ULTIMATE

WATER SMART INDUSTRIAL SYMBIOSIS

Online seminar
Membrane technologies

S.Casas, A.Kleyböcker, F.Fantone, C.Bruni, R.Serena

November, 25th 2020

Ultimate (June 2020 – May 2024):

Industry water-utility symbiosis for a smarter water society

- Promotion, establishment and extension of **Water Smart Industrial Symbioses**
- Development and demonstration of **innovative technologies** for symbioses
- **Assessment** of the technologies and development of **digital „support tools“**
- Development of **new business models** towards marketability

9 Symbioses between:

Industrial sectors

- Agro-food
- Beverage
- (Petro)chemical
- Biotech

Service providers

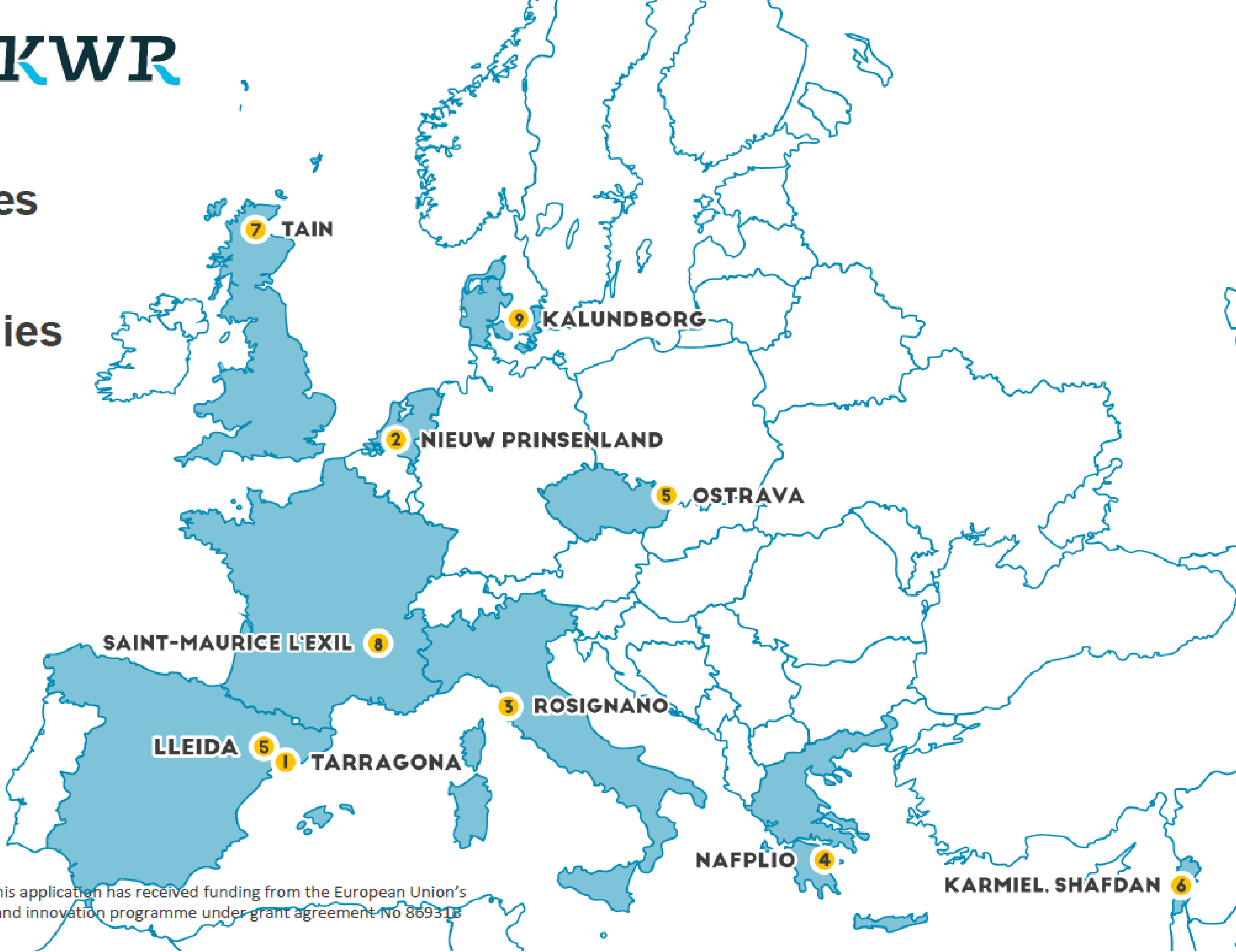
- Municipal utility
- Multi-industry utility
- Specialized SME
- Water services provider

Coordinator: KWR

9 Case Studies

27 Partners

37 Technologies



The project leading to this application has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 869318

