

European Twinning for research in Solar energy to (2) water (H₂O) production and treatment technologies
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Sol2H2O



UNIVERSIDADE
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Università
degli Studi
di Palermo



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INSTITUTO TECNOLÓGICO
DE CANARIAS



Gobierno
de Canarias

Fast Track School #2

**Beyond State of the Art in Solar-driven Water production &
Treatment technologies and brine treatment processes**

POZO IZQUIERDO, GRAN CANARIA, 25.26.09.2024

Sol2H2O



Ángel Rivero Falcón

Beyond SoA SWRO desalination brines valorization (DBV)

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DESAL+ LIVING LAB

Brine valorisation
open testbed



FORWARD OSMOSIS

Pilot plant
Results



NANOFILTRATION

Pilot plant
Results



BRINE CONCENTRATION

Pilot plant (OARO)
Results



ROADMAP

ZLD
New ITC tender

CONTENT

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DESAL+
DESALINATION
LIVING LAB

DESAL+ LIVING LAB

Canary Islands (Spain)



DESAL+ LIVING LAB



Fully-equipped public-private **ecosystem**



Cooperation | **Research** | Development | **Innovation** |
Validation Water desalination solutions with **renewable energies**

Since
2017
offering

A leading hub of skills and innovation in
desalination and water-energy nexus

R&D Projects
Equipment
Space, facilities & infrastructure



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DESAL+ LIVING LAB LOCATIONS

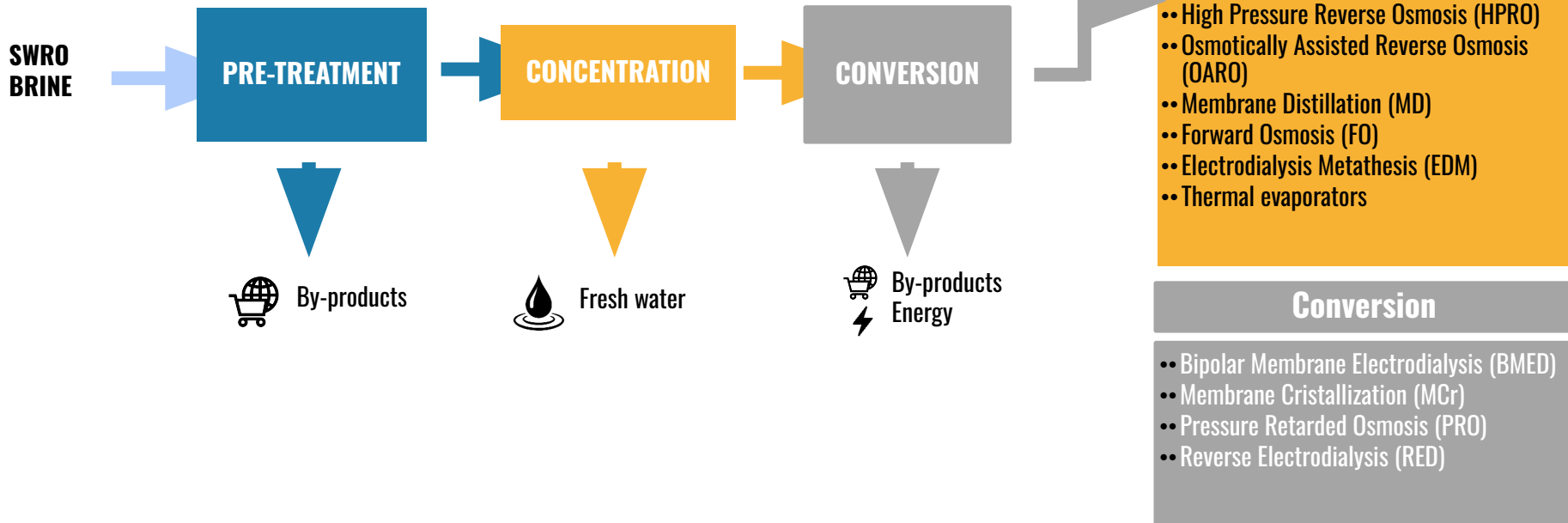


Infrastructure mainly in **Gran Canaria** and **Tenerife**, in the Canary Islands.

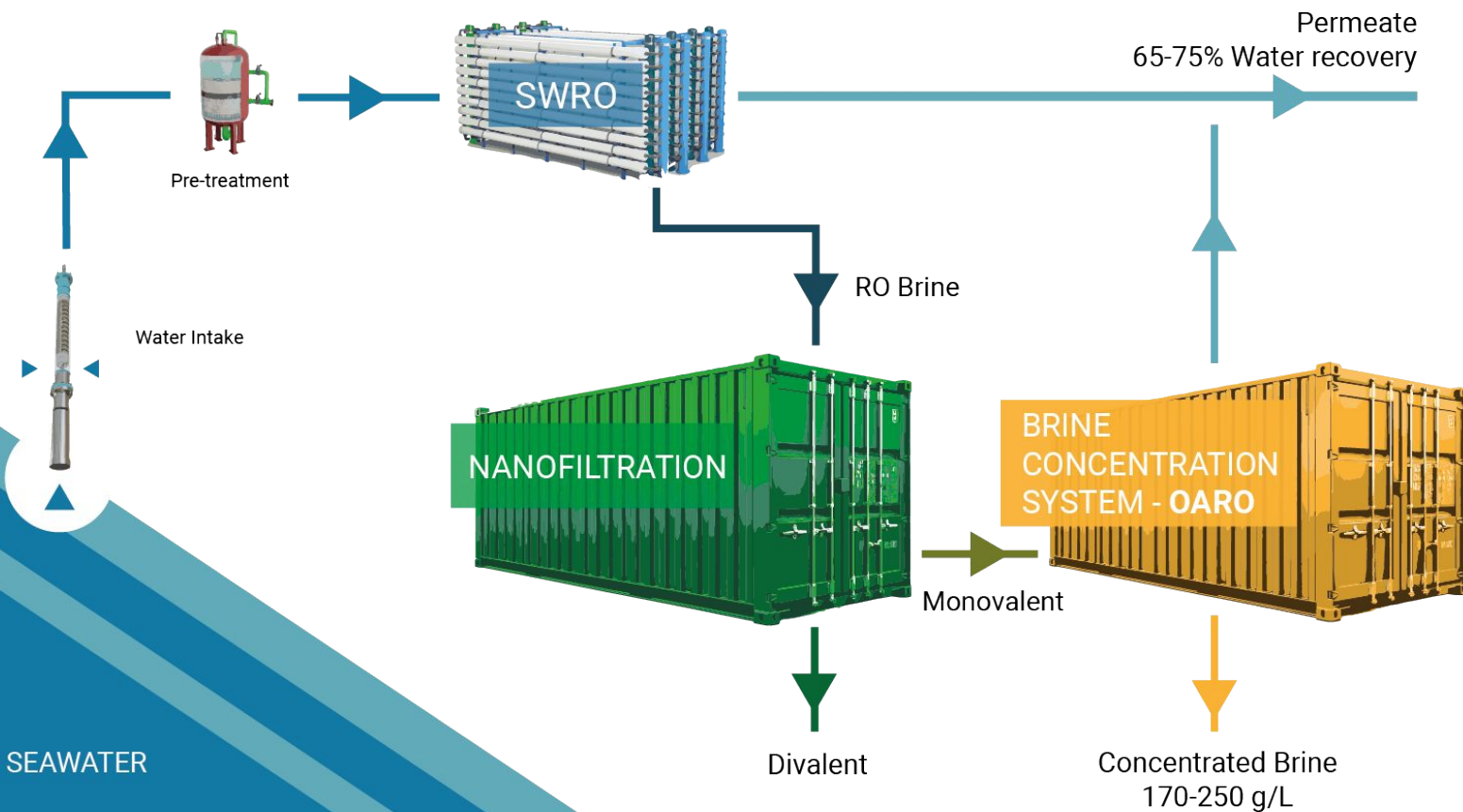
But also in **Cape Verde, Senegal, Mauritania, etc.**



