2023 KAOHSIUNG

In Conjunction With
9th IWA-ASPIRE
Conference & Exhibition 2023

Taiwan International Water Forum
Vision for Water
水未來

Innovation in RO seawater desalination: process optimization and minimization of the energy consumption.

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Director of Innovation
Water
acciona

THE WATER ROLE IN DEVELOPMENT

Access to water will remain a challenge in a water stressed world.

WATER ACCESS AND SANITATION

Population growth is challenging basic water access at our current path.

In 2030, at current rates:

- 18.6% of the population will lack safely managed **drinking water.**
- 32.5% of the population will lack safely **managed sanitation.**
- 22% of the population will lack **basic hand hygiene facilities.**
- More than **half the world's population** will be at risk of **water stress.**

DESALINATION FACTS AND FIGURES

The predominant desalination technology is **reverse osmosis.**

Countries with the world´s largest desalination water production capacity:

Midle East
lead by Saudi
Arabia

Spain
Largest market
in Europe

There are aproximately

18.000
desalination plants

in de world.

5.800
million USD

of desalination **CAPEX** in 2022.

$

8.200
million USD

of desalination **OPEX** in 2022.

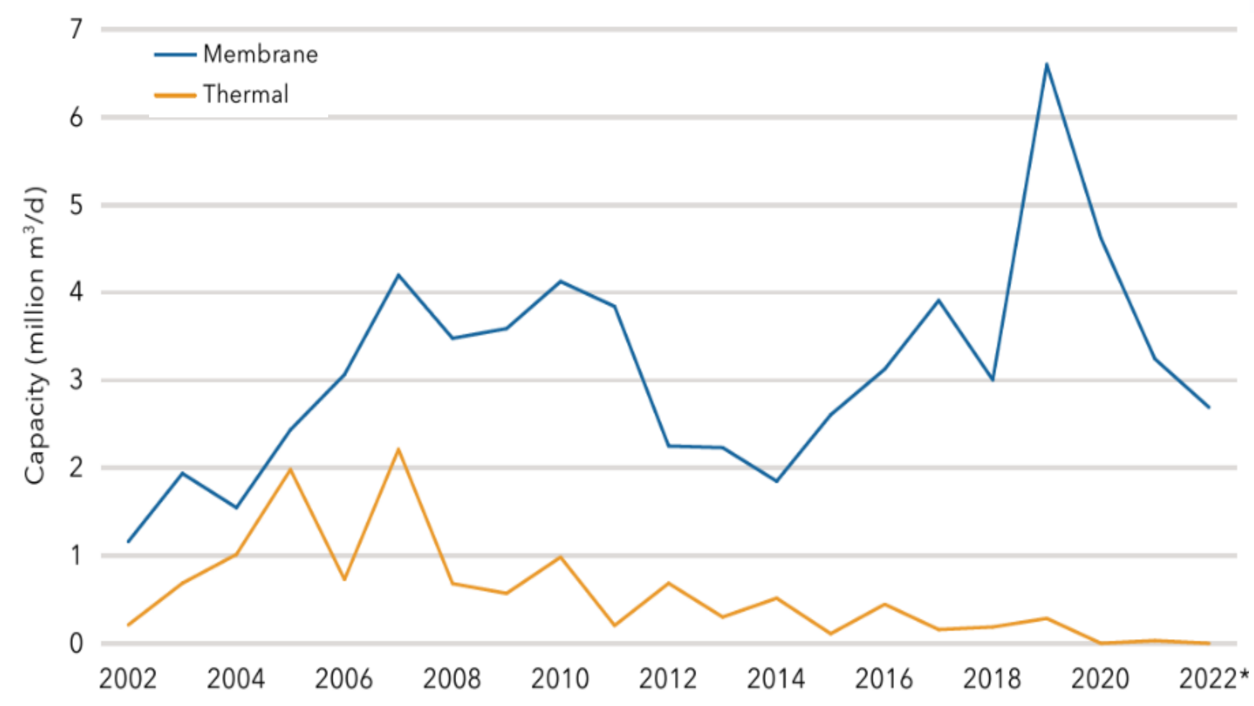
$

5
million m3/D

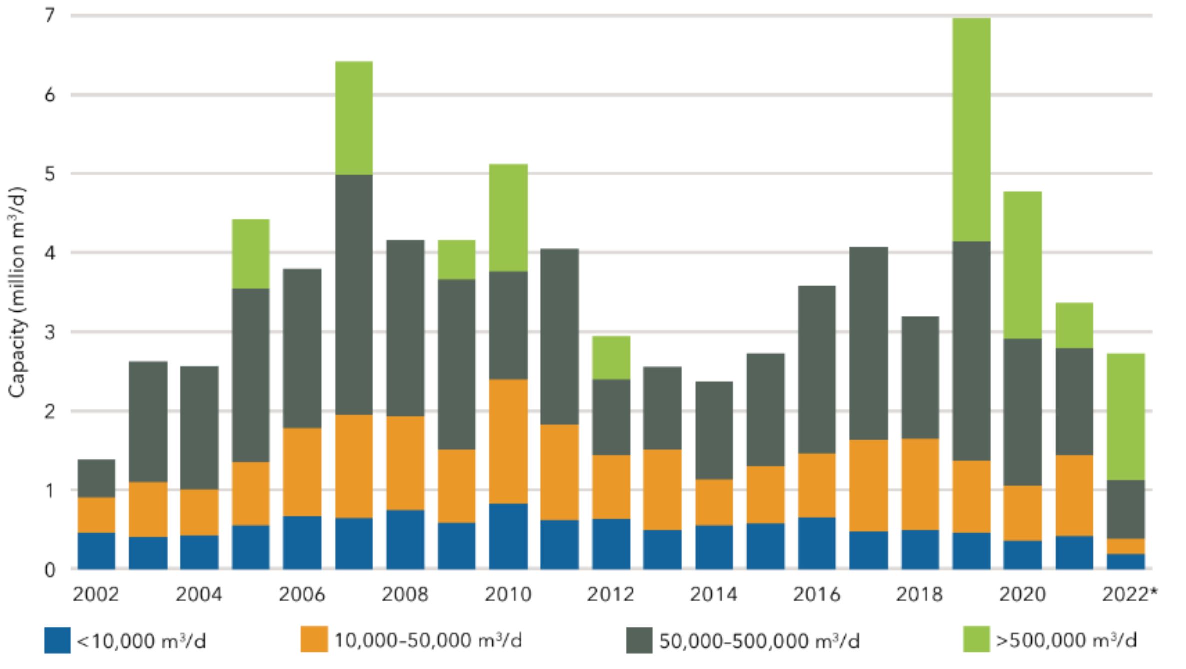
of desalination **contracted capacity** in 2022.

Source: GWI and DesalData

RO DESALINATION AS MAIN TECHNOLOGY



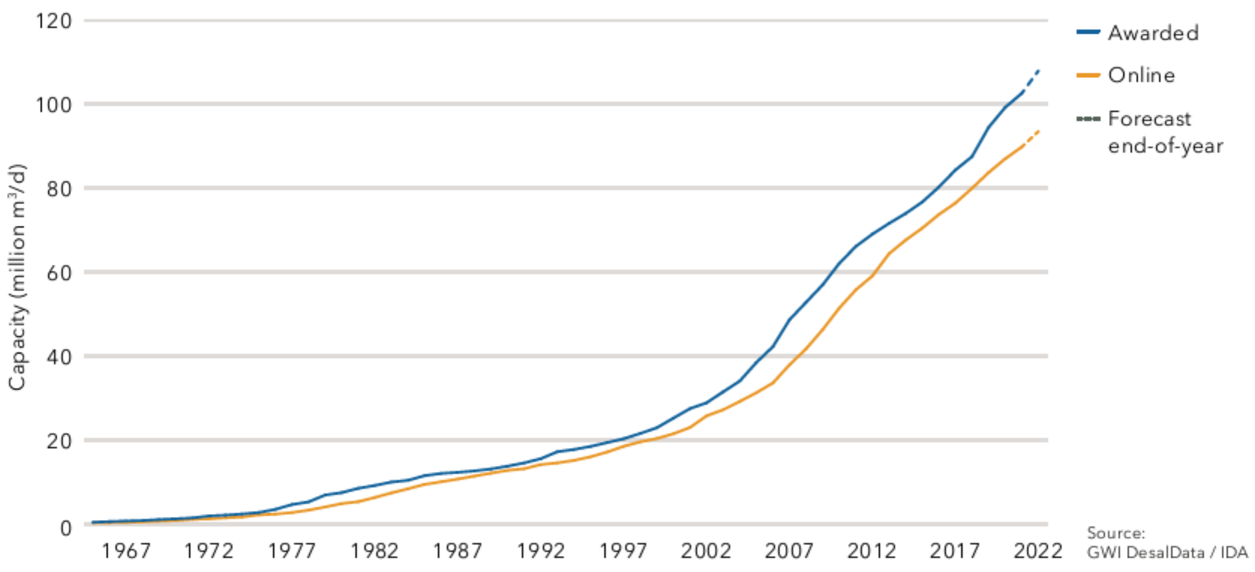
Additional contracted desalination capacity by technology (2002 - 2022).

