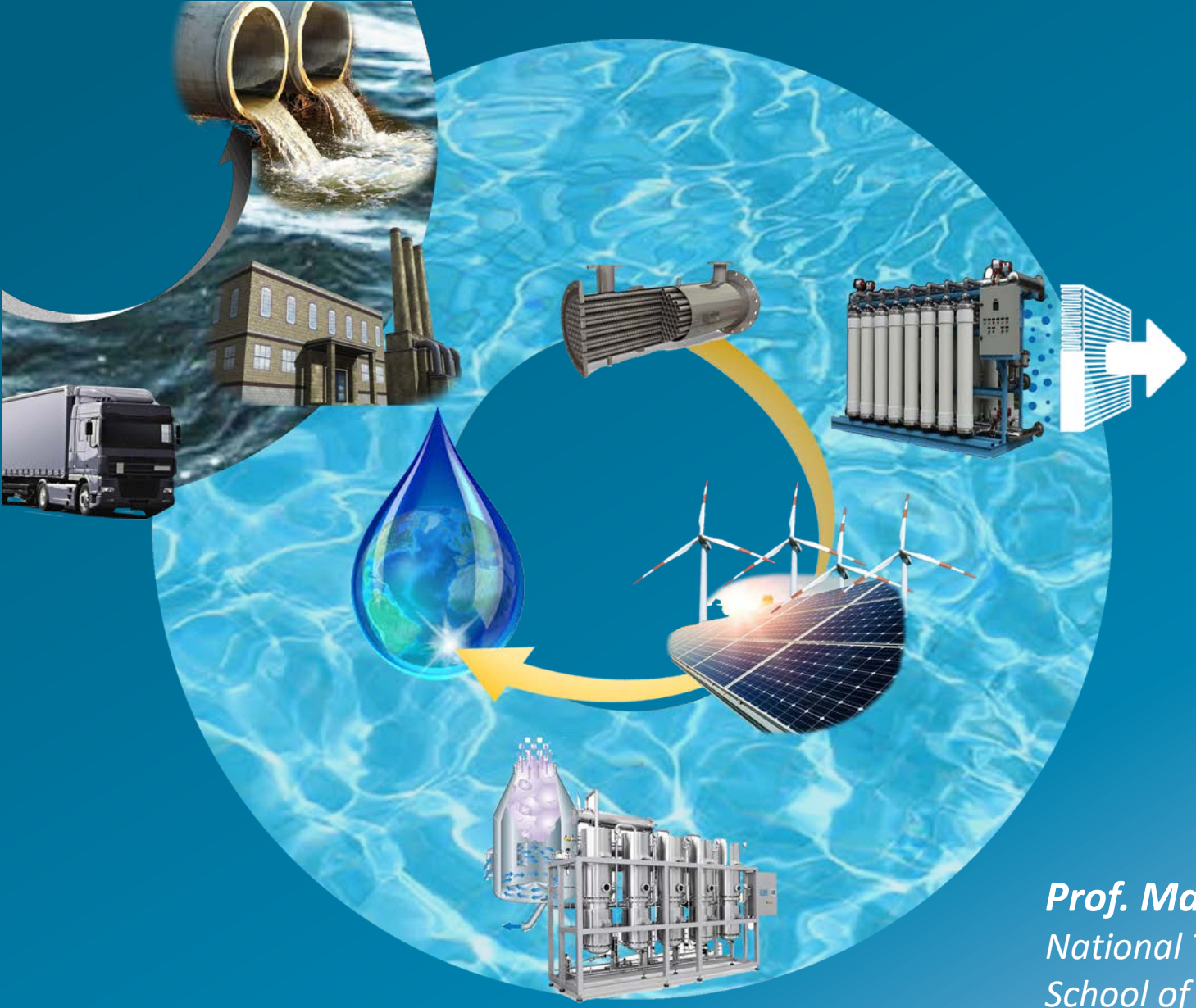


Integrated Brine Management

Prof. Maria Loizidou
National Technical University of Athens
School of Chemical Engineering
Unit of Environmental Science and Technology

Brine discharge problem

- Brine → high salt concentration in water (mainly NaCl)
- Produced → desalination plants, industry (chemical, coal mine, textiles, food etc)
- Brine discharge → Tones of salts and water are released to surface water bodies, sea or WWTP

Problems:

- Pollution of surface water bodies and sea (flora and fauna changes, limiting possibility to use river or lake water for agricultural, industrial and municipal purposes creating social, environmental, economical problems)
- Salination of soils (agricultural problems)
- Degradation of underground water bodies
- Accumulation of chlorides and sulfates

Brine recovery

- Tones of recovered salts could be reused by industry (some of them are in the EU list for Critical Raw Materials e.g Mg)
- Other valuable-high market price materials could be recovered apart from salts (such as biomolecules from food industry brines)
- Decrease of energy consumption and CO_2 emissions (less energy is used for the recovery of salts from brines compared to their conventional production)
- Millions of water m^3 could be reused for agricultural, industry and municipal purposes.
- Avoid water scarcity
- Better status of soil and water bodies

Timeline of UEST European Projects on brines

March 1, 2010

Sol-Brine Life project System for desalination brine treatment

June 1, 2017

Zero Brine Horizon 2020 project, treatment of brines from silica, textiles, desalination industry and coal mine

September 1, 2020

Water Mining, Horizon 2020 treatment of brines from chemical industry, WWTP and desalination plants

March 30, 2017

Green Awards, the best Life project of the last 25 years

October 1, 2019

Brine Mining Life project System for the treatment of coal mine brine

Sol Brine-General Information

"Development of an advanced innovative energy autonomous system for the treatment of brine from seawater desalination plants"

Sol - Brine

Area of implementation: Tinos Island, Greece

Project Budget: 1,209,689.00 €		**EC Funding (LIFE+):** 604,844.00 €
Duration: 39 months	**Start date:** 01/10/2010	**End date:** 31/12/2013

Municipality of Tinos Island (Project Coordinator)