3 Cross-cutting Technology Groups: 9 Topics


F. Fatone **C. Bruni**

UNIVERSITÀ POLITECNICA DELLE MARCHE

- Nutrient recovery
- High added value products
- Metal recovery

eurecat
Centre Tecnològic de Catalunya

S. Casas

- Membrane technologies
- Adsorption technologies
- Advanced oxidation processes

A. Kleyböcker

KOMPETENZZENTRUM Wasser Berlin

- Biogas technologies
- Heat recovery
- Digitalization

Coordinator: KWR

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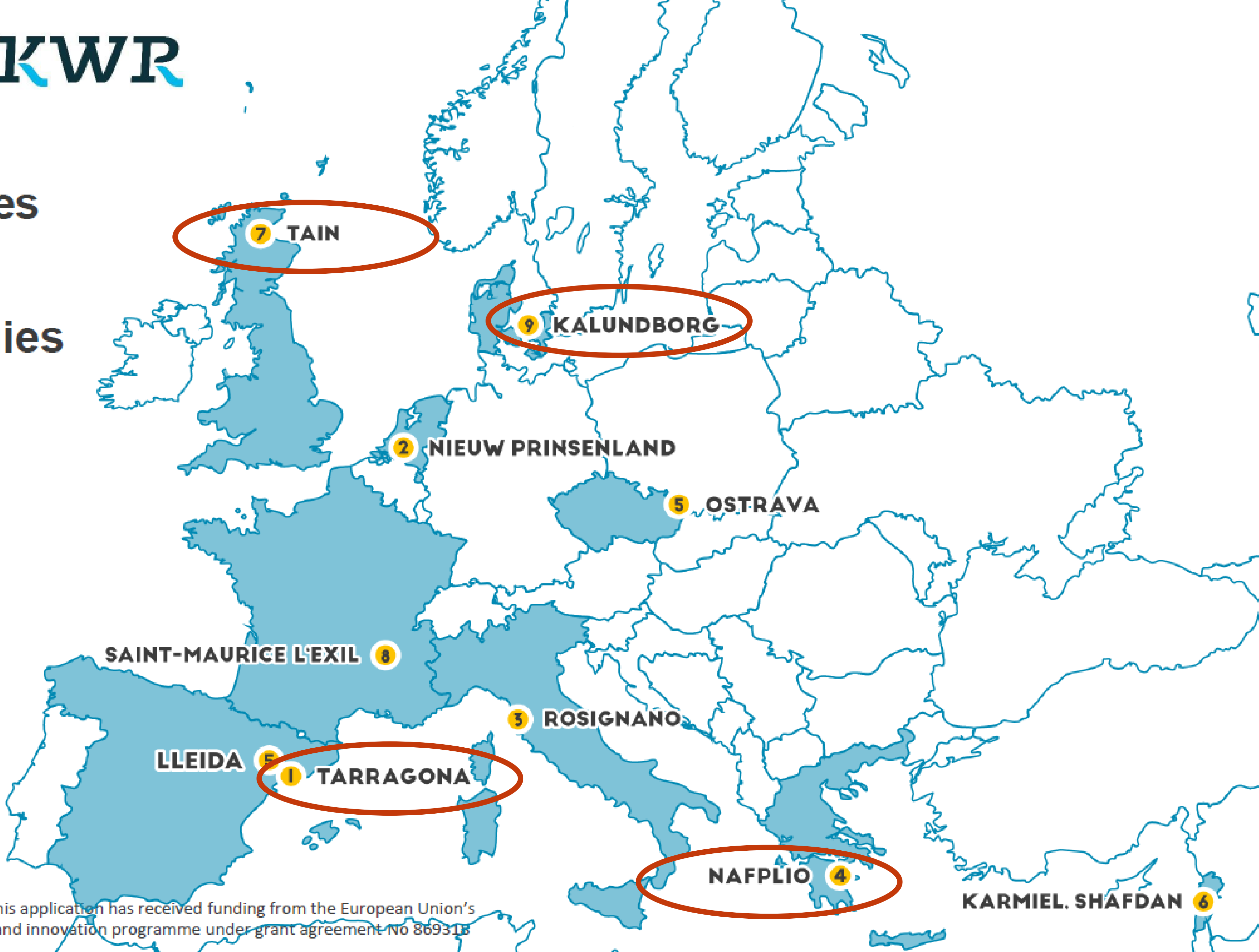

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Agenda

10:10	**Near zero liquid discharge systems in the petrochemical industry** Sandra Casas (EUT)
10:20	**Filtration and small bioreactor platform for wastewater reuse in the food industry** Dimitri Iossifidis (GtG)
10:30	**AnMBR and RO for water recovery in the beverage industry** Marc Pidou, (Cranfield Univ)
10:40	**Ultratight UF in fit-for-purpose water treatment systems in the biochemical industry.** Leo Vredenbregt (X-Flow)
10:50	**Nextgen Synergies: space technology for water reuse in a Dutch brewery.** Ralph Lindeboom (Semilla)
11:10	**Watermining Synergies: Pilot System for Water, Salt and Energy recovery from urban wastewater.** Maria Kyriazi (NTUA)
11:20	**Open discussion**
11:30	**Closure**

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ULTIMATE

WATER SMART INDUSTRIAL SYMBIOSIS

Near zero liquid discharge systems in the petrochemical industry

D.Montserrat, X.Martínez, S.Casas

Petrochemical Complex of Tarragona (Spain)

Industrial area that groups several companies **of the chemical and petroleum field.**

it has been considered the most important of this type in Catalonia, Spain and the south of Europe.

More than 30 companies operate in the petrochemical complex focusing on production of chlorine, alkaline salts, oxygen gas, fertilizers, insecticides, fuels, plastics and synthetic essences.

AITASA was created in 1965 to supply water to the complex. In 2012, a water reclamation plant was put in operation to supply industrial water.