GENERIC BRINE VALORISATION PROCESS DIAGRAM



CURRENT BRINE VALORISATION PROCESS





Canary Islands Institute of Tehcnology (ITC)
 DESAL+ LIVING LAB
 POZO IZQUIERDO
 Gran Canaria (Canary Islands, Spain)

BRINE VALORISATION OPEN TESTBED FACILITIES

Brine from

Mancomunidad Sureste SWRO
 2-Stage - 55% recovery

DESALRO 2.0
SWRO PLANT

DESAL+ SWRO
PLANT

BRINE CONCENTRATION
PLANT

NF PLANT

DEMONSTRATION PLOT for
 brine concentration and brine
 valorisation technologies

SW BEACH WELLS

FORWARD OSMOSIS PLANT
 5-10 m³/d

DESALRO 2.0

2500 m³/d SWRO
 40% recovery
 SEC = 1.85 kWh/m³

DESAL+

100 m³/d SWRO
 40% recovery
 SEC = 2.00 kWh/m³

NANOFILTRATION

Separation between
 monovalent and divalent ions
 140 m³/d (feed)

BRINE CONCENTRATION

OARO Technology
 40 m³/d (feed)

- Brine from Sureste
- Brine from DESALRO 2.0
- Brine from DESAL+
- NF Divalent
- NF Monovalent



BRINE VALORISATION OPEN TESTBED



Desalination brines

1-stage RO, 2-stage RO, NF, concentrated brine, FO



Research area to locate pilots, including **promising** and **disruptive** technologies



Simple and fast installations
Plug & play, pre-installed plot



Authorised **brine discharge** permit and support for project execution



Highly-qualified

ITC technicians and researchers



Variety of **renewable energy** technologies available



Special **tax deductions** for R&D projects



Support service for entrepreneurs and innovative companies

MAIN OBJECTIVES

Boost R&D with a high level technical location focused on applied research using actual desalination brines

Engage companies with pre-market solutions

Promote our testing site for International and private Project proposals



DESAL+
DESALINATION
LIVING LAB

DESAL+ LIVING LAB

POZO IZQUIERDO
Gran Canaria (Canary Islands, Spain)



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FORWARD OSMOSIS

Pilot plant

Results

FORWARD OSMOSIS

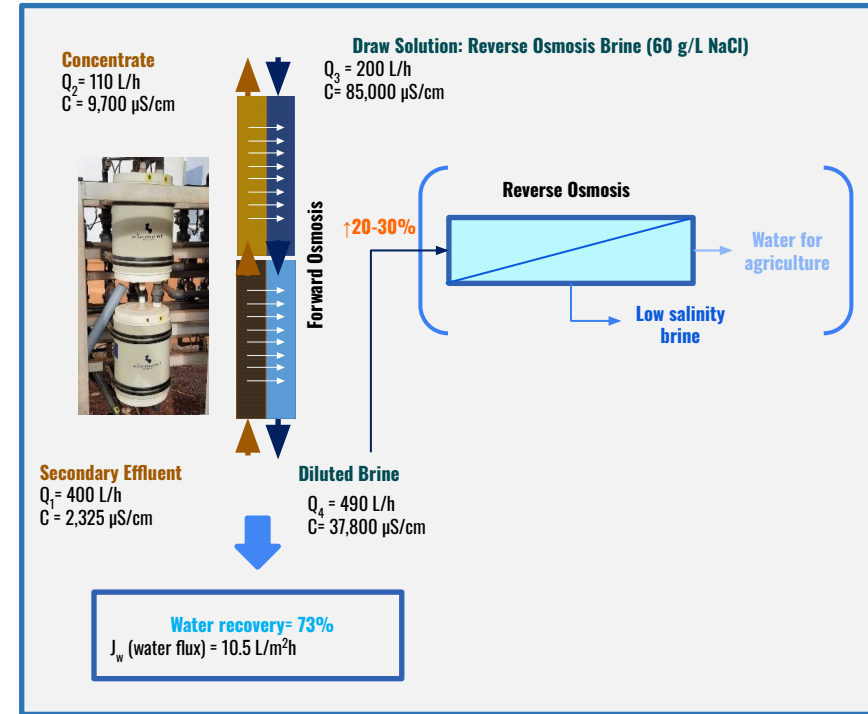
First pilot plant of Forward Osmosis in Macaronesia.

