wetsus

SaltGae

algae to treat saline wastewater

European Desalination Society

A novel Energy Recovery Device/RO test rig targeted to treat & recoup low industrial wastewater flows.

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H2020-Water-1b-2015

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Presentation Overview

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- Energy Recovery Devices
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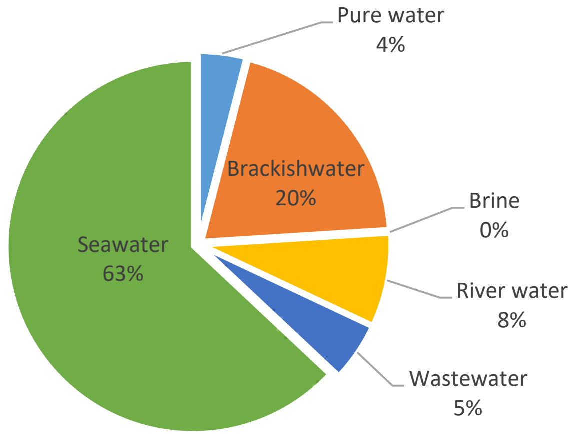
- Innovative Enery Recovery Device
- Membrane Selection – Initial Results
- Test Rig Design – Solidworks Model
- Expected Results
- Future Work
- Questions

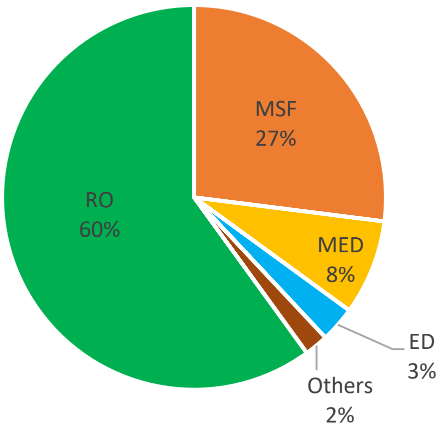
Background and Rationale

Water sources, treatment technologies and demand:

Available water sources

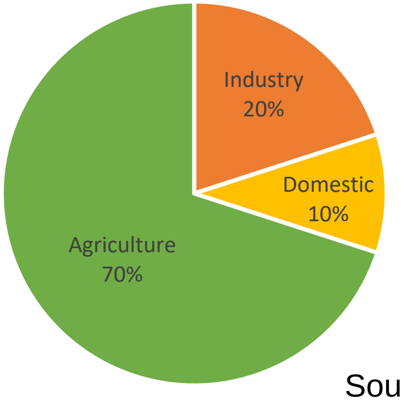


Desalination technology usage: Installed capacity



Source: Adapted from www.desaldata.com

Water demand by sector



Source: Adapted from www.worldometers.info/water/

MED: Multi Effect Distillation

MSF: Multi Stage Distillation

Background and Rationale

Water purification technology	Energy (kWh/m^3)	Reference
Brackish water RO (core process)	1	(Semiat 2008)
Seawater RO with Energy recovery (core process)	2.2 to 2.7	(Semiat 2008, Macedonio, Drioli 2010)
Seawater RO (all auxiliary requirements)	5 to 7	(Blank, Tusel et al. 2007, Macedonio, Drioli 2010)
MSF	16 to 20	(Darwish 2007, Mabrouk, Nafey et al. 2010)
MSF (all auxiliary requirements)	38.5 to 125	(Blank, Tusel et al. 2007)
MED	14	(Mabrouk, Nafey et al. 2010)
MED (all auxiliary requirements)	32 to 122.5	(Semiat 2008)
Ultra-Pure Water RO (all auxiliary requirements)	9.55 to 10.24	(Hu, Wu et al. 2008, SEMI 2005)

- In the 1970s: the specific energy consumption of seawater reverse osmosis (SWRO) ~ 20 kWh/m^3 (MacHarg and Truby, 2004)

Energy Recovery Devices

- Energy recovery devices have been one of several factors leading to lower energy footprint reverse osmosis (RO)

- Energy recovery devices include Pelton/Francis turbines; various pressure exchangers including the Energy Recovery™ PX pressure exchanger and Flowserve DWEER™

- DWEER™ operating flows: 160 m^3/h - 350 m^3/h

- Energy Recovery™ PX pressure exchanger operating flows: PX-30 reported as 4.5 to 6.81 m^3/h

- Is there a device available for relatively low flow rates and is this device economical?