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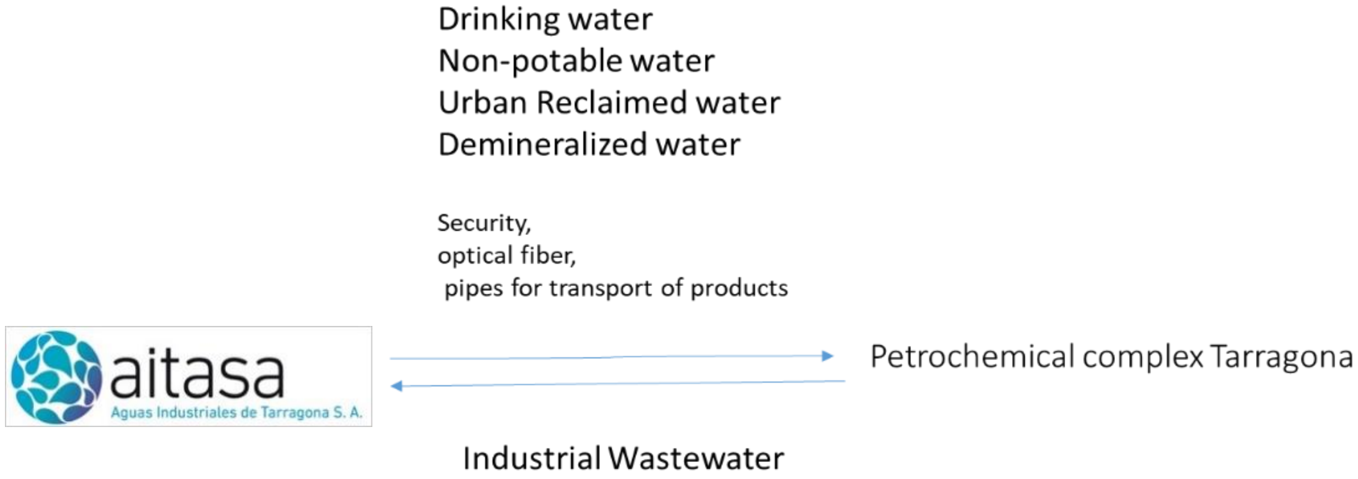
Tarragona symbiosis through AITASA



Drinking water
Non-potable water
Urban Reclaimed water
Demineralized water

Security,
optical fiber,
pipes for transport of products

Petrochemical complex Tarragona

Industrial Wastewater

Synergies in place since 1965

Kms of pipes that make up the network:

Industrial Water: 43.5 Kms. Average diameter: 500 mm
Chlorinated Water: 14 Kms. Average diameter: 200 mm

Distributed industrial water flow: 10 Hm^3 / year

Direct jobs:17

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Camp de Tarragona WRP

Industrial water reclamation for cooling towers, boilers and deminerilized uses

6,8 hm^3/year capacity for urban wastewater reclamation

EDAR Vila-Seca i Salou

EDAR Tarragona

Coagulation/floculation & settling (ACTIFLO)

Microfiltration (Discfilter)

Sand filter

Reverse Osmosis (2 passes)

Disinfection

Industrial water

Users: REPSOL, BASF, IQA, ERCROS, DOW CHEMICAL, CELANESE, BAYER, etc

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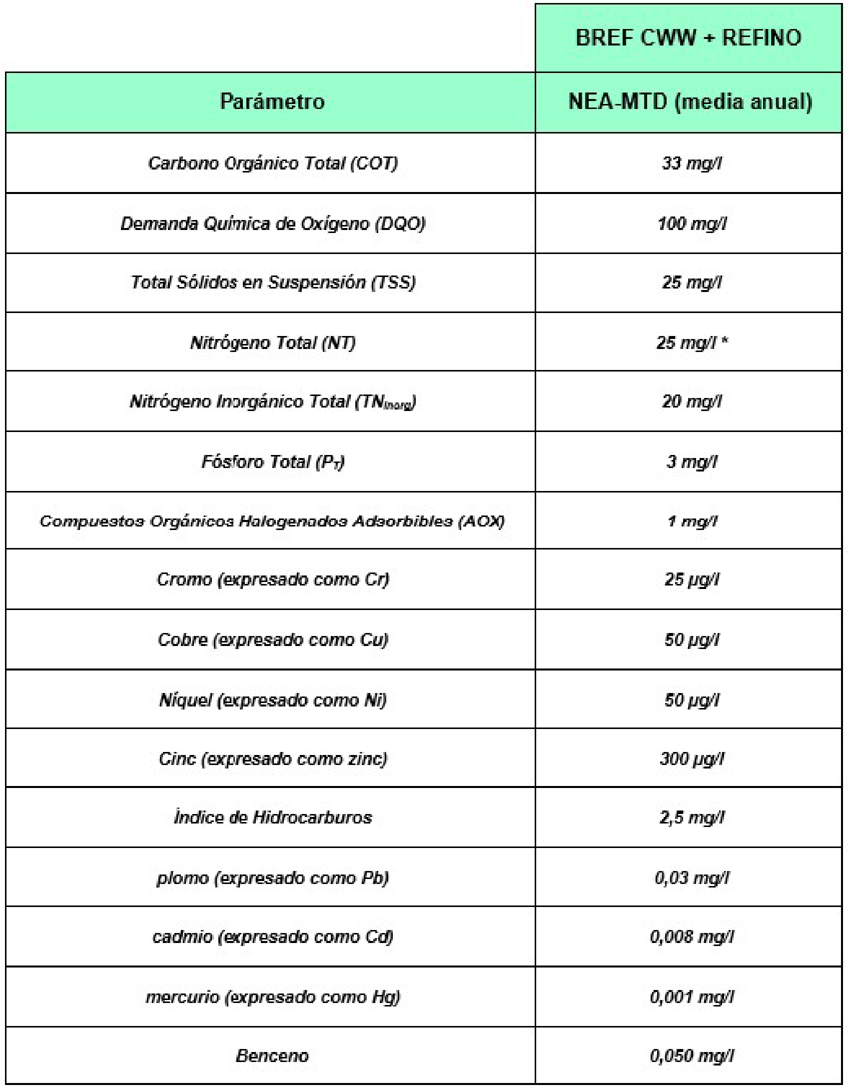
Industrial wastewater treatment

