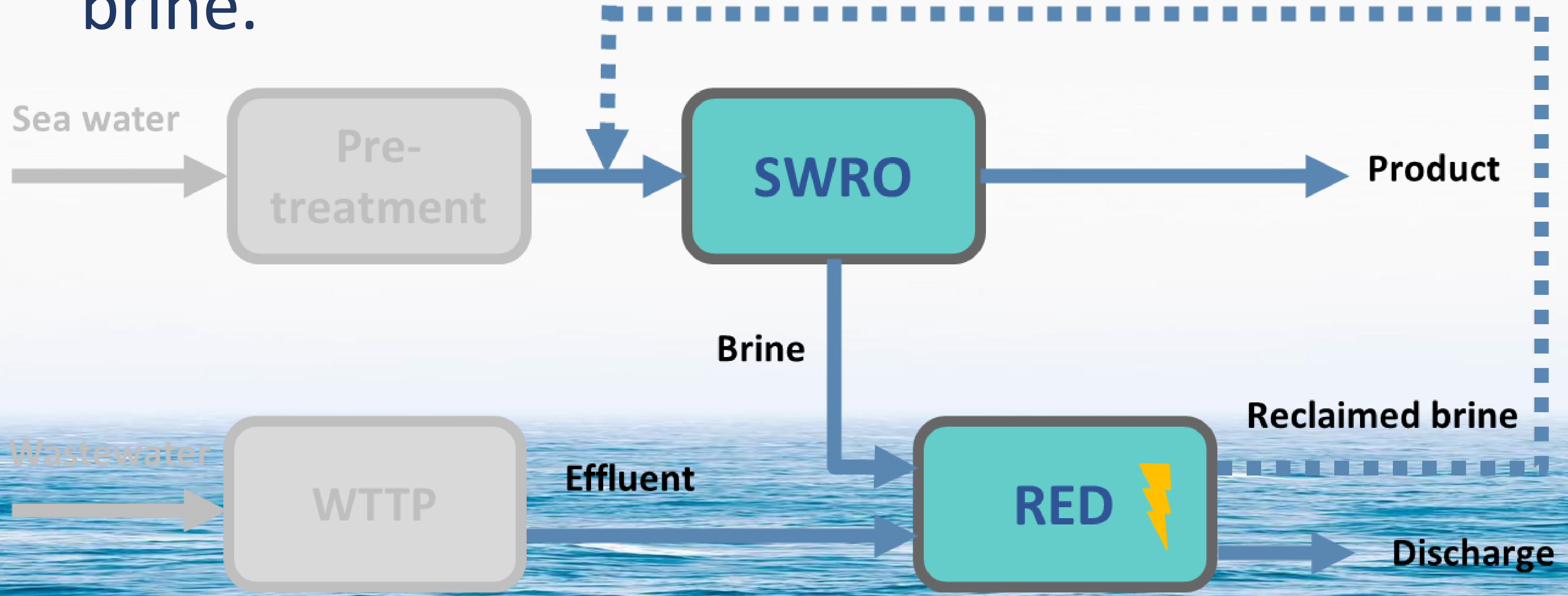

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Case Study: Indesal

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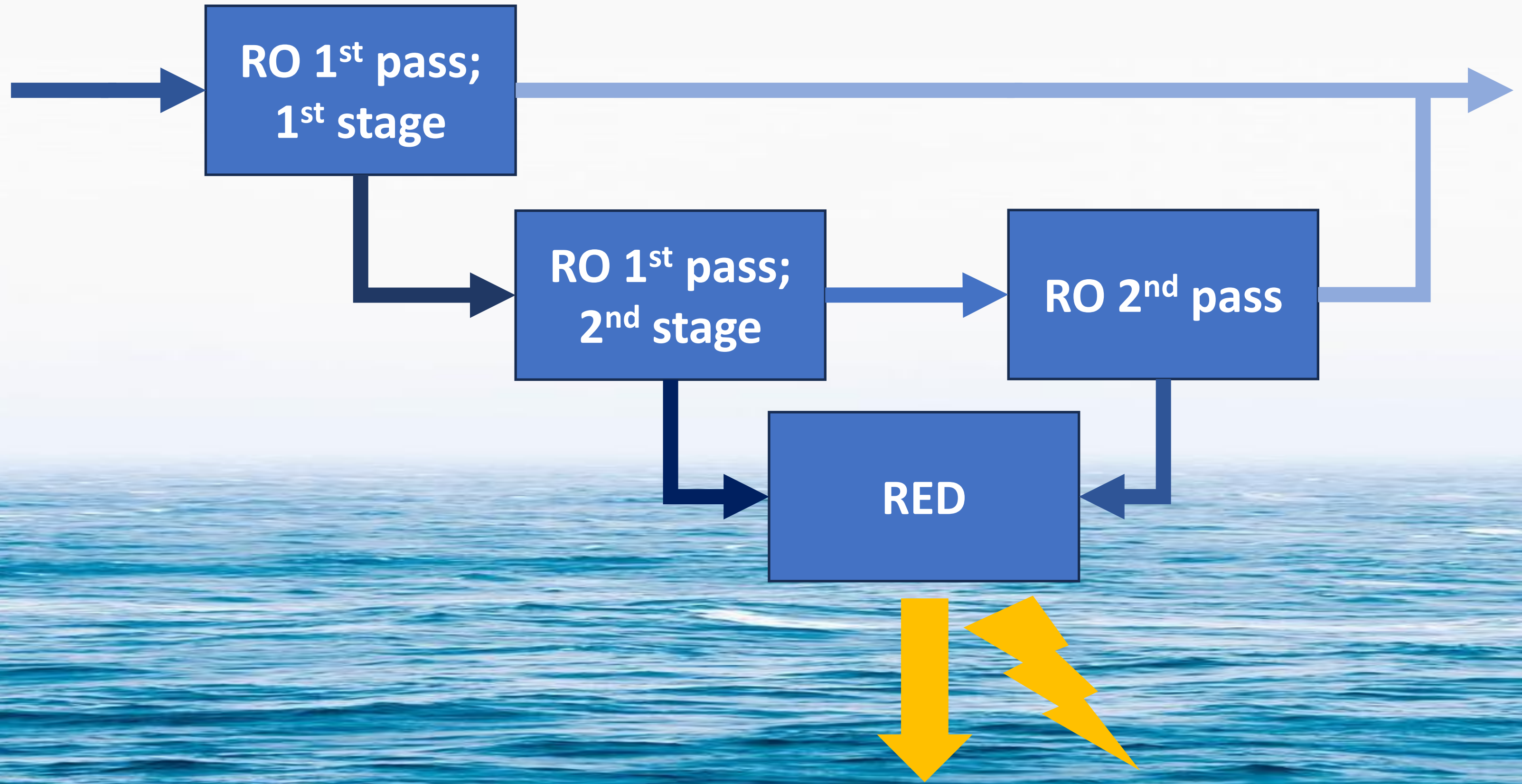
Energy recovery from a two pass LMS-RO process. Producing two rejects with a large difference in salinity.

Goal:

- Recovery of energy in desalination using RED.
- Recovery of chemicals from brine using EDBM.