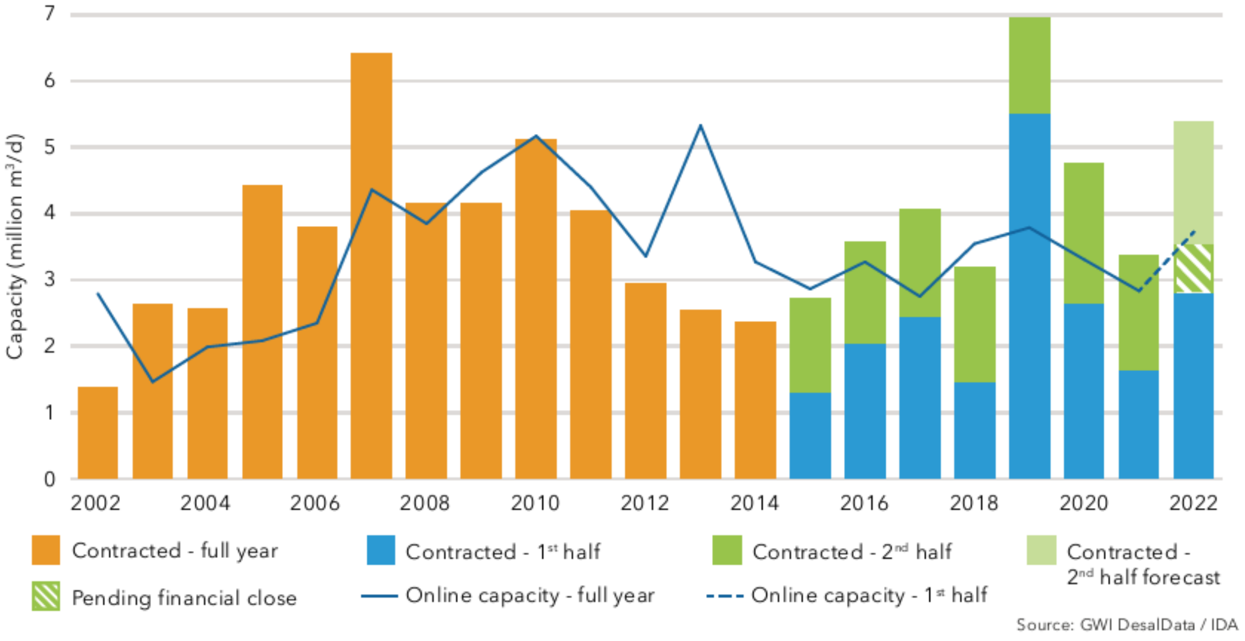


Contracted desalination capacity by plant size (2002-2022)

Source: GWI and DesalData

DESALINATION AS AN ALTERNATIVE WATER SOURCE.