Two inlets:

- Draw solution: Real RO brine (1-stage or 2-stage RO)
- Feed solution: Effluent from the secondary treatment of a wastewater treatment plant

Results:

- Increase in overall water recovery (20-30 %)
- Reduction in discharge volume ($\approx 73\%$)
- Integration of circular economy concept
- FO as pre-treatment of RO (less fouling and first barrier against contaminants)
- Improved water quality for agriculture. Rejection values:
Ammonium = 50%, Nitrate = 88%, Sulphate > 90%, Boron > 90%

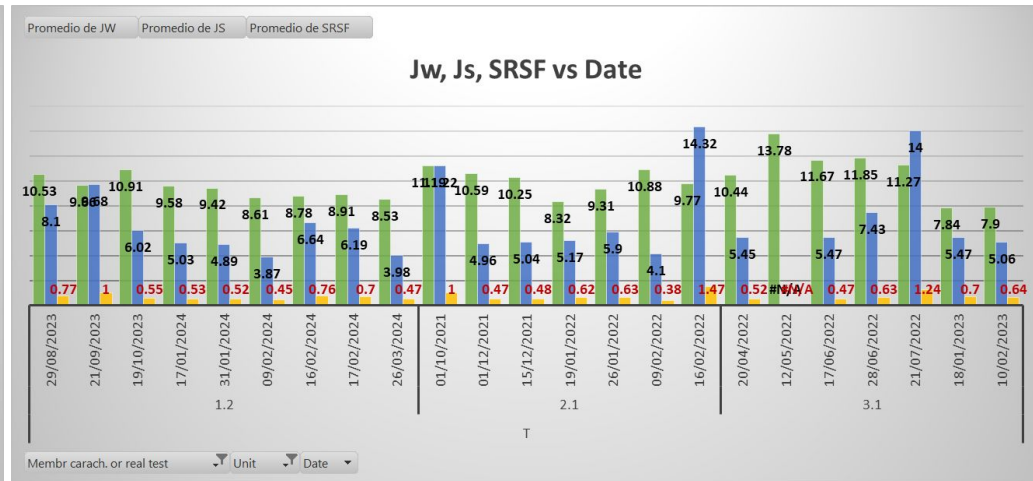
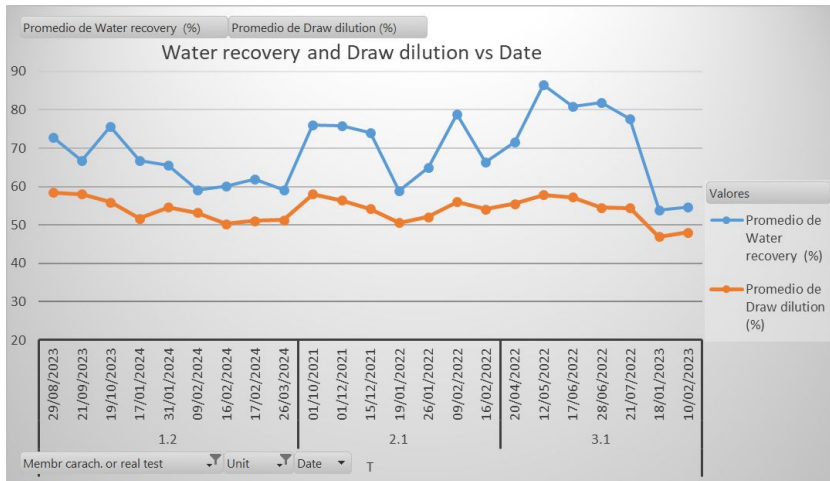


FORWARD OSMOSIS

This pilot plant **increases the research infrastructure in the Canary Islands.**

Researchers can carry out studies and tests seeking to increase existing knowledge on brine treatment emerging technologies.

Sinergies with wastewater treatment plants and **biotechnology.**



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NANOFILTRATION

Pilot plant

Results

NANOFILTRATION

- Membrane technology which allows separation of monovalent and divalent ions, applying less than 25 bar
- Pre-treatment of SWRO brines in brine valorisation processes, reducing risk of scaling
- Purification of NaCl in the monovalent-rich stream and concentration of high-value Mg in the divalent-rich stream
- No residues generated



	Water	Monovalent Ions	Multivalent Ions
Ultrafiltration			
Nanofiltration			
Reverse Osmosis			

NF PILOT PLANT

Possible configurations:

Feed flow = 3 – 6 m³/h

Number of membranes:

- 3 membranes
- 4 membranes
- 7 membranes



TORAY

Innovation by Chemistry

TORAY/CSM

NE8040-40 MEMBRANES

High productivity NF element



Different brines as input:

1-stage RO (64,000 mg/L TDS)

2-stage RO (77,000 mg/L TDS)