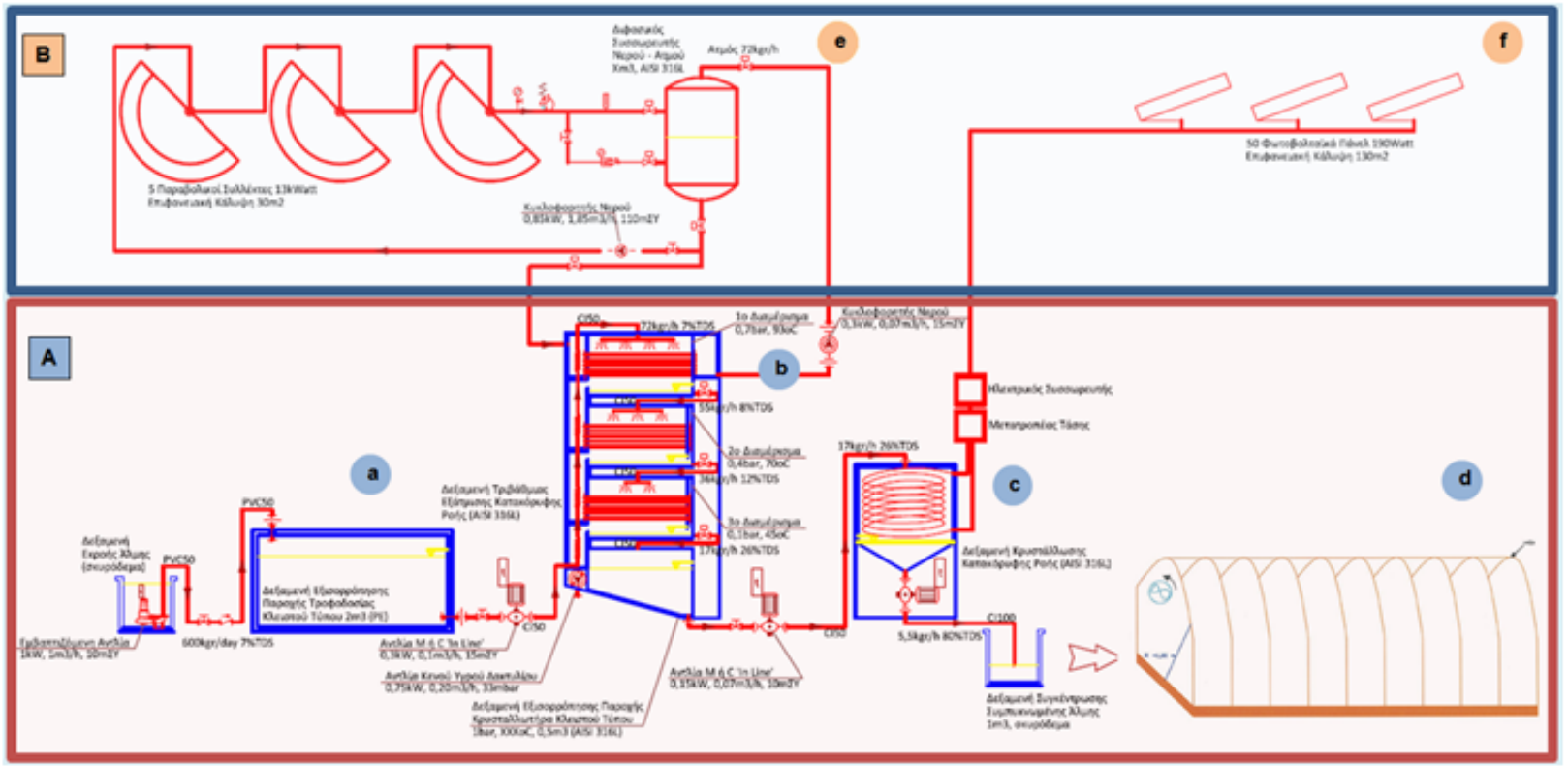
National Technical University of Athens

Culligan Hellas S.A.

Innovative aspects

- **Total brine elimination:** The system has been designed in line with the Zero Liquid Discharge principle
- **Water Recovery:** (> 90%)
- **Production of useful end-products.** (a) water of high quality and (b) dry salt. Products with market opportunities.
- **Energy autonomous operation:** Solar thermal collectors are used for delivering hot water and a PV for electricity. All energy requirements are covered exclusively through the use of solar energy.
- **Use of state-of the art technology**: Custom designed vacuum evaporation technology (evaporator and crystallizer) and solar dryer.

Single Line Diagram



Legend

A	Brine Treatment System	B	Energy supply system
a	Feed water tank	e	Solar thermal collectors
b	MED Evaporator	f	Photovoltaic generator
c	Crystallizer		
d	Dryer		