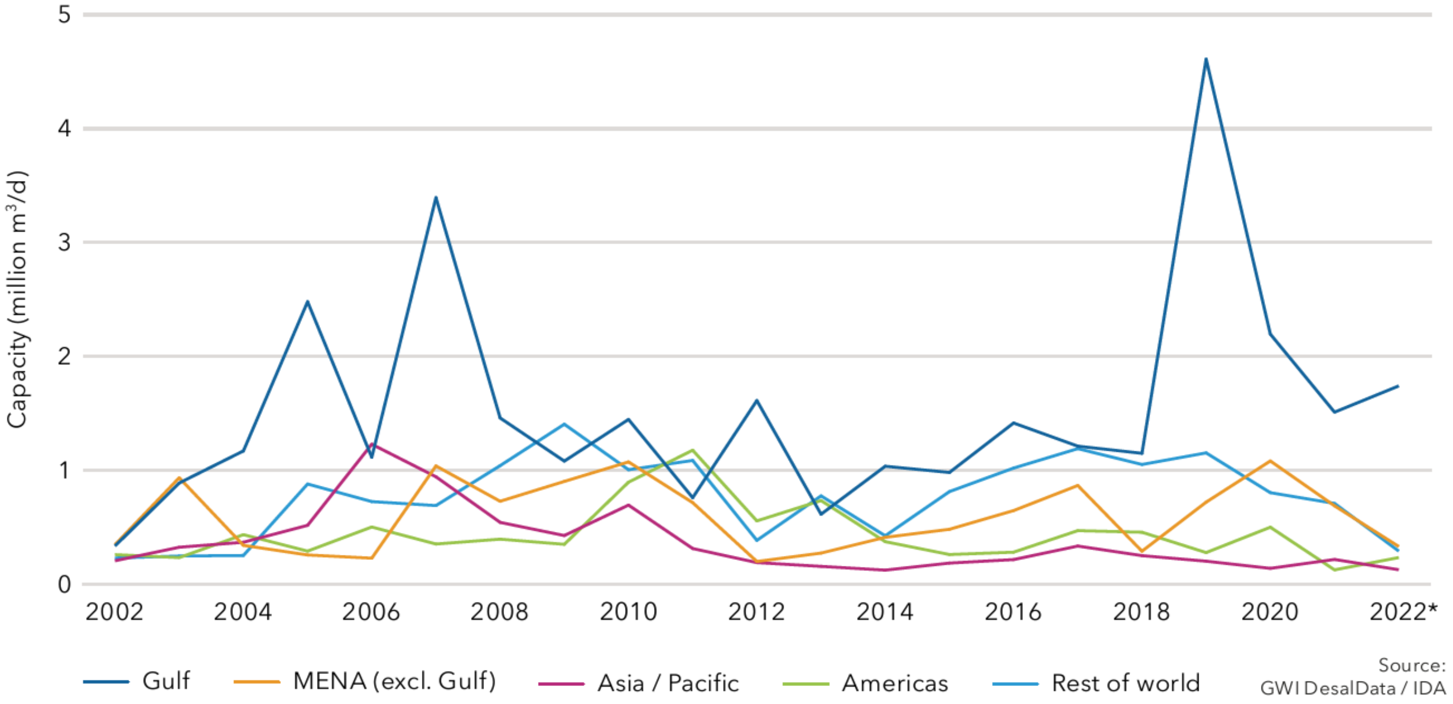


Cumulative contracted and online capacity since 1967

Incremental contracted and online capacity by year since 2002

Source: GWI and DesalData