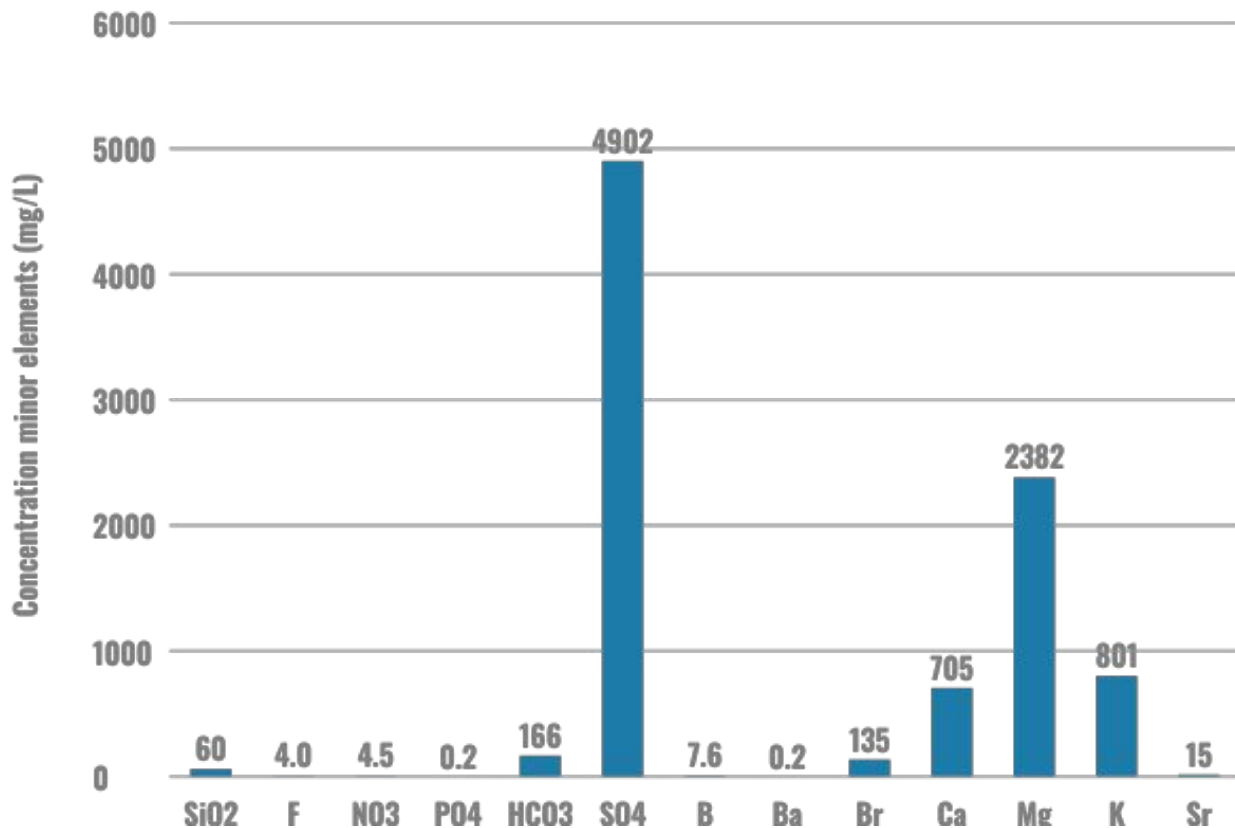
Regulation:

Recovery (%)

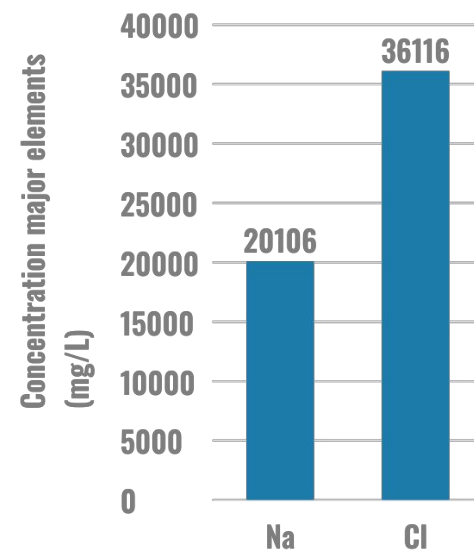
Divalent recirculation (%)



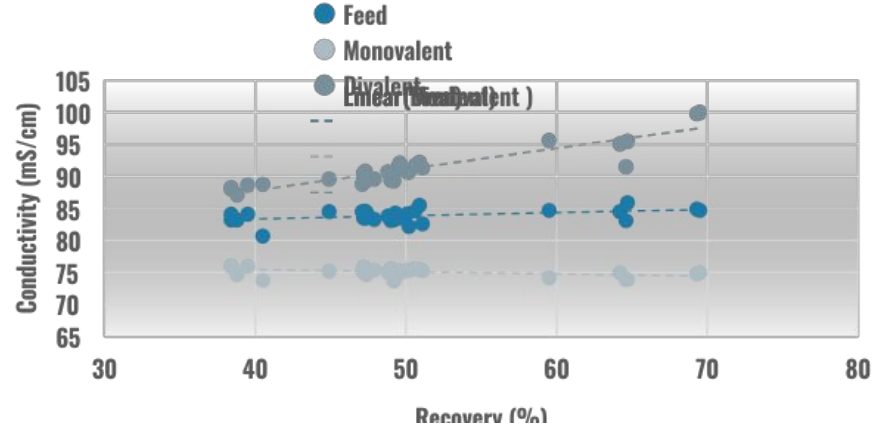
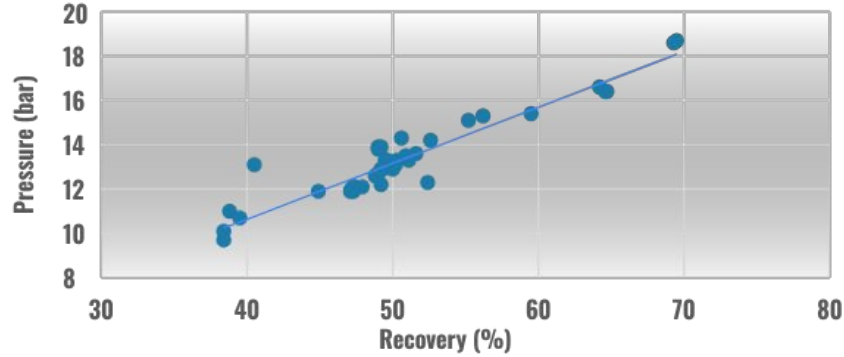
CHEMICAL COMPOSITION – NF FEED



Feed conditions	Value
Flow	6.0 m ³ /h
Concentration	64-65 g/L
Conductivity	83-85 mS/cm
Temperature	24-25 °C
pH	7.1
N ^o of membranes	7