To be commisioned in 2022

Goal: to meet the BREF

1,8 Mm3/h treatment capacity



	BREF CWW + REFINO
Parámetro	**NEA-MTD (media anual)**
Carbono Orgánico Total (COT)	*33 mg/l*
Demanda Química de Oxígeno (DQO)	*100 mg/l*
Total Sólidos en Suspensión (TSS)	*25 mg/l*
Nitrógeno Total (NT)	*25 mg/l **
Nitrógeno Inorgánico Total (TN_{inorg})	*20 mg/l*
Fósforo Total (P_T)	*3 mg/l*
Compuestos Orgánicos Halogenados Adsorbibles (AOX)	*1 mg/l*
Cromo (expresado como Cr)	*25 µg/l*
Cobre (expresado como Cu)	*50 µg/l*
Níquel (expresado como Ni)	*50 µg/l*
Cinc (expresado como zinc)	*300 µg/l*
Índice de Hidrocarburos	*2,5 mg/l*
plomo (expresado como Pb)	*0,03 mg/l*
cadmio (expresado como Cd)	*0,008 mg/l*
mercurio (expresado como Hg)	*0,001 mg/l*
Benceno	*0,050 mg/l*

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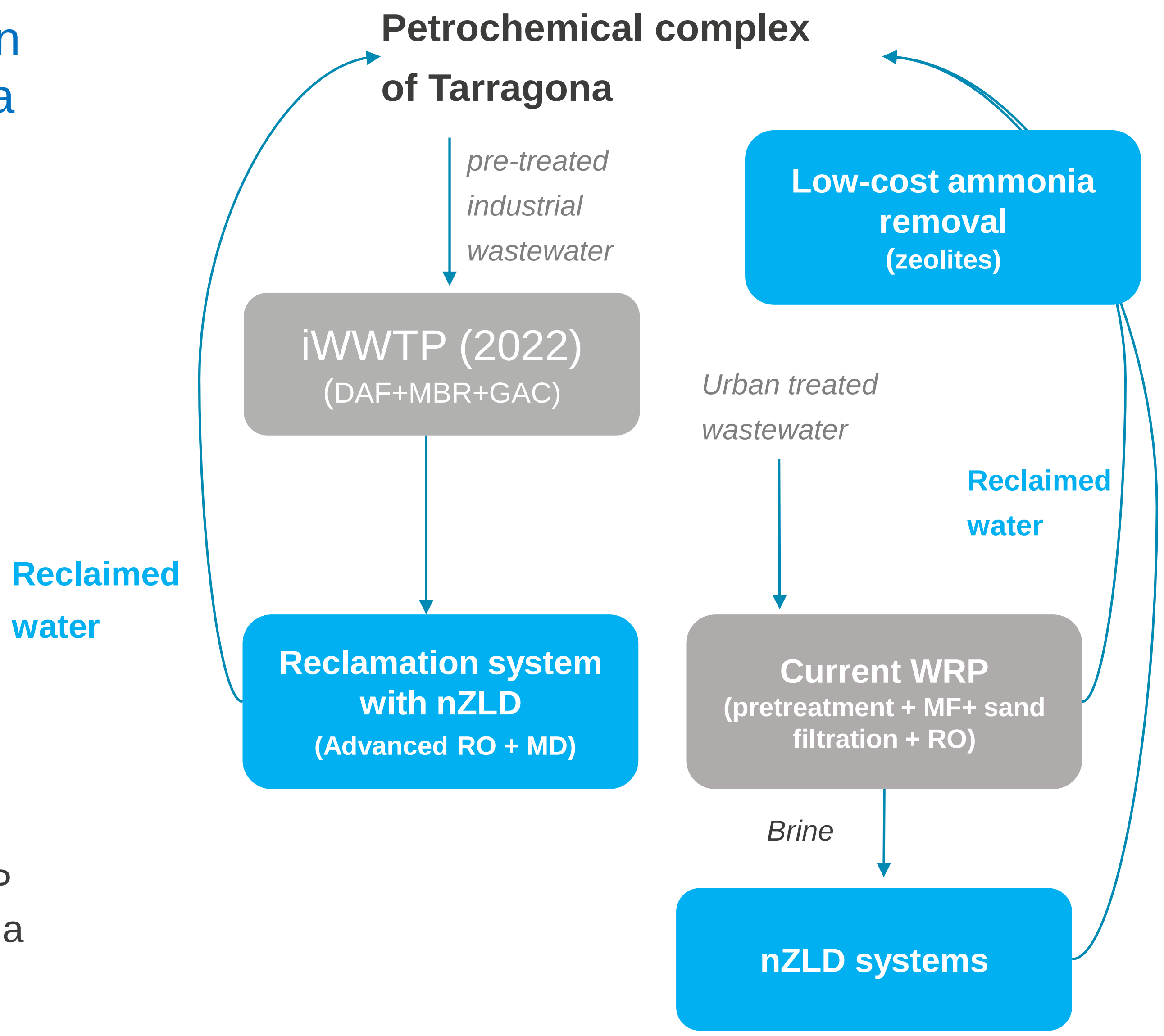
WATER - Task 1.2.1

Increasing reclaimed water availability in the petrochemical complex of Tarragona

Partners:

eurecat Centre Tecnològic de Catalunya

aitasa Aguas Industriales de Tarragona S. A.



OBJECTIVE:
Increase reclaimed water availability for the complex by 20%:

- → Defining a tertiary treatment with nZLD technologies from the future iWWTP
- → Increase water recovery of the current WWRP with nZLD technologies. Remove the ammonia with low-cost technologies (zeolites).