Source: Energy Recovery™ Product catalogues

DWEER™: Dual Work Exchanger Energy Recovery

Sources: http://www.energyrecovery.com/water/px-pressure-exchanger/
https://www.flowserve.com/en/products/pumps/specialty-products/energy-recovery-device/energy-recovery-device-dweer)

Project Overview - SaltGae

Saltgae.eu

- H2020-WATER-1b-2015
- €9.8 million in funding
- 36 months duration
- Holistic and resource efficient approach to industrial wastewater treatment for EC Food & Beverage Industry
- Focused on industries required to treat saline wastewaters e.g. canned fish, meat processing, pickled vegetables, leather tanneries and aquaculture

Source: environmentalleverage.com

Wastewater from the Food & Beverage industry

- Wastewaters with high concentrations of biodegradable organic matter, suspended solids, nutrients (mainly nitrogen and phosphorus) and salt (concentrations up to 15%)

Sources: http://www.environmentalleverage.com/industry/food%20and%20beverage/Food_%20Beverage.html

Project Overview - SaltGae

Objectives of SaltGae:

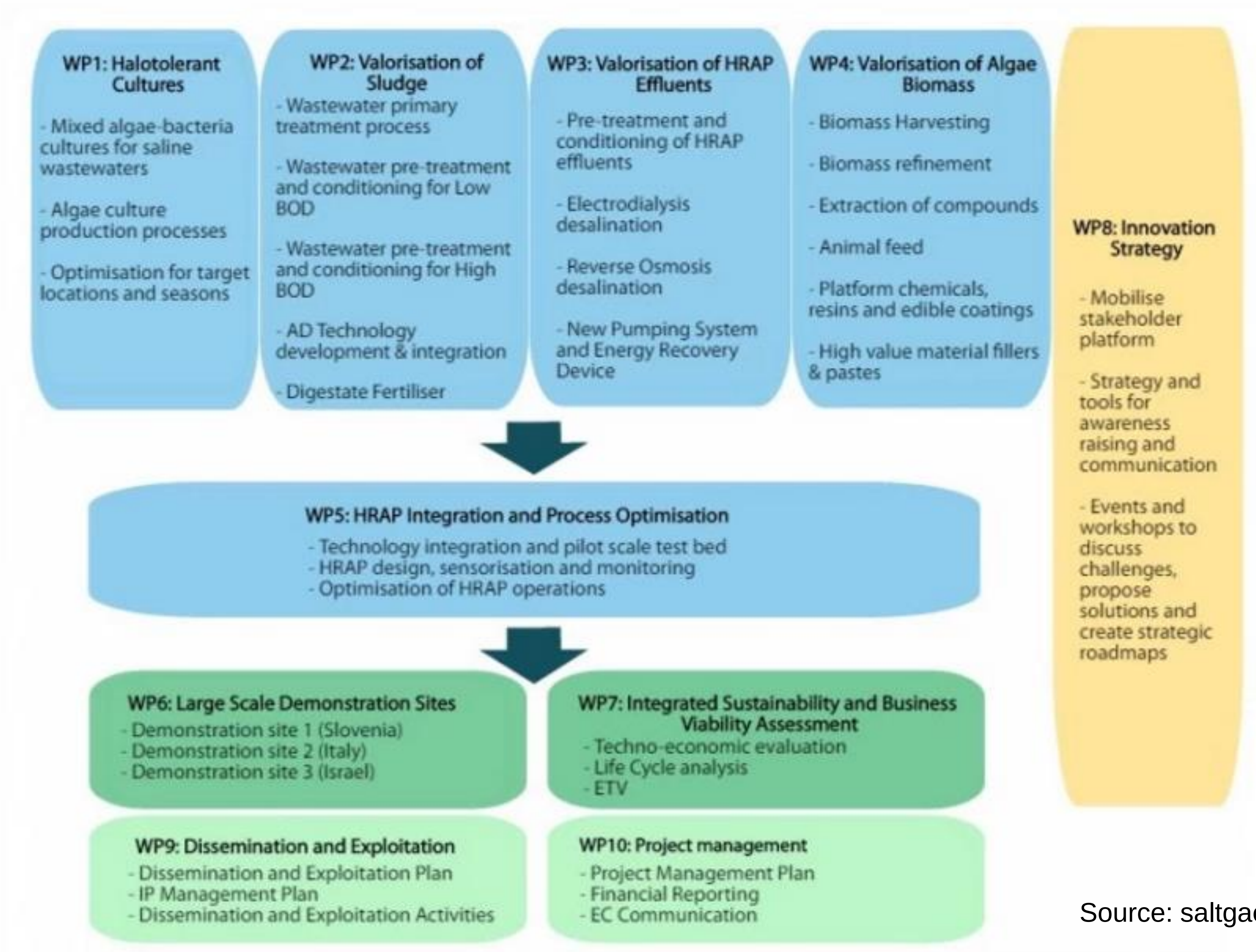
- A techno-economically viable solution for the treatment of saline wastewaters