Pilot

Evaporator

Crystallizer

Pilot

Dryer

System

Pilot

Site Visit

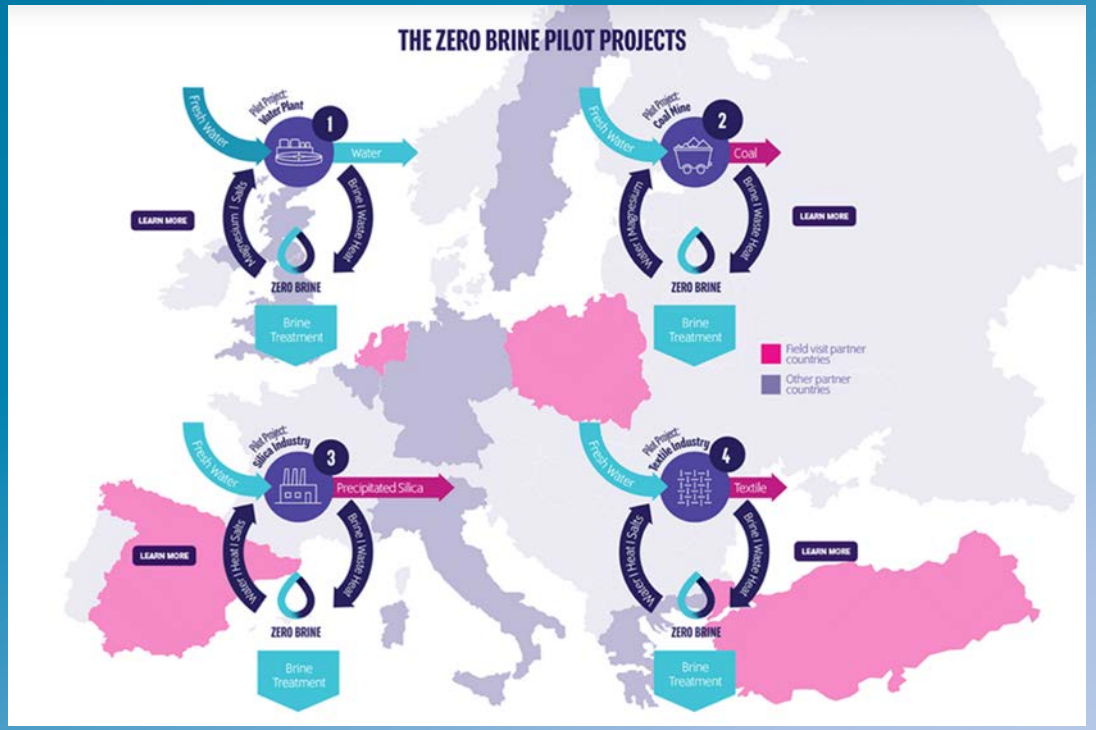
Sol Brine-EU Green Awards

The Best Life Project of last 25 years

Zero Brine

ZERO BRINE

"Re-designing the value and supply chain of water and minerals: a circular economy approach for the recovery of resources from saline impaired effluent (brine) generated by process industries"



Area of implementation: The Netherlands, Spain, Poland, Turkey

Project Budget: 11,078,222 €		**EC Funding:** 9,992,209 €
Duration: 54 months	**Start date:** 01/06/2017	**End date:** 30/11/2021