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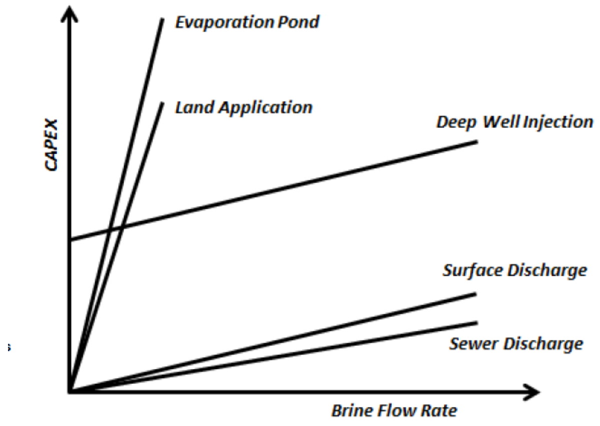
nZLD systems

Optimize water production and minizimize wastes through brine treatment

Brine → liquid solution with high salinity (TDS > 35000 mg/L)



ZLD schemes: hindered by high costs… nZLD can be interesting to minimize volume

Brine → Concentration → Crystallization → Salt

Concentration:

Electrodialysis EDR
Reverse Osmosis RO
Membrane Distillation MD
Forward Osmosis
Evaporation (MSF, MCV)

60-80% Water recovered

Crystallization:

Evaporation
Membrane Crystallization
Solar ponds
Advanced Solar Evaporation

Water

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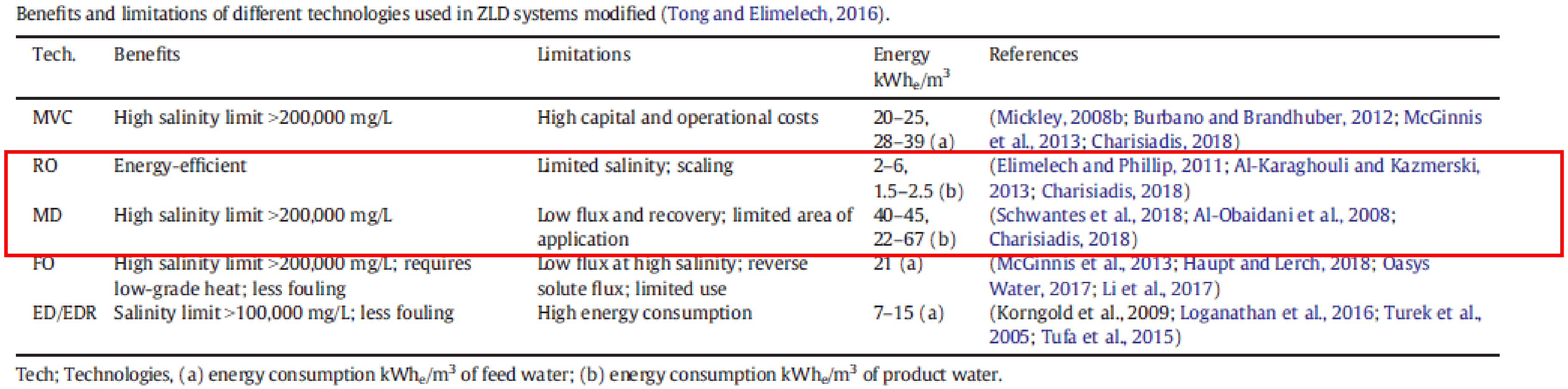
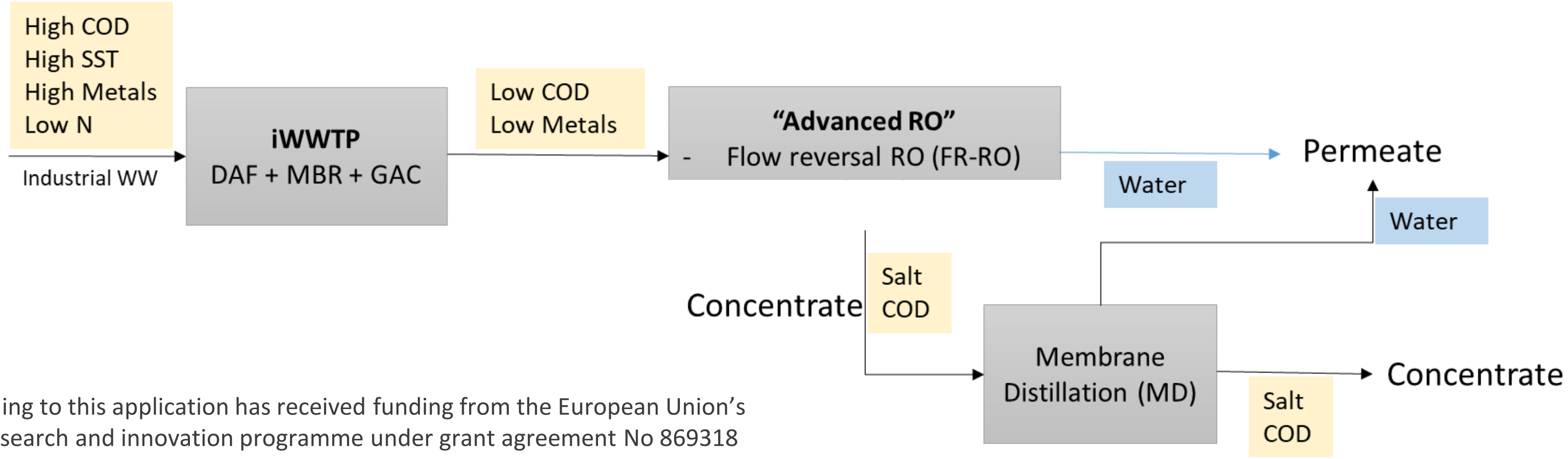
nZLD concentration



Benefits and limitations of different technologies used in ZLD systems modified (Tong and Elimelech, 2016).