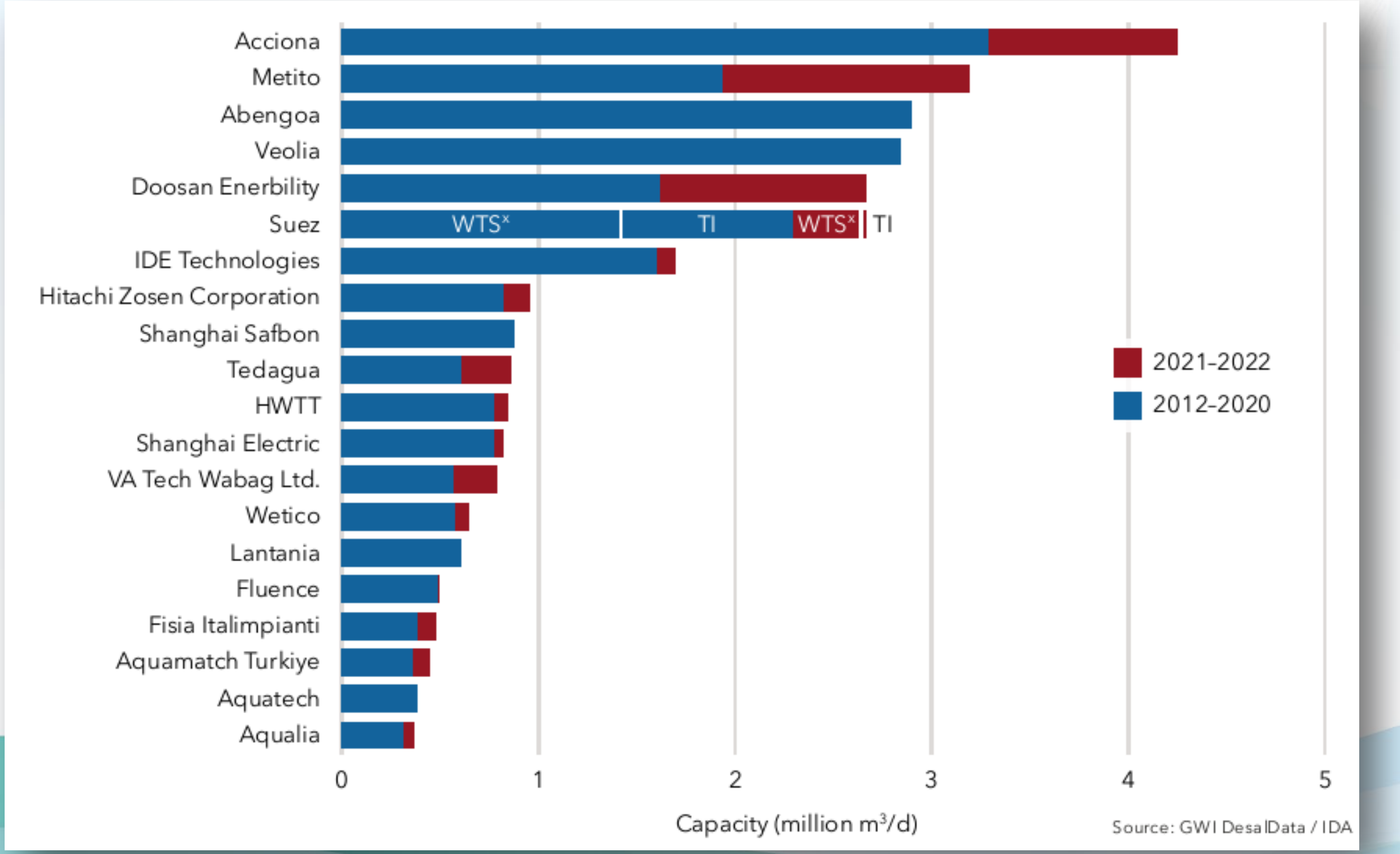
WATER SCARCITY AS A DRIVER



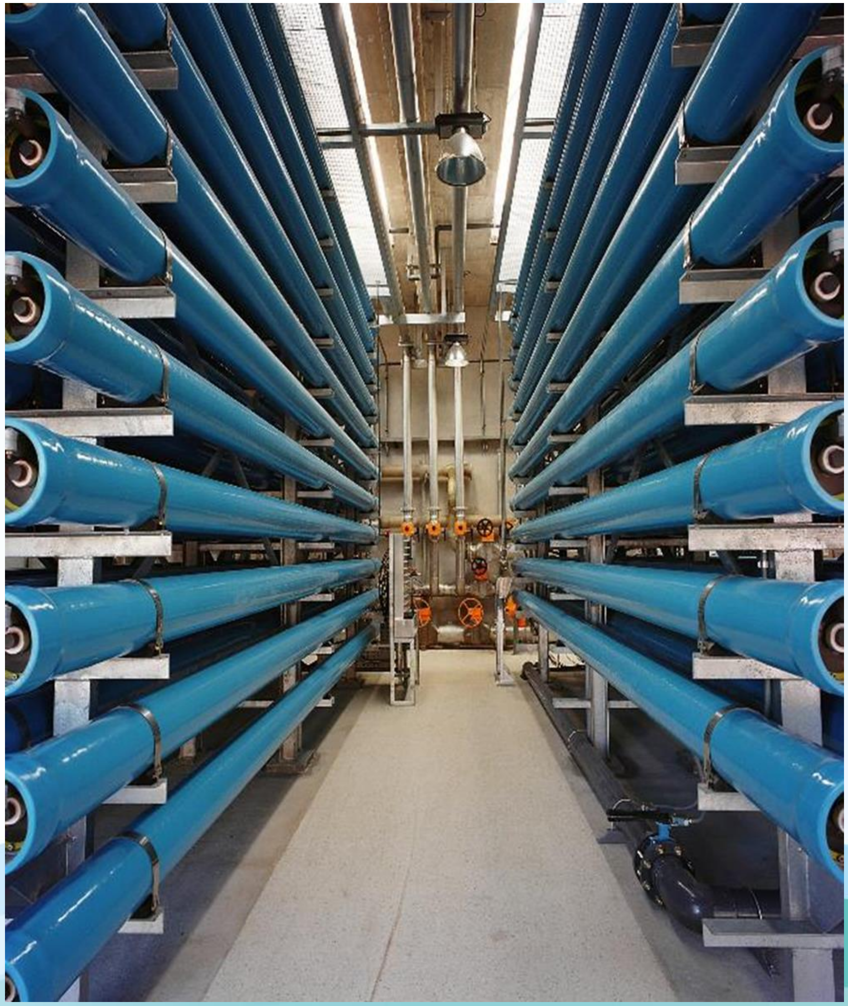
Annual contracted seawater desalination capacity by región (2002 - 2022)