- Specifically considers three different production processes across three pilot plants:
  - Tannery Plant located in Slovenia (~40 g/l salinity)
  - Whey Plant located in Italy (~10 g/l salinity)
  - Aquaculture Plant located in Israel (~3 g/l salinity)

- SaltGae suite of technologies:
  - High Rate Algal Ponds (HRAPs) hosting synergistic mixtures of halotolerant bacteria and algae
  - Anaerobic digestion
  - Energy efficient desalination to treat HRAP effluents for reuse/recycling

- Valorisation of perceived waste products

SaltGae – WP3



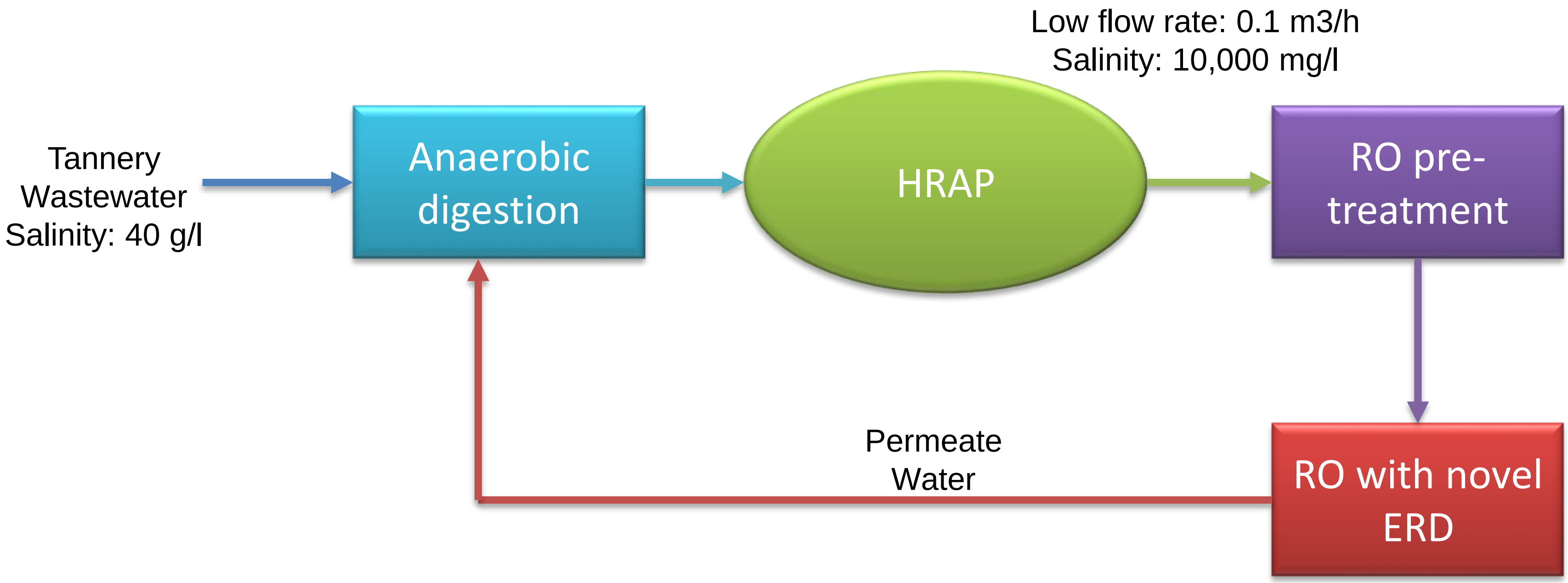
Source: saltgae.eu

SaltGae – WP3

WP3: Valorisation of HRAP effluents

- Pre-treatment and conditioning of HRAP effluents
- Reverse osmosis incorporating novel energy recovery device
- Electrodialysis

Pilot Plant in Slovenia:



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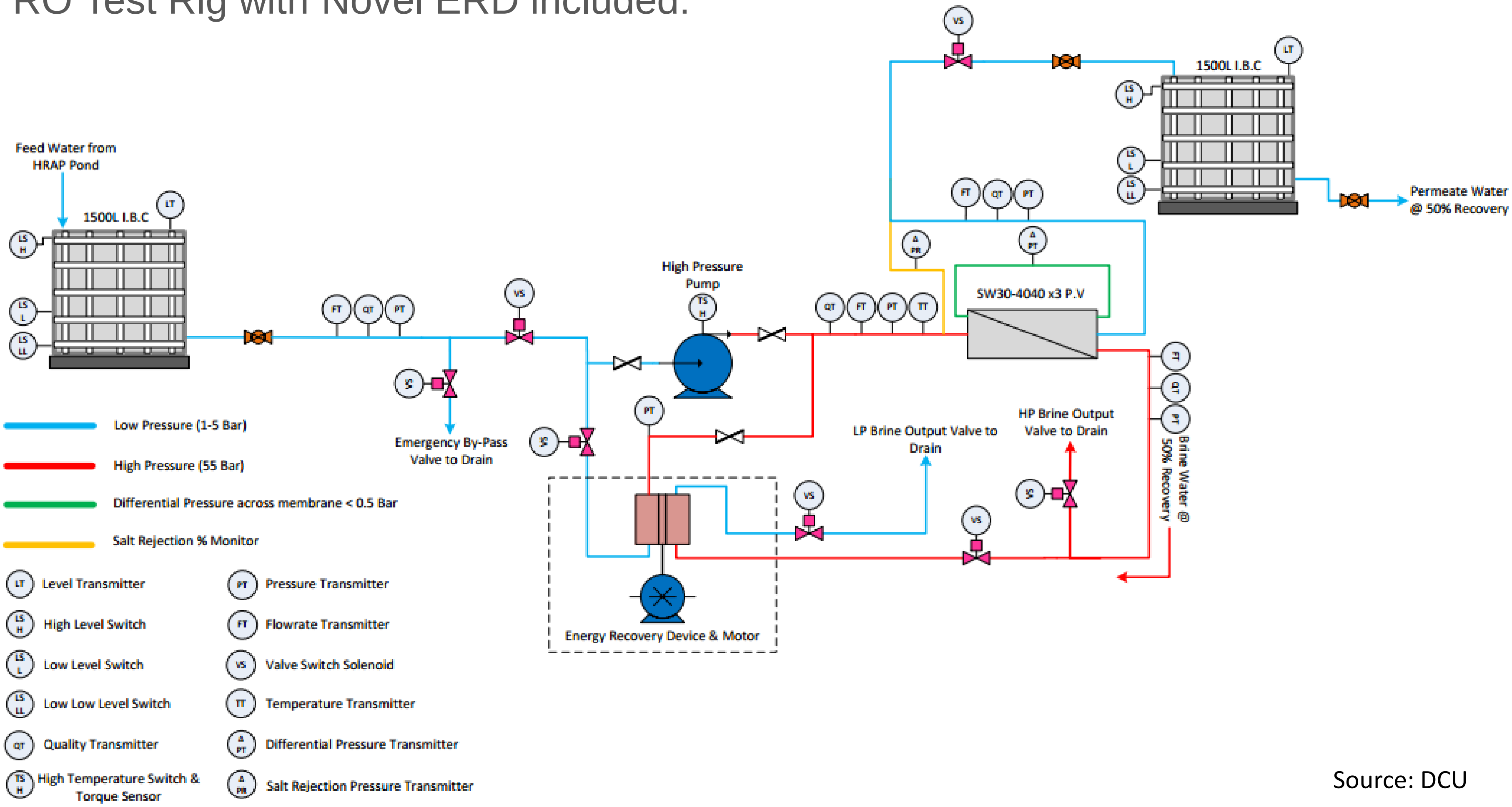
Test Rig Design – P&ID Diagram