Tech.	Benefits	Limitations	Energy kWh$_e$/m^3	References
MVC	High salinity limit >200,000 mg/L	High capital and operational costs	20–25, 28–39 (a)	(Mickley, 2008b; Burbano and Brandhuber, 2012; McGinnis et al., 2013; Charisiadis, 2018)
RO	Energy-efficient	Limited salinity; scaling	2–6, 1.5–2.5 (b)	(Elimelech and Phillip, 2011; Al-Karaghouli and Kazmerski, 2013; Charisiadis, 2018)
MD	High salinity limit >200,000 mg/L	Low flux and recovery; limited area of application	40–45, 22–67 (b)	(Schwantes et al., 2018; Al-Obaidani et al., 2008; Charisiadis, 2018)
FO	High salinity limit >200,000 mg/L; requires low-grade heat; less fouling	Low flux at high salinity; reverse solute flux; limited use	21 (a)	(McGinnis et al., 2013; Haupt and Lerch, 2018; Oasys Water, 2017; Li et al., 2017)
ED/EDR	Salinity limit >100,000 mg/L; less fouling	High energy consumption	7–15 (a)	(Korngold et al., 2009; Loganathan et al., 2016; Turek et al., 2005; Tufa et al., 2015)

Tech; Technologies, (a) energy consumption kWh$_e$/m^3 of feed water; (b) energy consumption kWh$_e$/m^3 of product water.



High COD
High SST
High Metals
Low N

Industrial WW

iWWTP
DAF + MBR + GAC

Low COD
Low Metals

“Advanced RO”
- Flow reversal RO (FR-RO)

Water

Permeate

Water

Concentrate

Salt
COD

Membrane Distillation (MD)

Concentrate

Salt
COD

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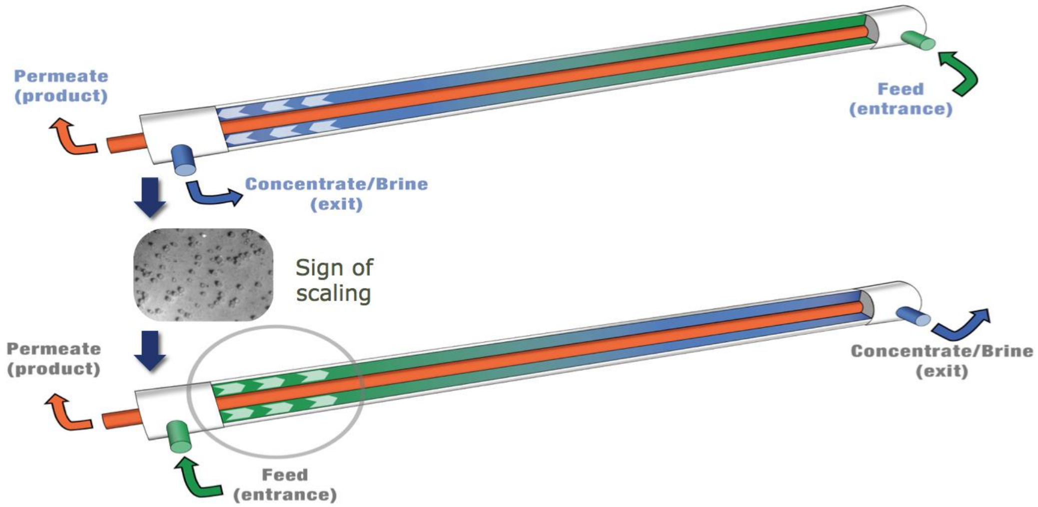
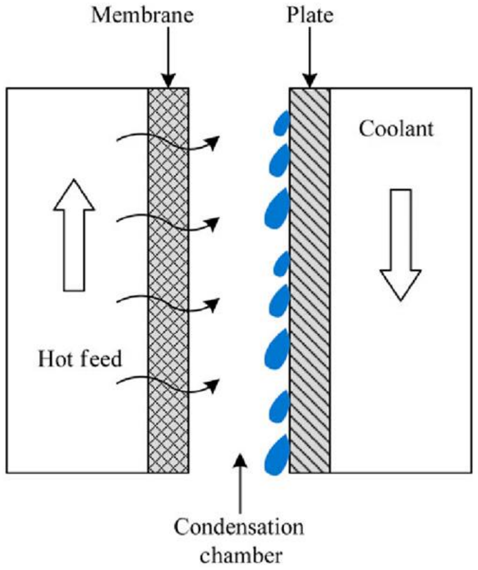
nZLD technologies proposed in CS1

Flow reversal RO (FR-RO)



- Inhibits and prevents mineral scaling (no anti-scaling required)
- Switches connection of feed and concentrate before supersaturated solutions can precipitate from the concentrate onto the membrane.
- Reduction of volume disposal up to 60% compared to RO.

Membrane distillation



- Thermally driven process in which only vapor molecules are able to pass through a porous hydrophobic membrane. The driving force of this process is the vapor pressure differential between both sides of the membrane.
- MD can also be used in conjunction with other separation processes (UF or RO) , is competitive for desalination of brackish and seawater, is an effective process for organic and heavy metal removal from aqueous solutions.