HORIZON 2020

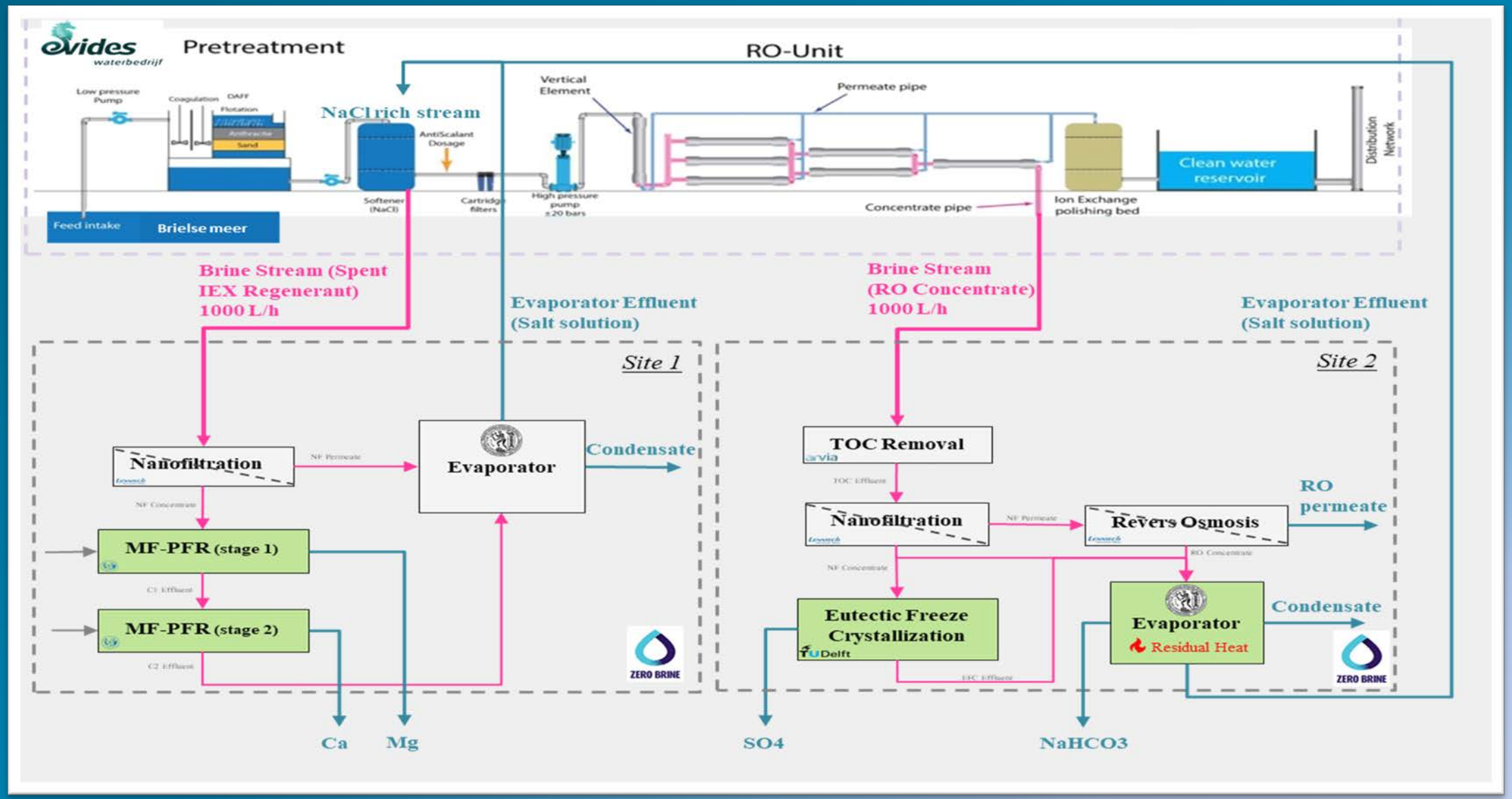
Zero Brine-Partners

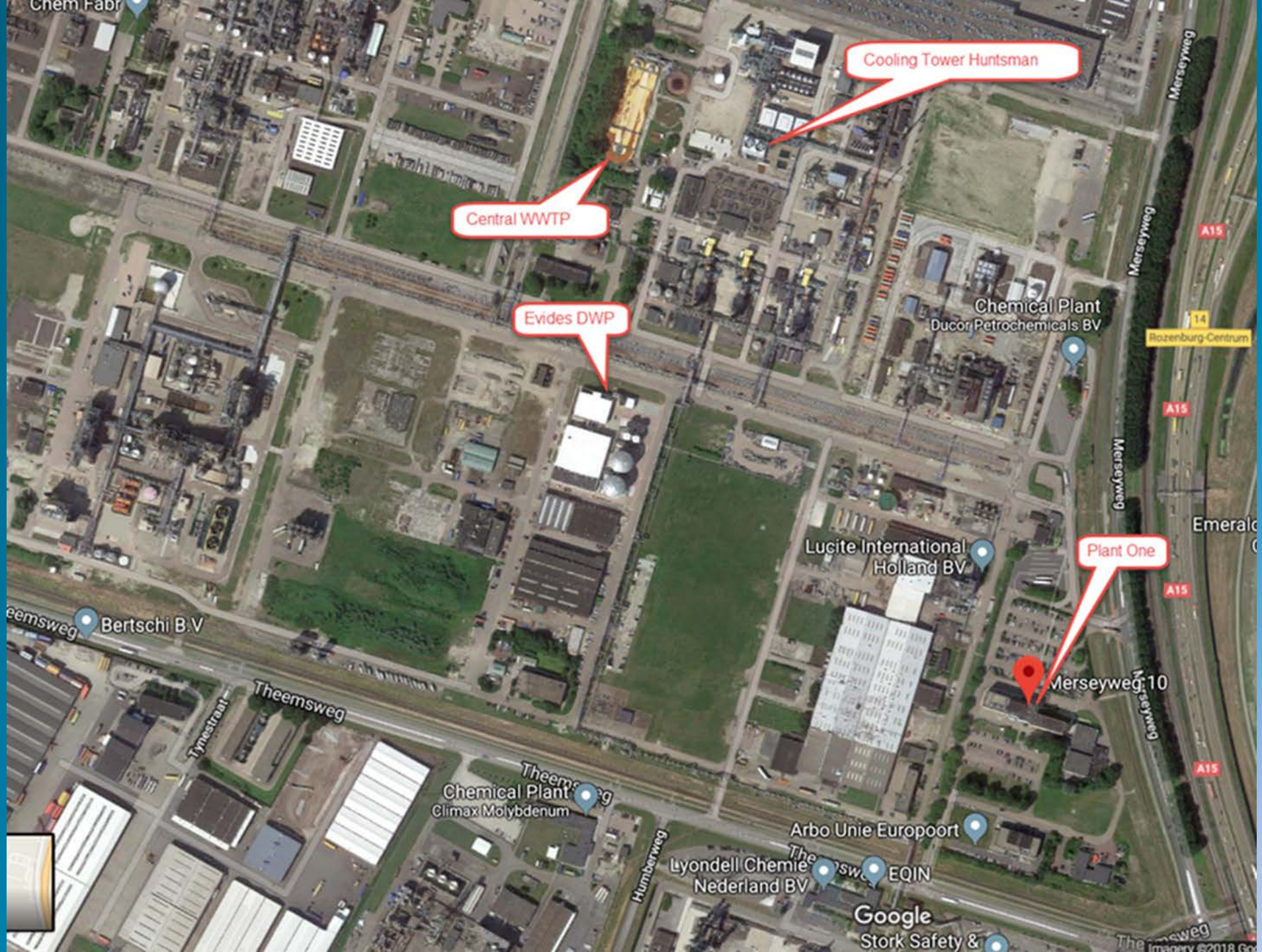
NL Pilot in Demineralised Water Plant EVIDES

"EVIDES provides tones of drinking water and water for industrial use in the Netherlands. Tones of brines from its demineralized processes are discharged in Rotterdam port sea"

- Magnesium and Calcium from brine
- Sulphates removal
- $NaHCO_3$
- High quality water
- High concentration and high-purity NaCl solution which will be used for the regeneration of EVIDES ion exchange resins
- Circular economy model

NL Pilot Process Flow Diagram




Cooling Tower Huntsman
Central WWTP
Evides DWP
Chemical Plant
Ducor Petrochemicals BV
Plant One
Lucite International
Holland BV
Merseyweg 10
Bertschi B.V
Theemsweg
Tynestraat
Chemical Plant
Climax Molybdenum
Arbo Unie Europoort
Lyondell Chemie
Nederland BV
EQIN
Google
Stork Safety &
Merseyweg
A15
Rozenburg-Centrum
Humberweg