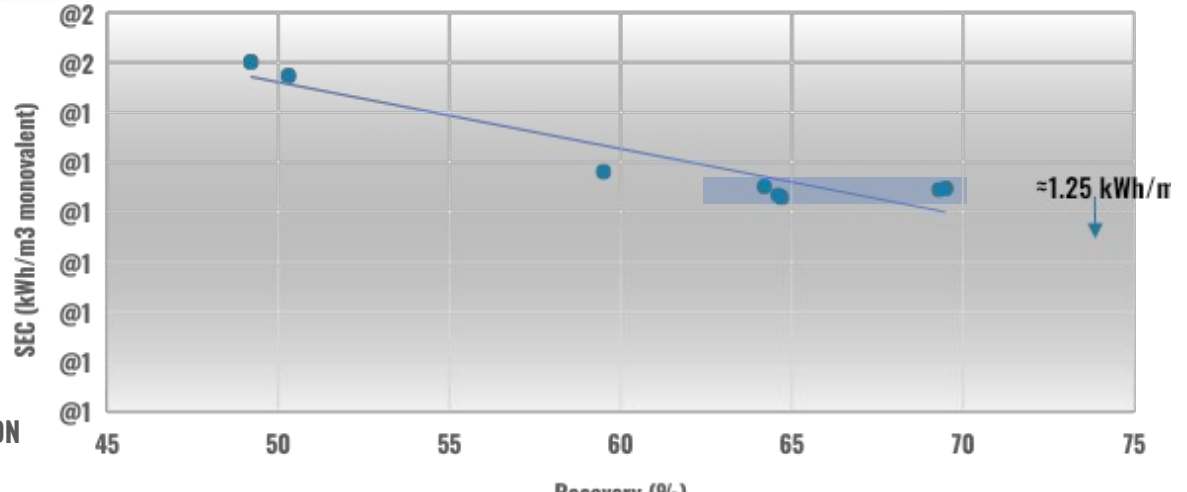


RESULTS – NF



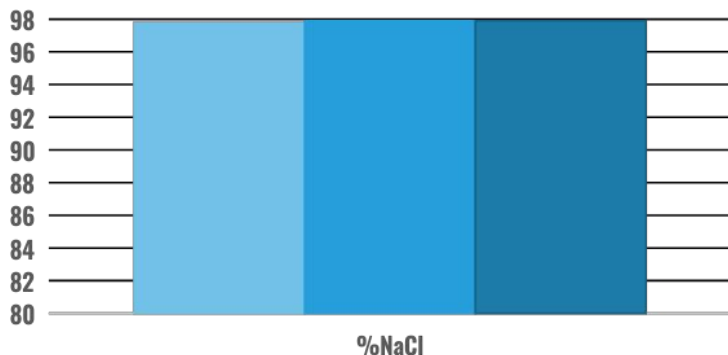
Robust system with replicable data and low energy consumption
(Considering Feed pump + HPP without ERD)

ENERGY CONSUMPTION

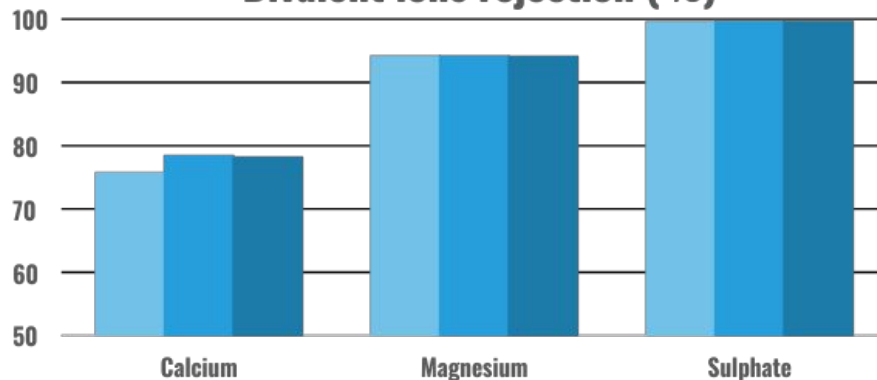


RESULTS – NF

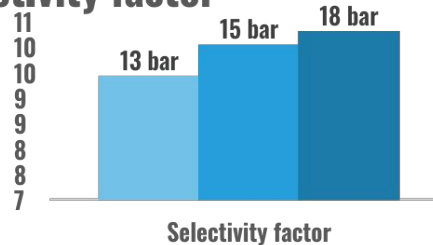
%NaCl in monovalent stream



Divalent ions rejection (%)



Selectivity factor



$$S = \frac{100 - \%R_{monov}}{100 - \%R_{div}}$$

Results compared to other pilot plants:

- ✓ Higher purity of NaCl
- ✓ Increased rejection of divalent ions
- ✓ Better selectivity of monovalent and divalent ions

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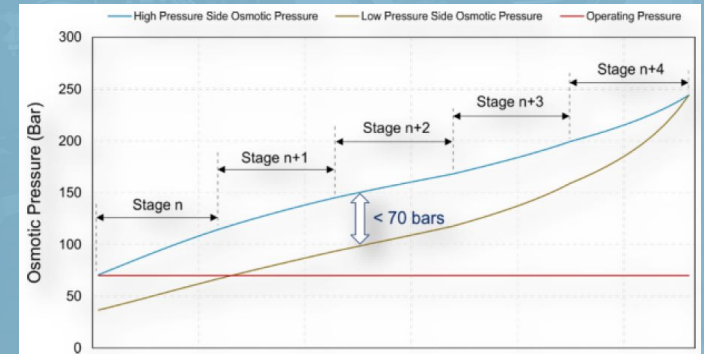
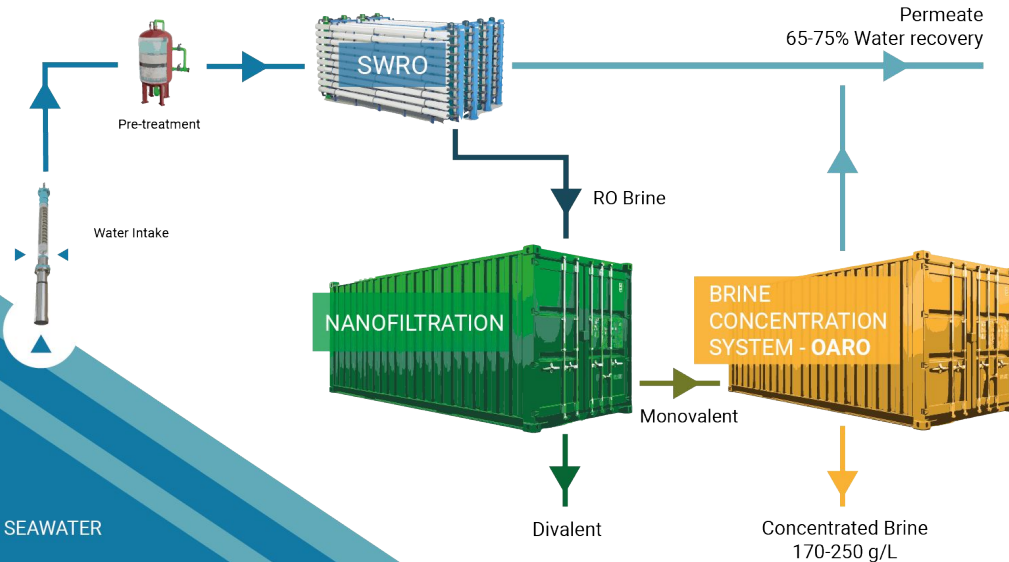
BRINE CONCENTRATION