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FR-RO

Desalination 485 (2020) 114462

Contents lists available at ScienceDirect

Desalination

ELSEVIER

Application of feed flow
industrial wastewaters

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Desalination 308 (2013) 63–72

Contents lists available at SciVerse ScienceDirect

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Self-adaptive feed flow reversal operation of reverse osmosis desalination

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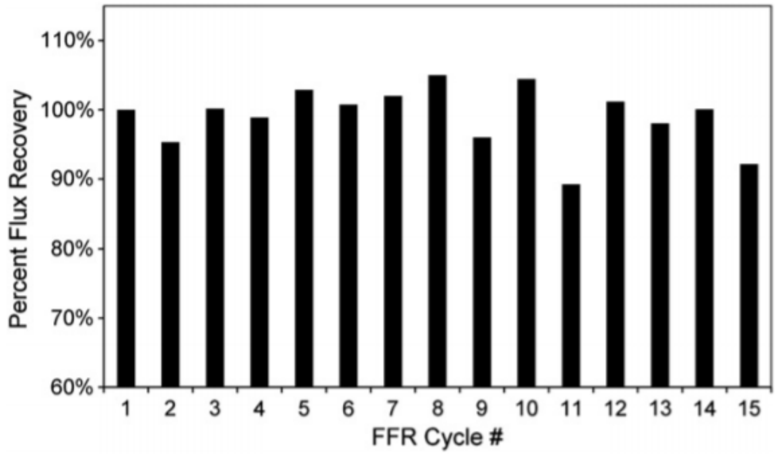

Fig. 10. Percent recovery for the tail element (PV6) permeate flux for the series of FFR cycles for Test #2 (69% recovery for period of 88 h, $SI_{gm} = 2.76$; Table 3).

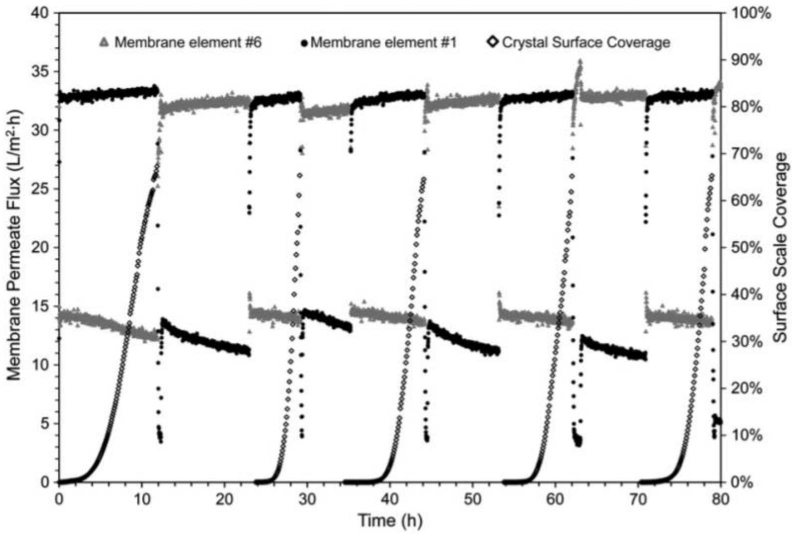

Fig. 12. Permeate flux (normalized) for membrane elements PV1 and PV6 during NFF and FFR periods, along with percent surface crystal coverage in the MeMo cell monitored area (M3 operation at 81% recovery with $SI_{gm} = 3.45$, with the FFR trigger set to 65% surface scale coverage in the MeMo monitored area, Test #3, Table 3).

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MD

Source: Chapter 4: Membrane Distillation. Thermal Solar Desalination, Elsevier Ltd. (2016)

DCMD

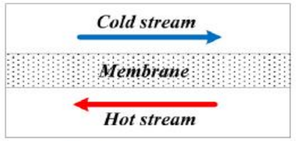

Figure 4.3 Direct contact membrane distillation.

SGMD

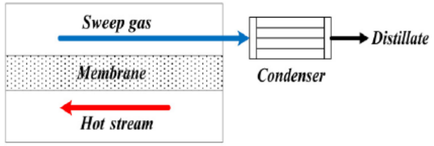

Figure 4.5 Sweep gas membrane distillation.

AGMD

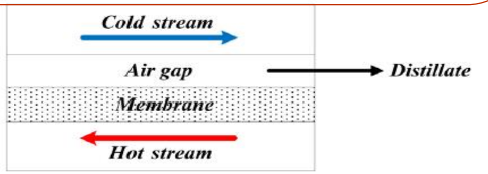

Figure 4.4 Air gap membrane distillation.

VMD

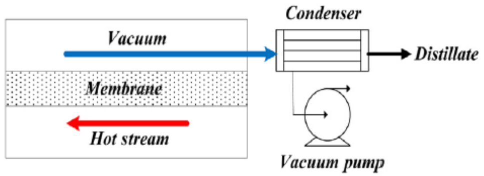

Figure 4.6 Vacuum membrane distillation.