NL Pilot

NL Pilot

NL Pilot

NL Pilot

NL Pilot results

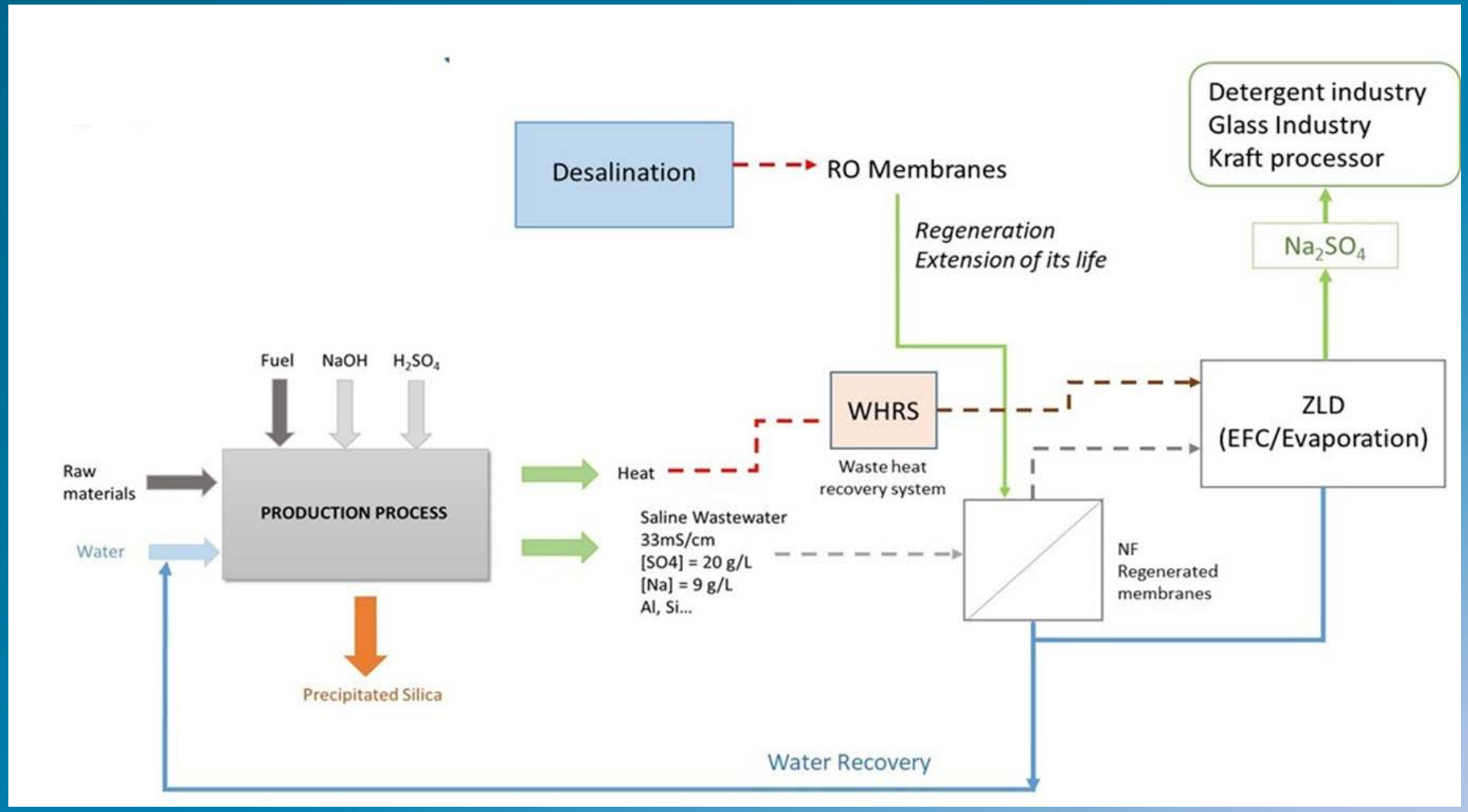
- Ca and Mg removal of around 93%
- Purity of recovered Mg crystals is 84-90% and Ca crystals is 93-99%
- Water recovery of about 90%
- Quality improvement of end products would have positive impact on annual revenues (3,000,000-8,000,000 €/year)
- Avoiding environmental penalties due to brine discharge
- Internal valorization of NaCl solution

ES Pilot Silica Industry

"IQE produces a brine with high concentrations of NaCl, sulphates, color and impurities"

- Na_2SO_4 recovery
- Clean water to be reused in the procedure
- System coupling with waste heat
- Circular economy model

ES Pilot Process Flow Diagram



ES Pilot Results

- 0,9 m^3 of water recovered / m^3 of wastewater treated
- 20 kg of Na_2SO_4 / m^3 of wastewater (about 90 %)
- Use of waste heat
- Economic benefits
- Environmental benefits (water consumption reduction at IQE: >70%)

Brine Excellence Centers (BEC)

- ✓ Netherlands, Poland, Italy, Greece and Spain
- ✓ Shared use of technologies
- ✓ Shift towards replication roadmap and activities
- ✓ Three follow-up projects
- ✓ Simulation software at DLR online available