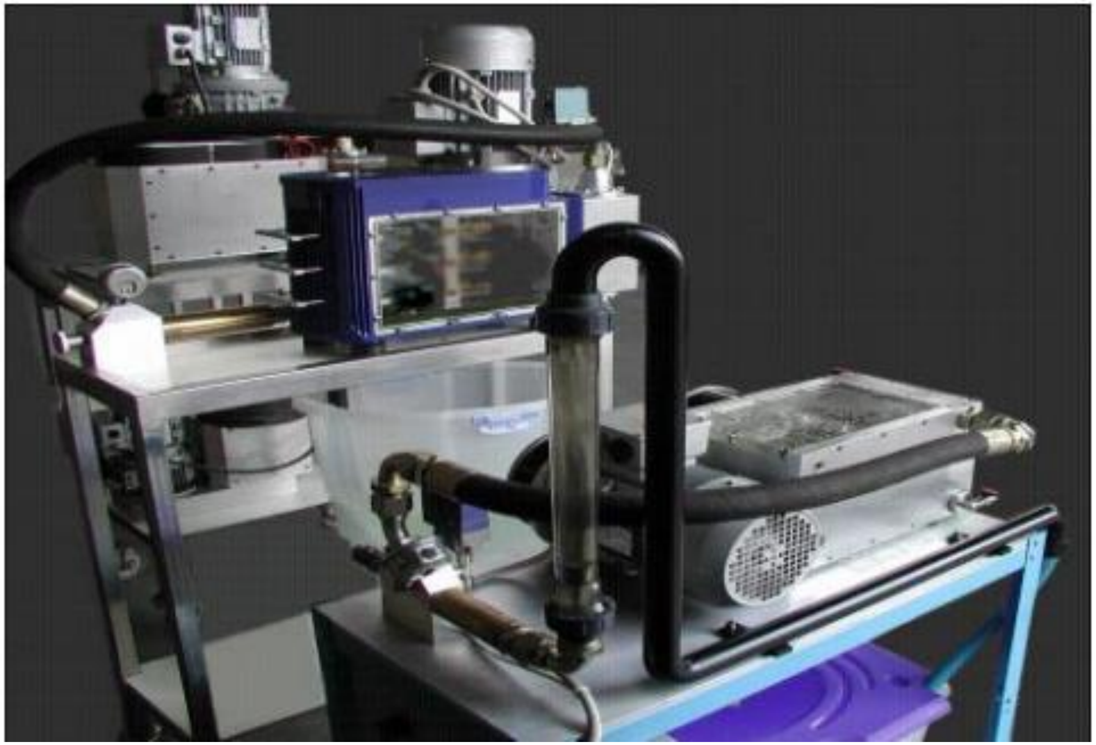
RO Test Rig with Novel ERD included:



Source: DCU

Innovative Energy Recovery Device

One of the various prototypes of the pump/ERD



Source: saltgae.eu

- Initial test rig for the pump/energy recovery device
- Reciprocating, positive displacement pump/ERD
- This innovative ERD is IP Protected and therefore cannot be discussed in detail as of yet