Selection of MD:

- **Operation modes**
- **Materials available for membranes**

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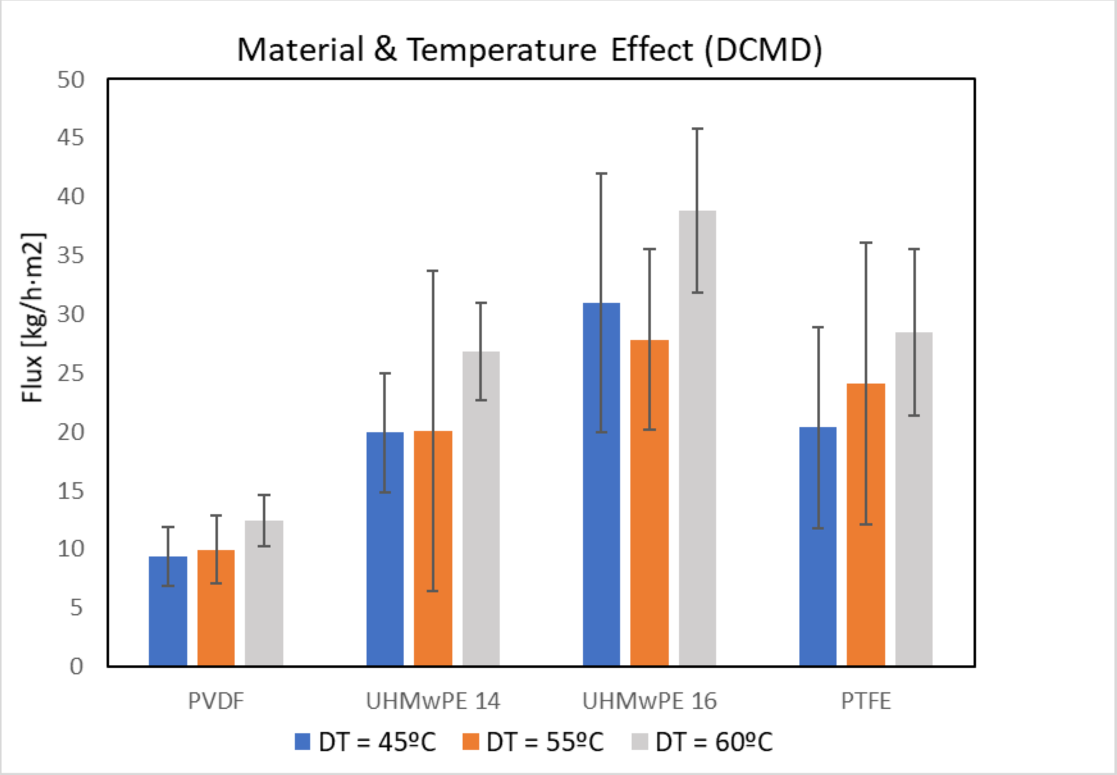
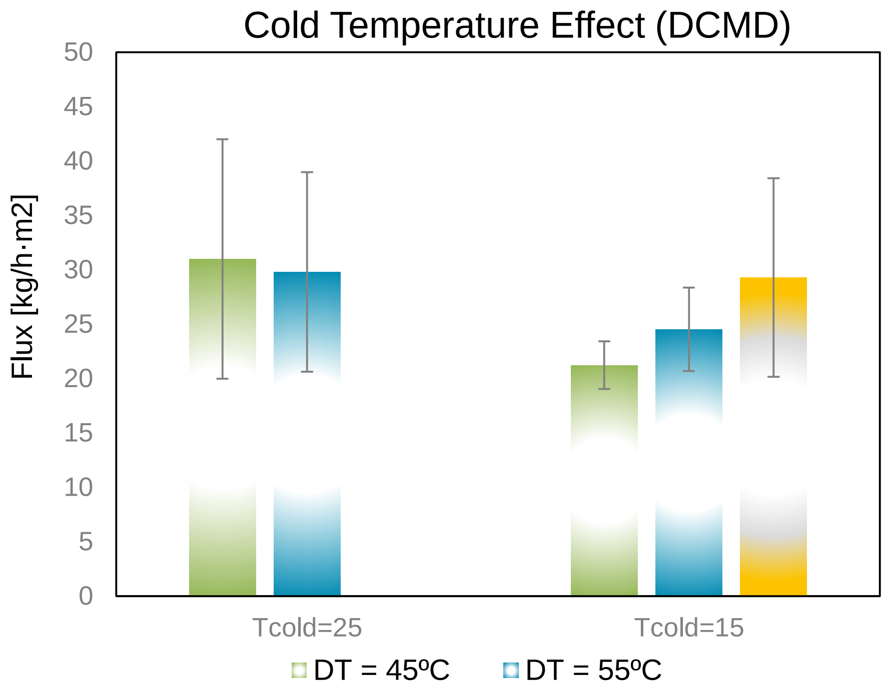
MD preliminary results

UHMwPE16 material is the most promising material for the application

Tests with syntethic brine (35 g/L – 50 mS/cm)





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Next steps in CS1

		2020							2021												2022											
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Internal milestones:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Review of historical operation and quality data of the site. Definition of extra campaigns required. Analysis of samples.	EUT	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨																					
Sampling and analysis for extra analitical campaigns and collection of data for baseline	AIT	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																						
Set-up experimental plan and laboratory equipment	EUT						🟨	🟨	🟨	🟨																						
Definition of requirements for reuse	AIT							🟩	🟩	🟩																						
Trials of proposed technologies at bench scale. Optimitzation of the system	EUT								🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨						
Site adaptation	AIT															🟩	🟩	🟩	🟩	🟩												
Definition of prototype for construction	EUT														🟨	🟨	🟨	🟨														
Prototype construction and installation	AIT														🟩	🟩	🟩	🟩	🟩	🟩												
Operation of prototype and optimization	AIT																				🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Prototype follow-up and monitoring	EUT																				🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨
Evaluation of results and integration of water sources	EUT																															

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Conclusions

nZLD Systems will be evaluated in CS1 of ULTIMATE with a focus on:

- Increasing water availability at least 20% more than conventional Systems (conventional RO)
- Reduce fouling and scaling in membrane treatments (RO)
- Evaluate MD and FR-RO for brine concentration and optimize their operation (estimate OPEX of the system)

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