Greece BEC
National Technical University of Athens

The Netherlands BEC
DELFT University of Technology

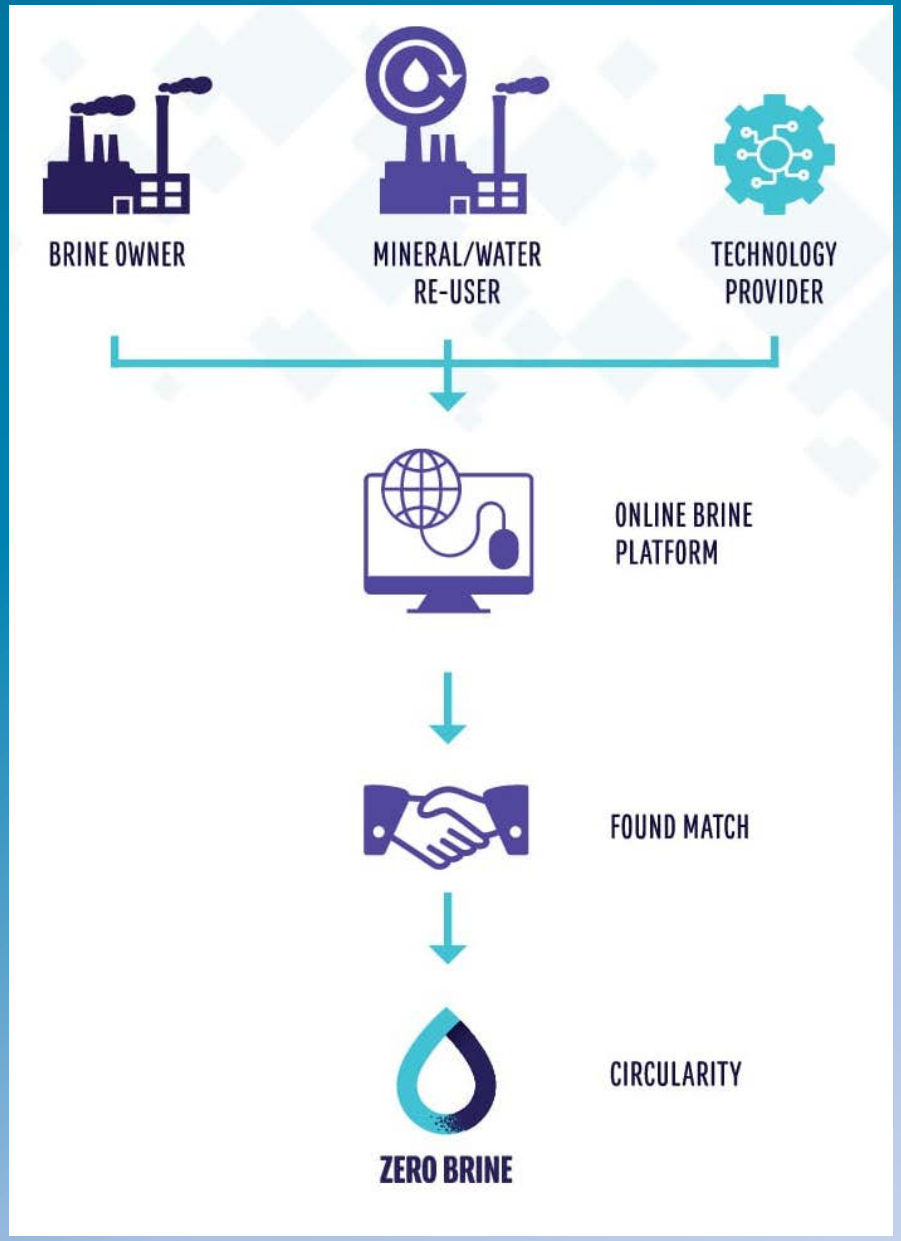
ITALY BEC
University of Palermo

SPAIN
Eurecat

POLAND BEC
Silesian University of Technology

Online Brine Platform developed by NTUA

- On-line matchmaking of
  - brine owners with technology providers
  - brine owners with salts or water end users
- Database with more than 200 brine producers in the Netherlands
- Salt users from 5 large industrial clusters are registered
- Workshops about OBP and Zero Brine results in the Netherlands, Italy, Spain, Poland
- Athens Workshop: Zero Brine results, OBP registration and use by stakeholders in Greece and Cyprus



Brine Mining-General Information

"Demonstration of an advanced technique for eliminating coal mine wastewater (brines) combined with resource recovery"

Life BRINE MINING

Area of implementation: Poland

Project Budget: 6,383,847 €	**EC Funding (LIFE+):** 3,508,365 €

Duration: 54 months	**Start date:** 01/10/2019	**End date:** 1/03/2024

Partners

Coordinating beneficiary

National Technical University of Athens

Beneficiaries

GLOWNY INSTYTUT GORNICTWA

LENNTECH

NEVIS-NOVEL Environmental Solutions S.A.

SEALEAU B.V.

Silesian University of Technology

POLSKA GRUPA GORNICZA

THERMOSSOL STEAMBOILERS S.A.

Titan Salt B.V.

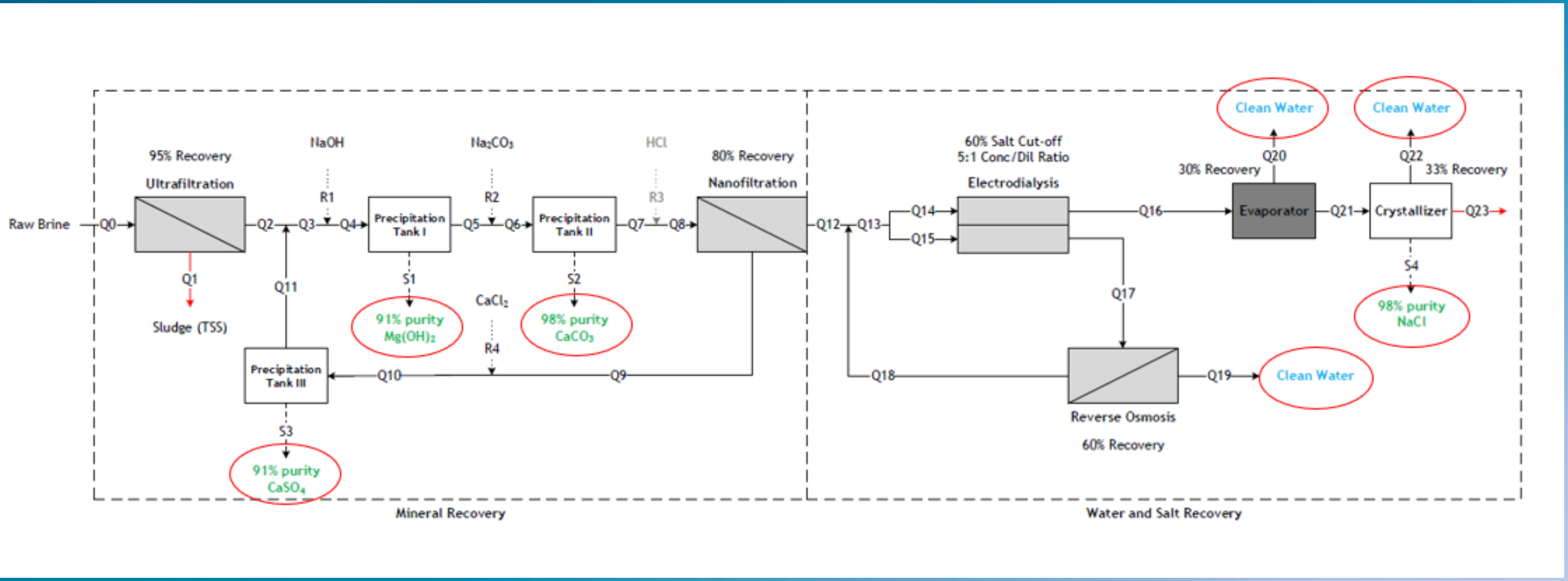
The problem

- EC aims to eliminate the electricity production from extracted coal.
- The total hard coal production in Europe in 2015 is 100 Mtones.
- Poland is the dominant producer in EU (approximately 72% of total European production).
- Coal mines generate vast amounts of saline water.
- Direct or indirect drainage of these streams to water bodies.
- Ecological status of rivers: moderate.
- Vistula river: 55% of fresh water in Poland
- Vistula salination:150-200 million $ per year (losses in industry, agriculture and water transport).