Membrane Selection – Initial Results

Dow ROSA9.1 Software Calculations

Project Information: Site Location: Slovenia

Case-specific: Rev1

System Details

Feed Flow to Stage 1	3.00 m³/h	Pass 1 Permeate Flow	1.50 m³/h	Osmotic Pressure:	
Raw Water Flow to System	3.00 m³/h	Pass 1 Recovery	50.00 %	Feed	7.84 bar
Feed Pressure	62.05 bar	Feed Temperature	25.0 C	Concentrate	15.60 bar
Flow Factor	0.85	Feed TDS	10000.00 mg/l	Average	11.72 bar
Chem. Dose	None	Number of Elements	3	Average NDP	49.72 bar
Total Active Area	22.02 M²	Average Pass 1 Flux	68.14 lmh	Power	5.75 kW
Water Classification: Wastewater with Conventional pretreatment, SDI < 5				Specific Energy	3.83 kWh/m³

Stage	Element	#PV	#Ele	Feed Flow (m³/h)	Feed Press (bar)	Recirc Flow (m³/h)	Conc Flow (m³/h)	Conc Press (bar)	Perm Flow (m³/h)	Avg Flux (lmh)	Perm Press (bar)	Boost Press (bar)	Perm TDS (mg/l)
1	SW30-4040	1	3	3.00	61.71	0.00	1.50	61.13	1.50	68.14	0.00	0.00	31.98

Typical sample of results made in Dow ROSA9.1

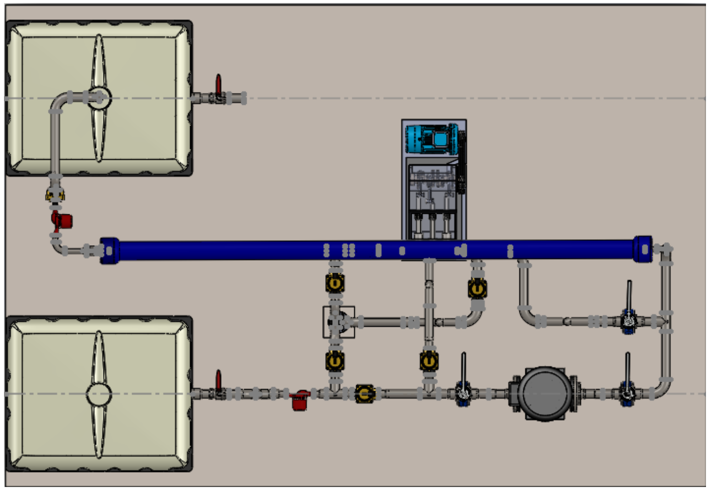
Source: Dow Rosa9.1

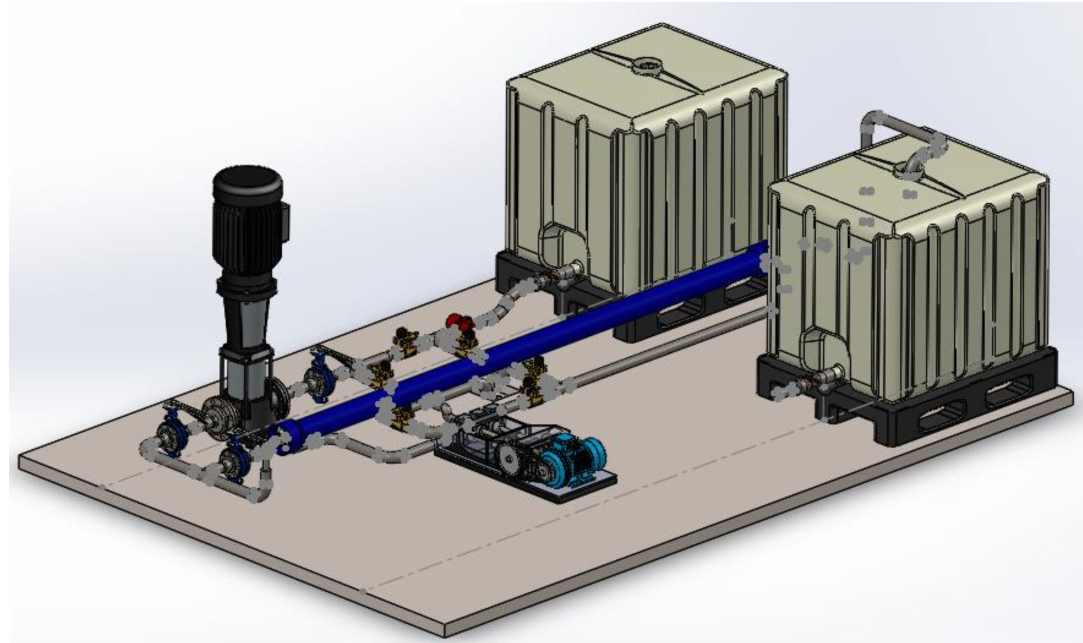
- In order for the new ERD to function optimally, we require sufficient brine line pressure and flow
- This involves a slight trade off between water quality and energy consumption