Pilot plant (OARO)

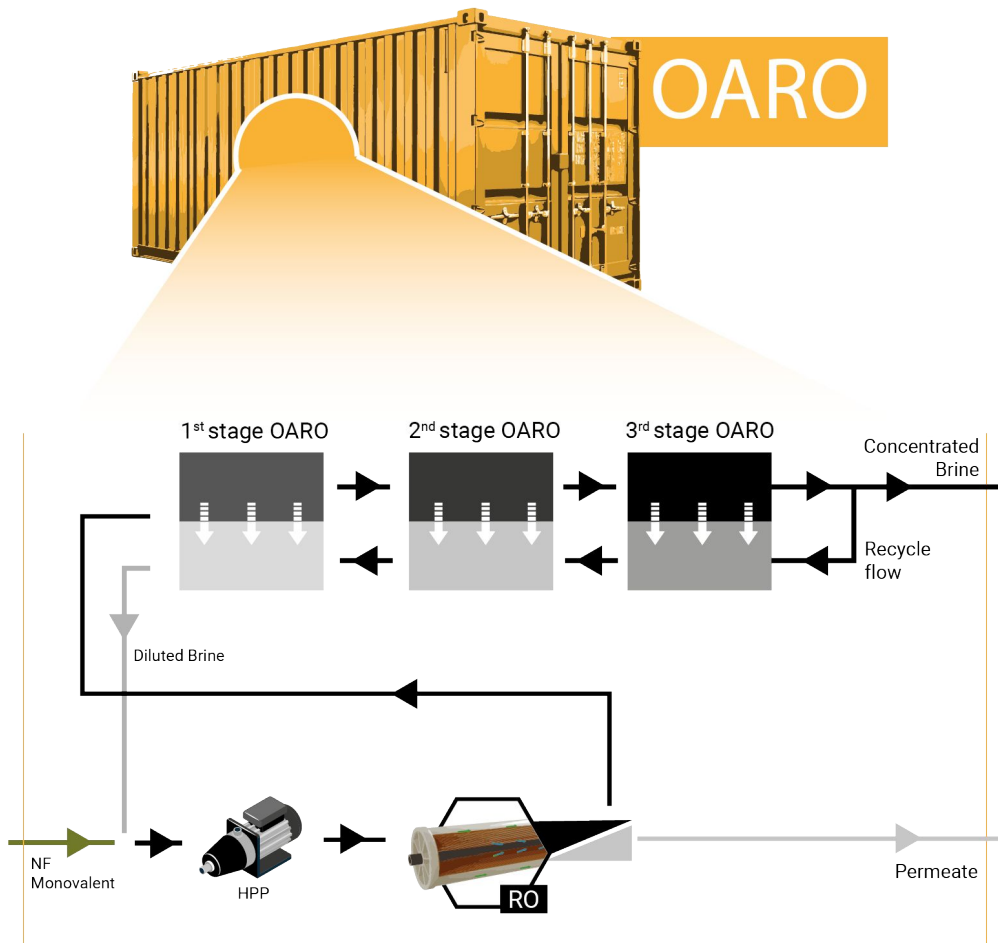
Results

BRINE CONCENTRATION – OARO

- Membrane technology which allows high concentrations, applying less than 70 bar
- High concentration of SWRO brines to nearly saturated concentration in a system of various stages using only one high pressure pump
- High system recovery (75-85%) increasing global fresh water production
- Lower energy consumption than conventional thermal systems



Operating principle of OARO process (Hyrec)



OARO PILOT PLANT

Description:

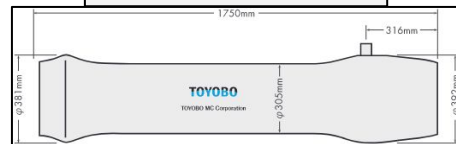
Feed flow = 1.3 – 2.4 m³/h

Membranes:

- 1-stage RO
- 3-stage OARO



TOYOBO FB10155S SERIES
Hollow fiber membranes



Different brines as input:

Depending on NF pilot plant configuration and RO brine used



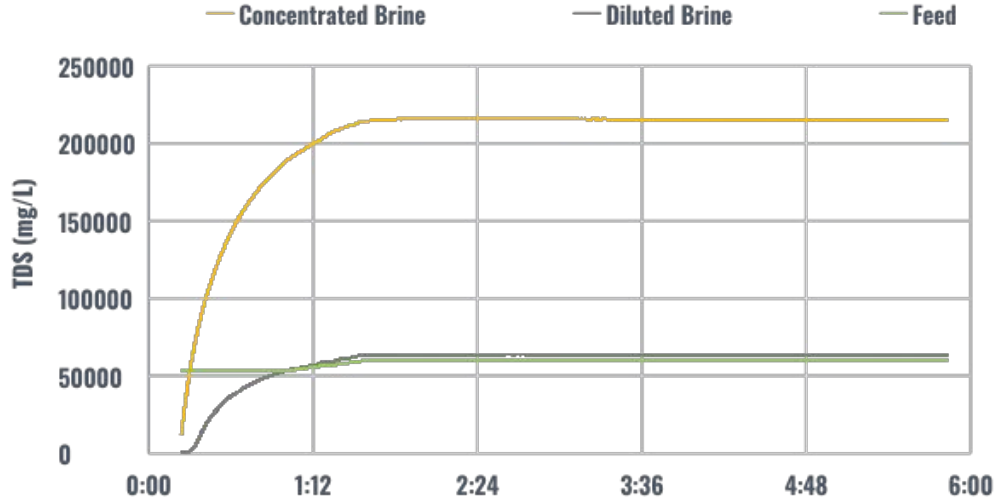
Regulation:

Pressure (bar)

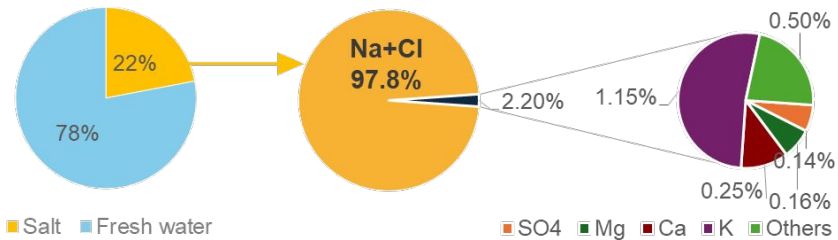
Concentrated brine recirculation (%)



RESULTS - OARO

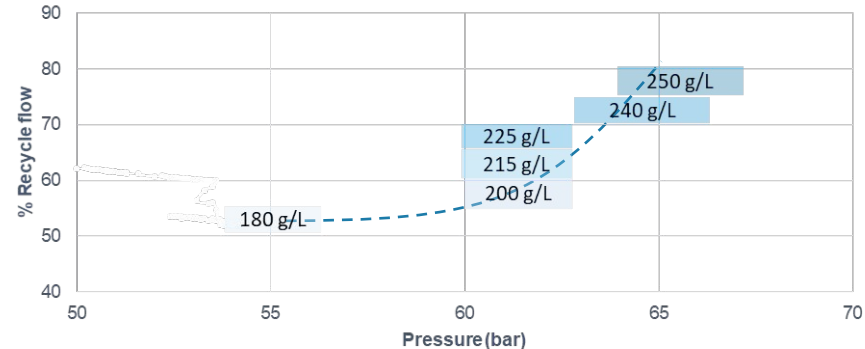


Chemical composition of concentrated brine: 225,000 mg/L

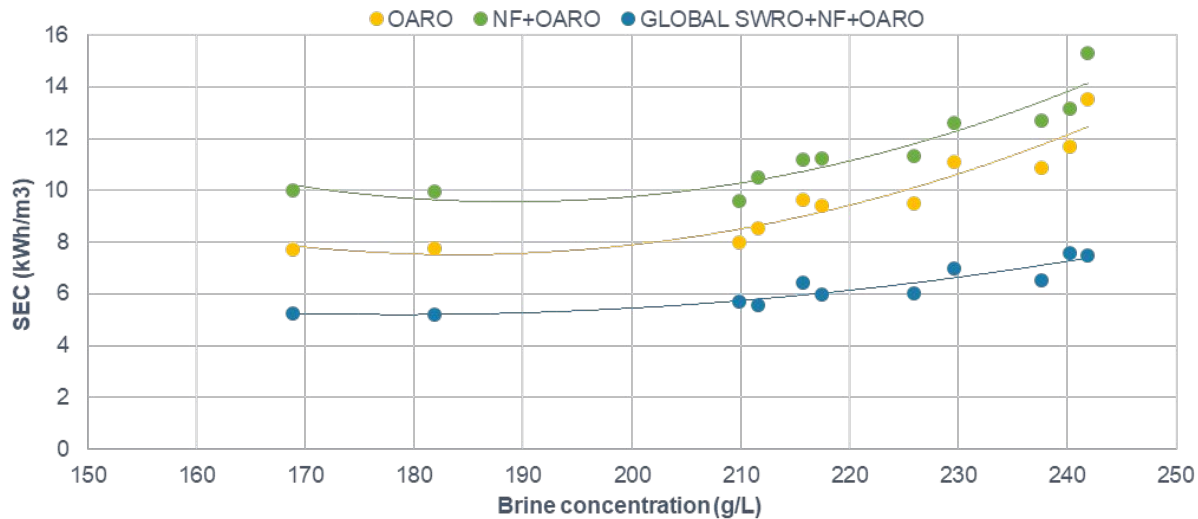
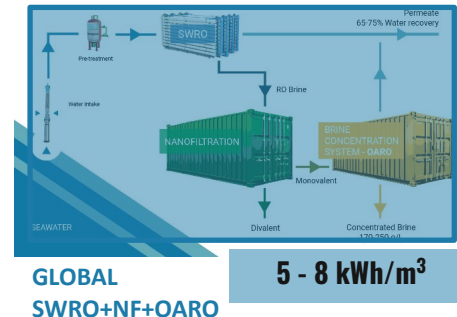
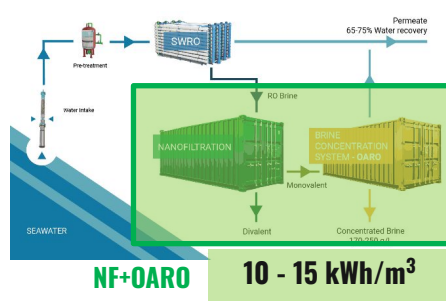
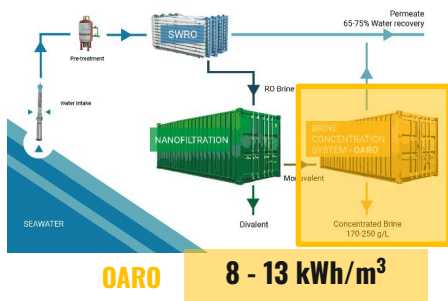


TESTING CONDITIONS – OARO

Feed conditions	Value
Flow	1.35 - 2.45 m ³ /h
Concentration	53 – 55 g/L
Conductivity	73 - 75 mS/cm
Temperature	24 - 25 °C
pH	7.2 - 7.3
Nº of OARO stages	3