Source: GWI and DesalData

TOP 20 PLANT SUPPLIERS BY AWARDED DESALINATION CAPACITY (2012–2022)

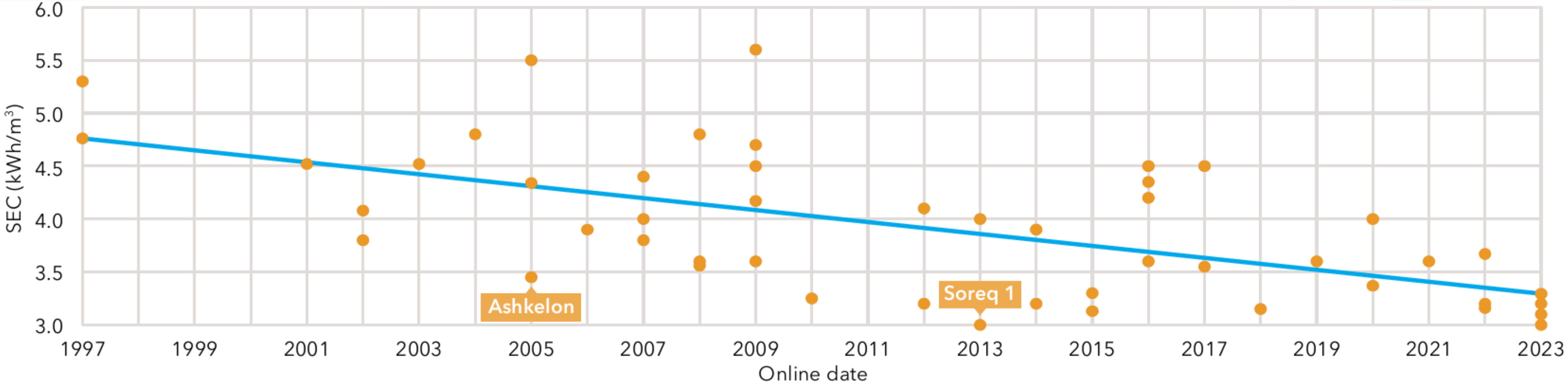


Source: GWI DesalData / IDA



Source: GWI and DesalData

RO SEAWATER SPECIFIC ENERGY CONSUMPTION (SEC)