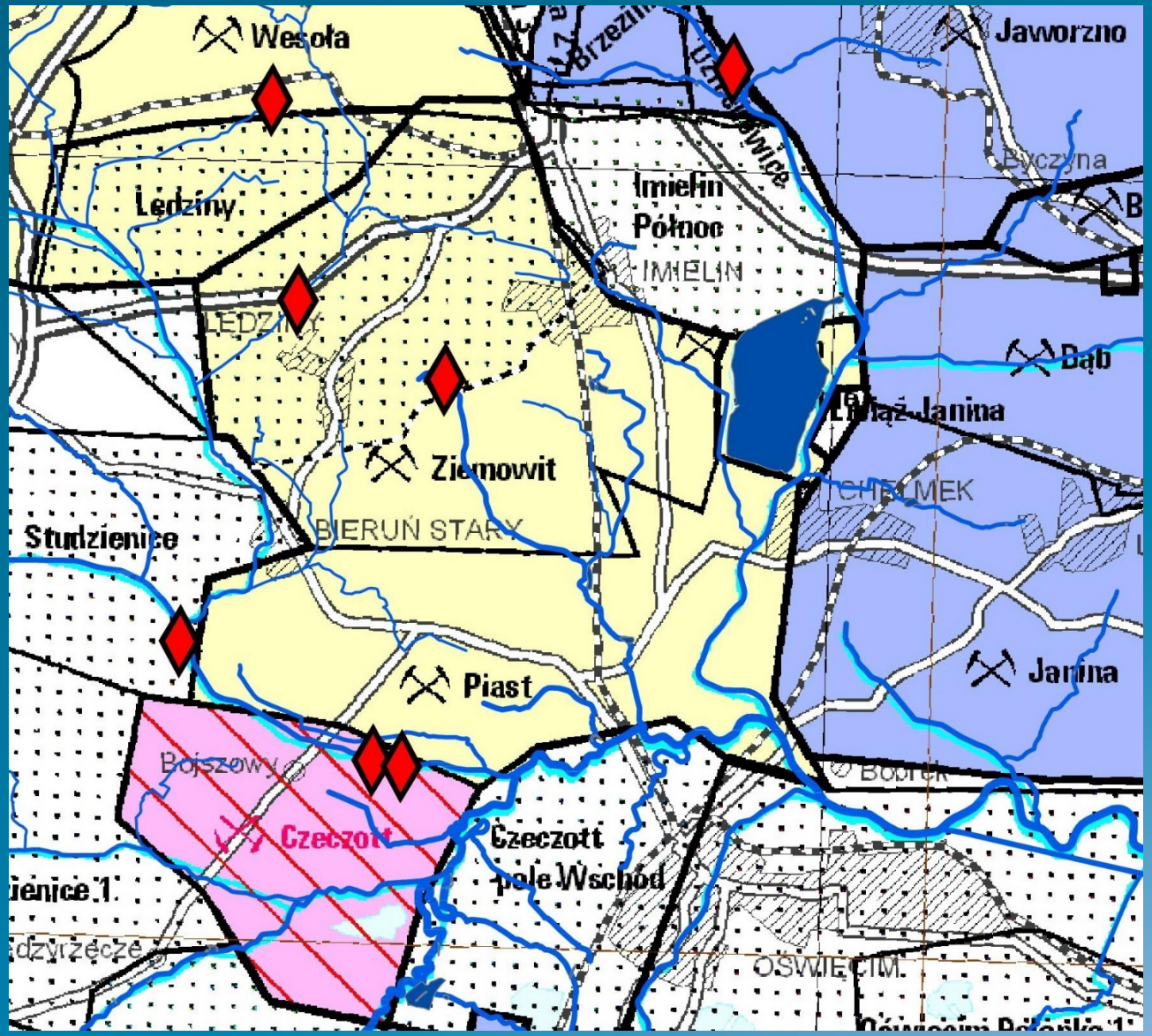
Main Objectives

- Economically viable, innovative system for the elimination and full recovery of resources included in the coal mining brines.
- A system able to treat and directly recover end-products (minerals/salts and water) of high quality and purity.
- End-products that satisfy market specifications.
- Water Framework Directive (WFD) and the Circular Economy package
- To decrease the energy consumption compared to current best practice

Process Flow Diagram



Demonstration of plant location



Water Mining-General Information

"Next generation water-smart management systems: large scale demonstrations for a circular economy and society"

38 partners

Area of implementation:
The Netherlands, Italy, Spain, Cyprus

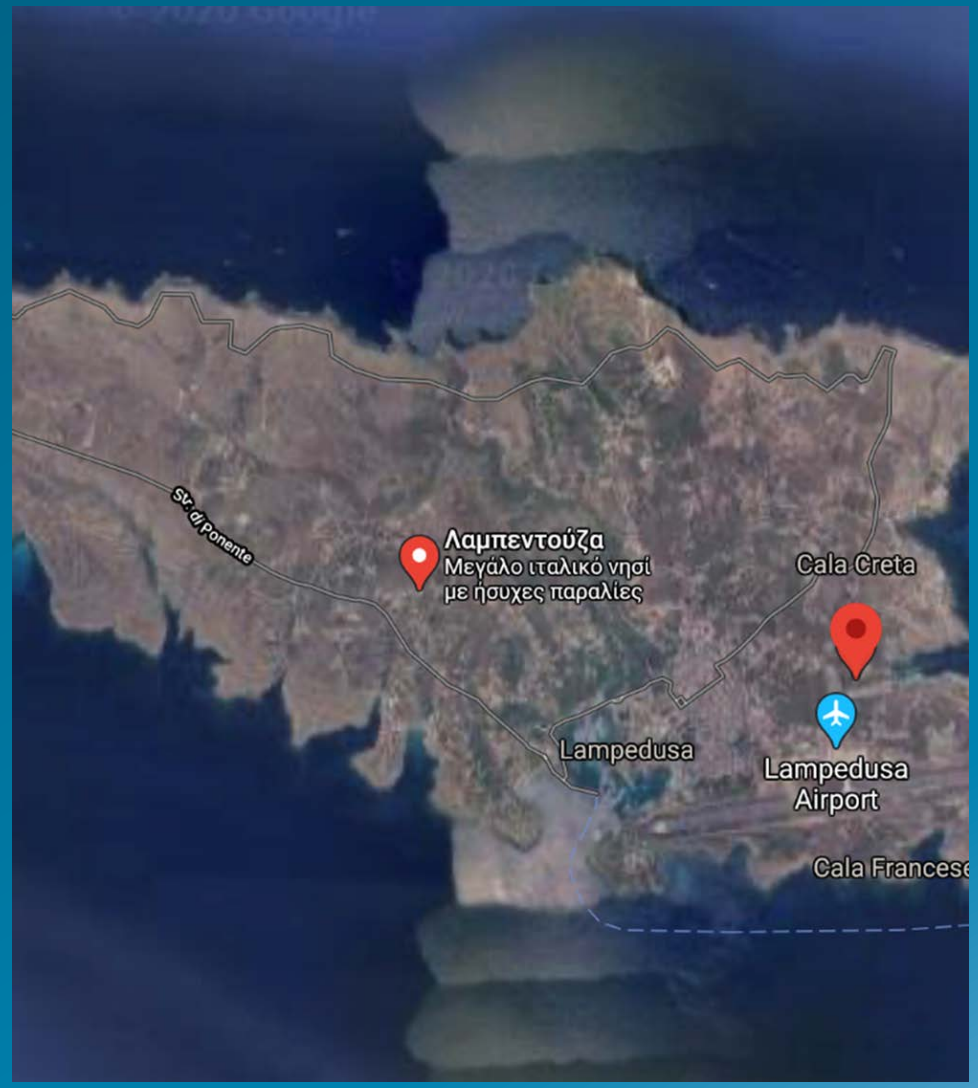
Project Budget: 19,097,946 €	**EC Funding (LIFE+):** 16,876,959 €
Duration: 48 months	**Start date:** 01/09/2020
	End date: 31/08/2024