SPECIFIC ENERGY CONSUMPTION



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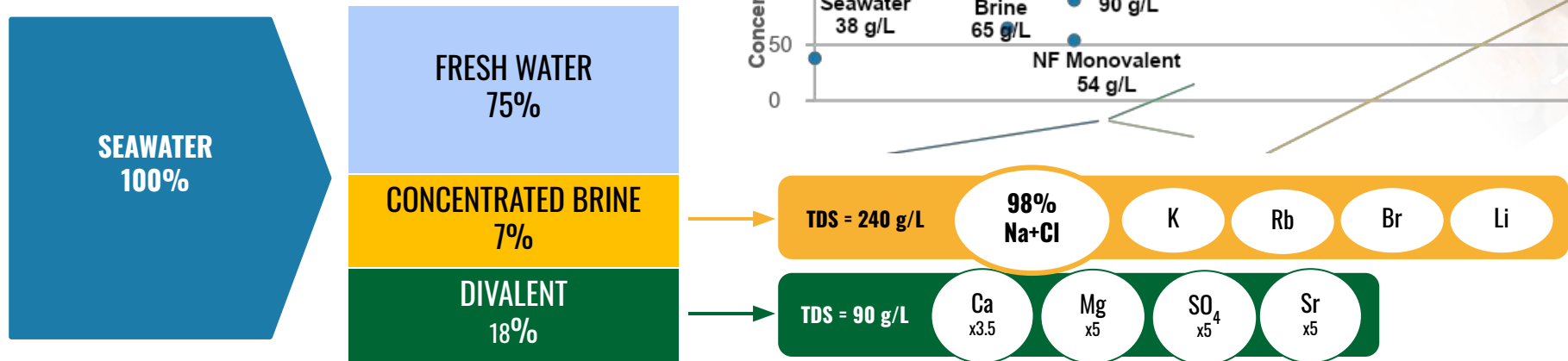


ROADMAP

ZLD

New tender - ITC

SYSTEM TOWARDS ZERO LIQUID DISCHARGE (ZLD)



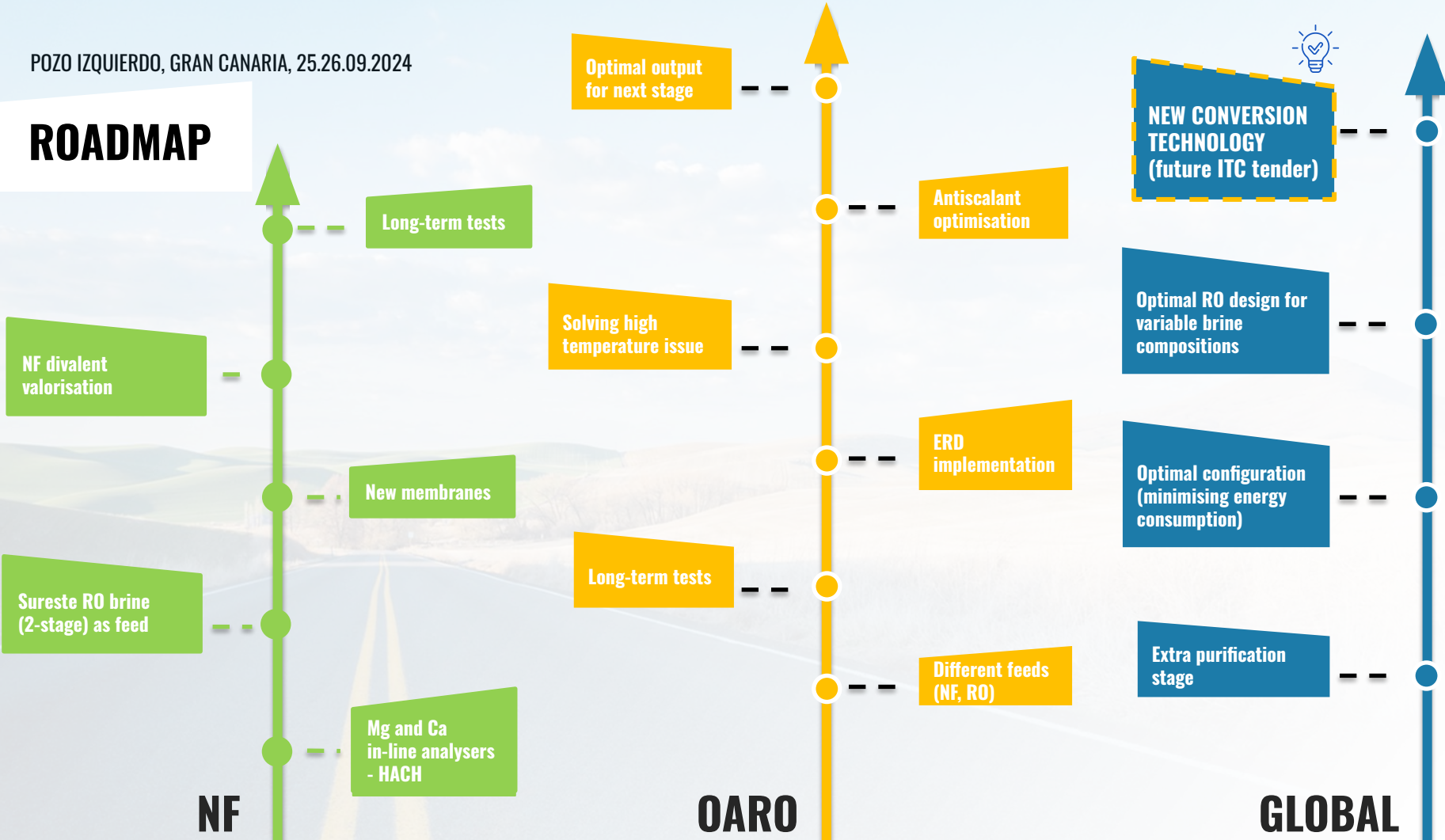
Increase water production compared to traditional SWRO system

Production of high-concentrated brine with high-purity NaCl

Production of a concentrated product valuable for other industries

Valorizing high-value minerals from SWRO brine

ROADMAP



NF

OARO

GLOBAL

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