What does this mean?

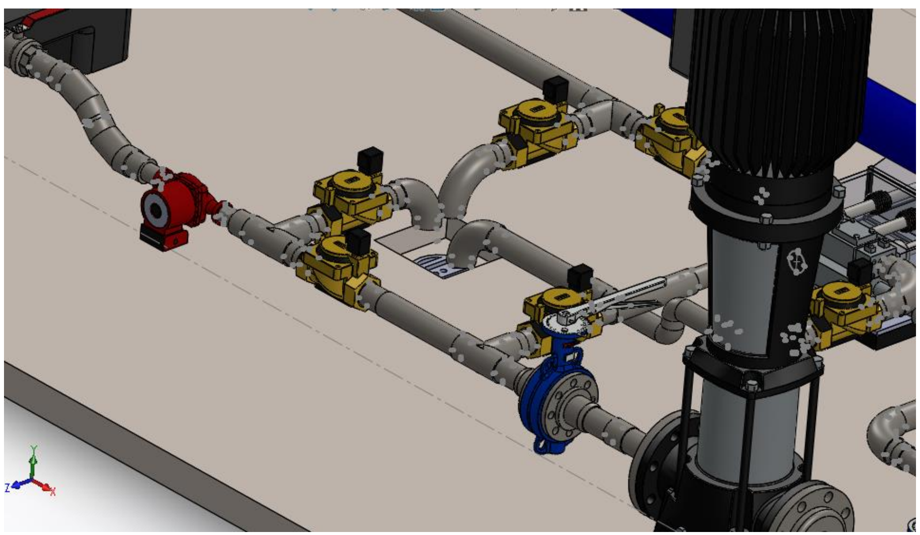
- Higher Energy Recovery from the new ERD for lower flow rates
- Minimum mixing between brine and feed water
- Innovative design minimises flow fluctuations