HORIZON 2020

General Information

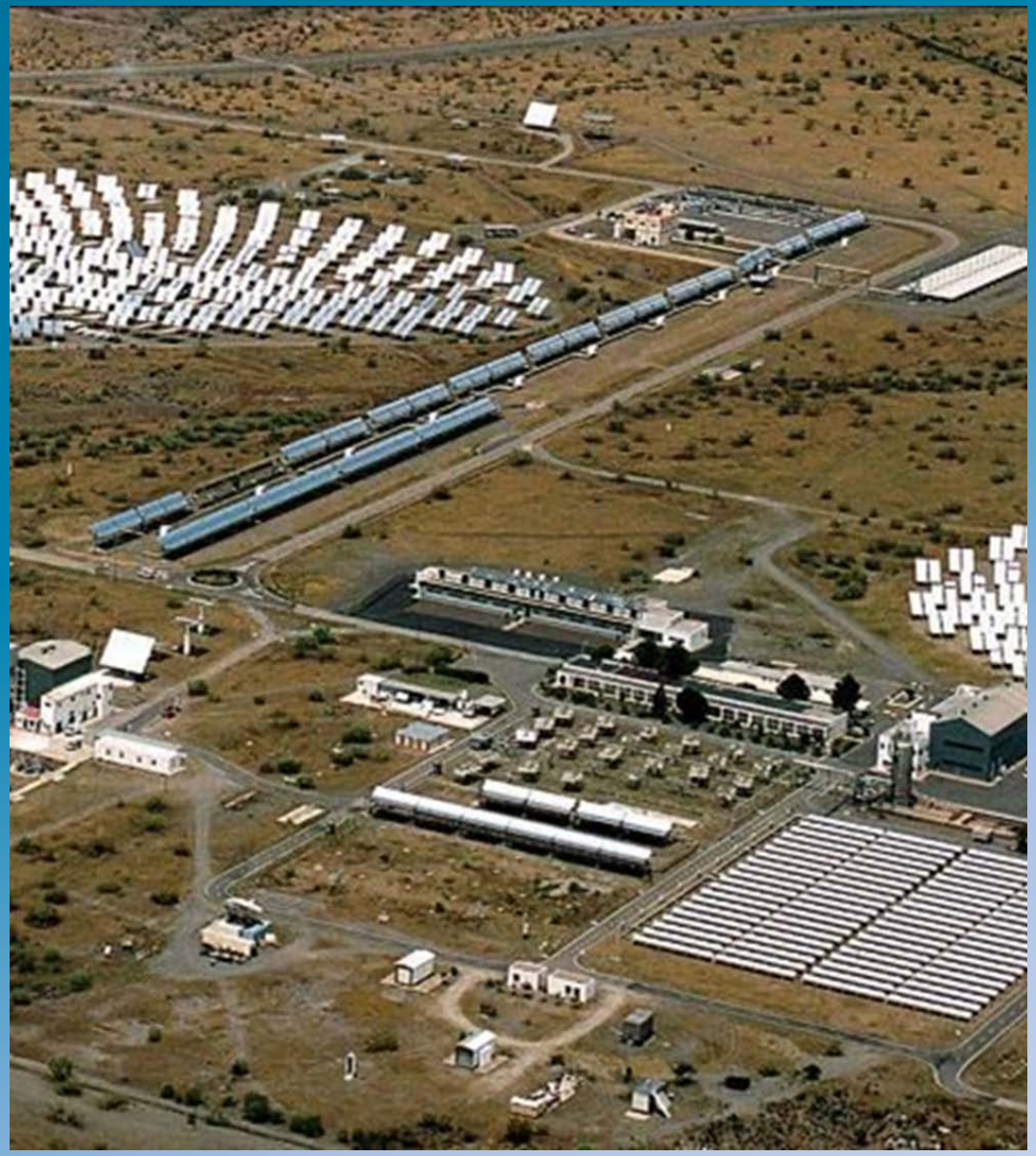
- **Water**: The most important resource across all supply chains.
- **Three forms**: as resource, as consumable, as durable.
- **Resource**: need to find alternative sources of water (desalination plants in Italy and Spain)
- **Consumable**: water reuse must be maximized (WWTP effluents treatment in Spain, the Netherlands and Cyprus).
- **Durable**: water must be kept in a close loop promoting Zero Liquid Discharge (Hexion case in the Netherlands)

Desalination and sustainable brine management



SELIS
Lampendusa

PSA SPAIN



Desalination and sustainable brine management targets

- 50% of energy requirements will be covered by renewable energy,
- water recovery ≥ 90 %,
- magnesium purity > 90 %,
- sodium chloride purity > 90 %
- reduced energy requirements for seawater desalination process by 25-30 %,

Demonstration for phosphorus, water, salt and energy recovery from urban wastewater

(LARNACA-Cyprus, ACSA-Spain)

Demonstration for phosphorus, water, salt and energy recovery from urban wastewater

- Phosphorus recovery.
- Mg, Ca, and NaCl recovery.
- High-quality water
- Anaerobic digestion as a cost-effective technology to recover energy (as biogas).
- Two-stage biological process, performing partial nitration and anammox as a cost-effective alternative to remove nitrogen at mainstream conditions.

Way forward in brine management and circular economy.

Gained knowledge could be applied on a large-scale sea water desalination project

(demo capacity > 100 m^3/day)

Thank you for your attention!

Prof. Maria Loizidou

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School of Chemical Engineering

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