INDESAL Life

Energy recovery from the salinity diffeCo-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

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Application: Energy storage and lithium recovery

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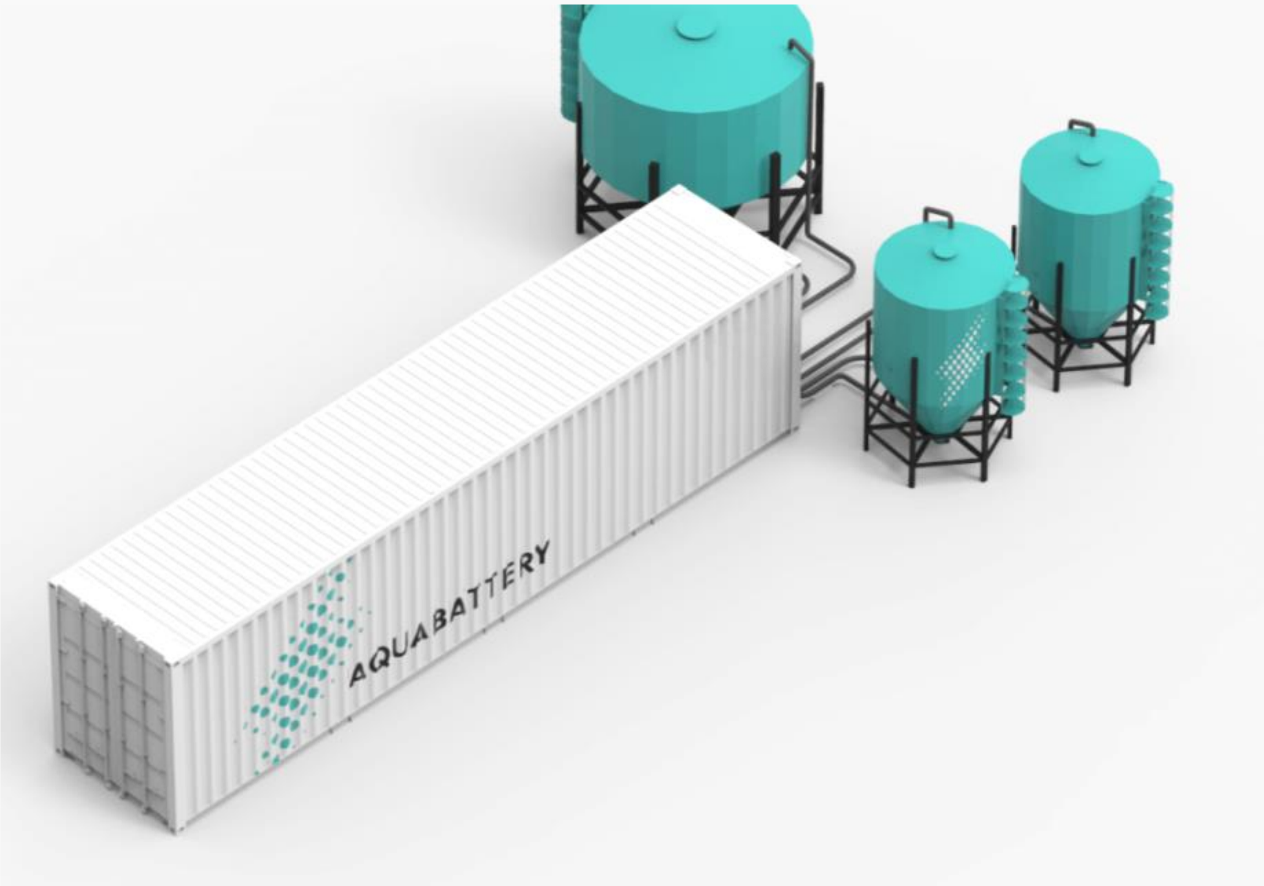
Energy storage:

- Salt battery using EDR / RED
- Acid / alkaline battery using EDBM

AQUABATTERY



Recovery of metal ions:

- Conversion of Li_2CO_3 to LiOH using EDBM

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Conclusions

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Application of ElectroMembrane stacks offer a new route by which water technology can:

- Help solve major environmental issues
- Tackle major opportunities
- And is capable of recovering valuable resources in the meantime

The potential of ElectroMembrane stacks is also recognized by industries.

- Winner of the Aquatech Innovation Award.

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Questions?

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Thank you for your Attention

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