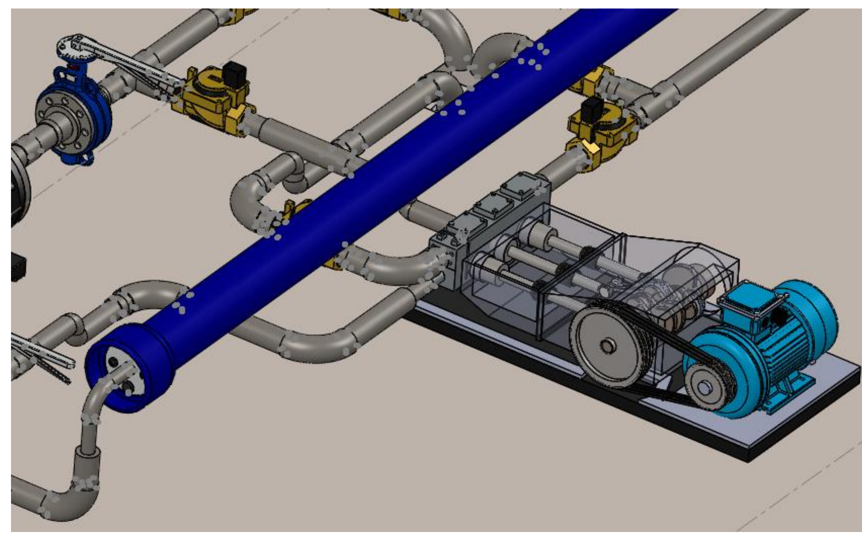
Test Rig Design – Solidworks Model





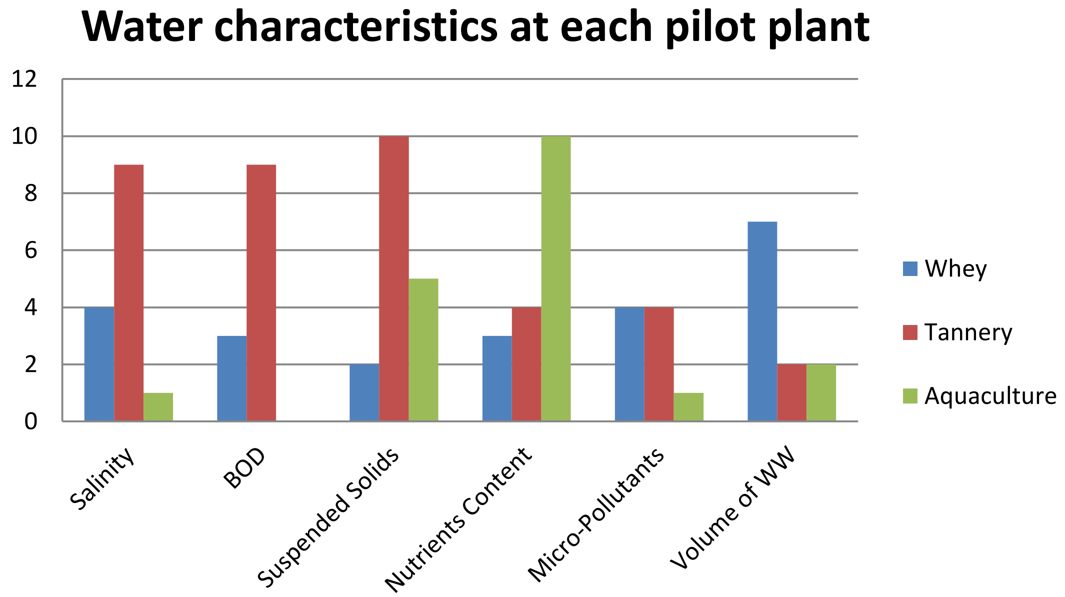
Source: DCU





Optimising Energy Efficency

- Water treatment requirements, and the associated energy requirements to treat water/wastewater to designated standards, vary according to application.
- Typically, the energy requirements are a function of scale, technology, incoming water quality and product water quality requirements.
- The proposed SaltGae design results in a more tailored, combined RO/ERD solution for each given wastewater site which yields more suitable water qualities (due to RO) whilst maintaining a low overall energy consumption (due to ERDs).



Future Work

- Manufacture the RO test rig
- Automation & calibration of RO test rig & respective instrumentation
- Programming of RO test rig's programmable logic control (PLC)
- Test programme for high pressure pump, ERD, incorporating RO
- Optimisation of overall system control strategy
- Once tested and optimised, deploy the system in Israel and Slovenia
- Design system suitable for telemetry for remote monitoring

Questions

Any Questions?

Thank you for listening!

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KOTO

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DCU

PTP SCIENCE PARK

OXIDINE Water Technology

NOVA id FCT Associação para a Inovação e Desenvolvimento da FCT

PRODUMIX

EXTRACTIS

INSTM

iBET Instituto de Biologia Experimental e Tecnológica

EUBIA

enco engineering & consulting

FOOD+i CLUSTER

European Desalination Society

SP your Science Partner

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