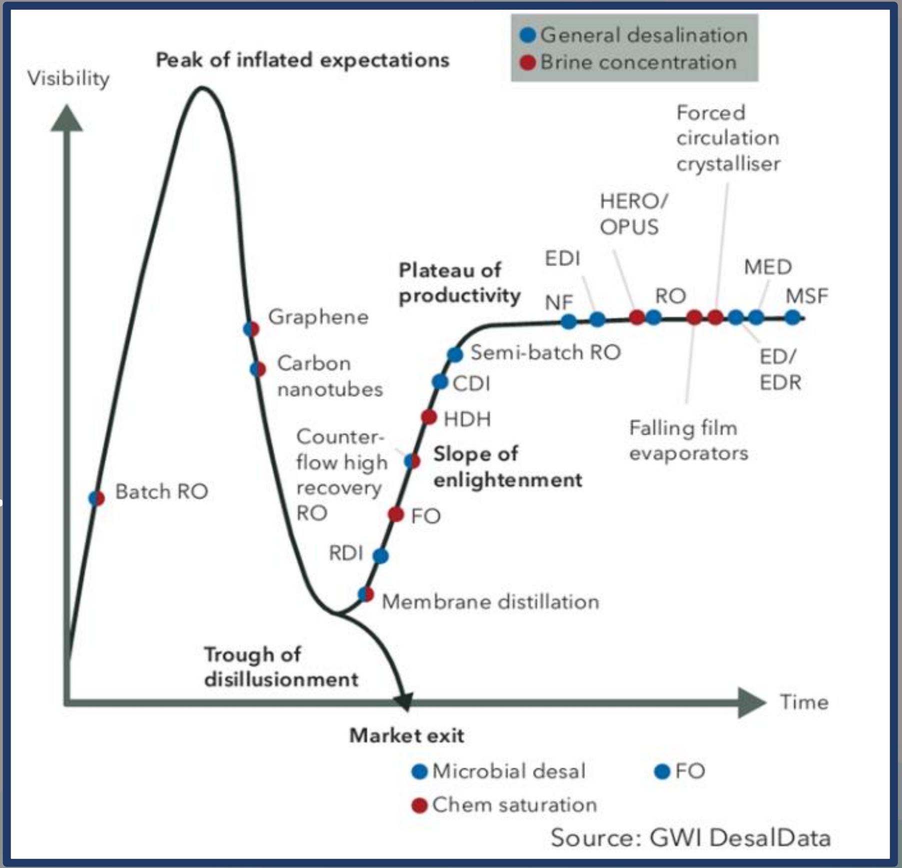
Energy consumption per m^3 of water in desalination projects 1997-2023.

Source: GWI and DesalData

INNOVATION TRENDS

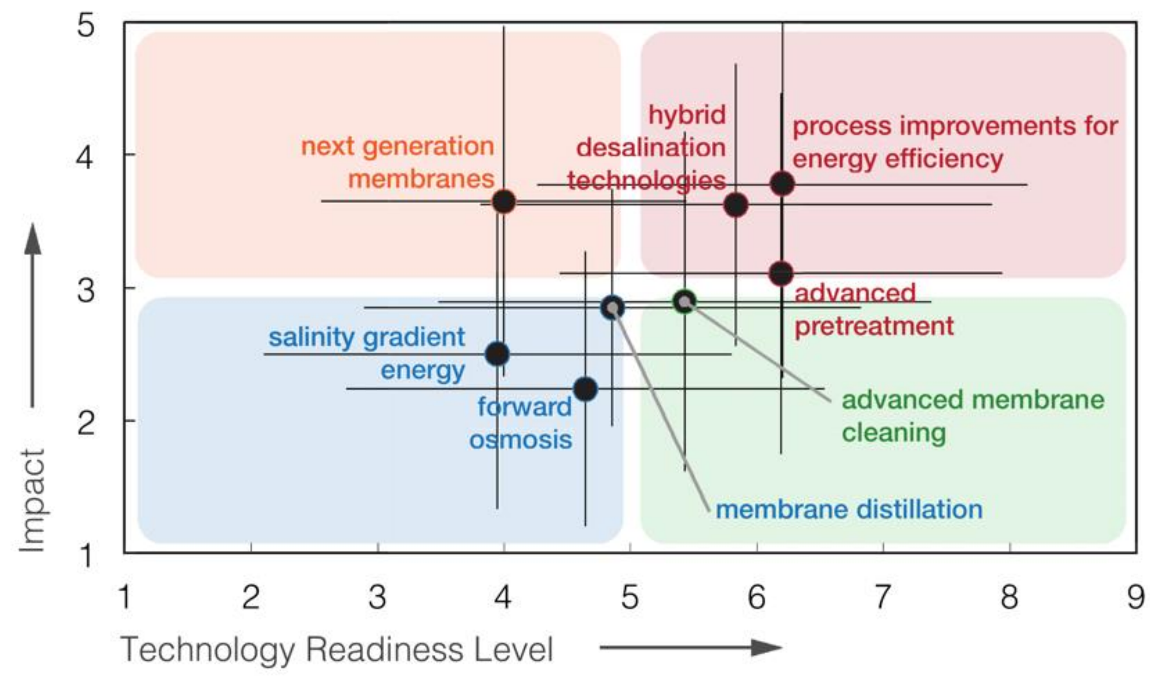
Innovation is focused on:

- **Economies** of scale.
- **Higher flux** membranes.
- **Higher recovery** rates.
- New process configurations.
- Renewable energy application.
- Addressing biofouling.
- Brine concentration.
- Digital Innovation.

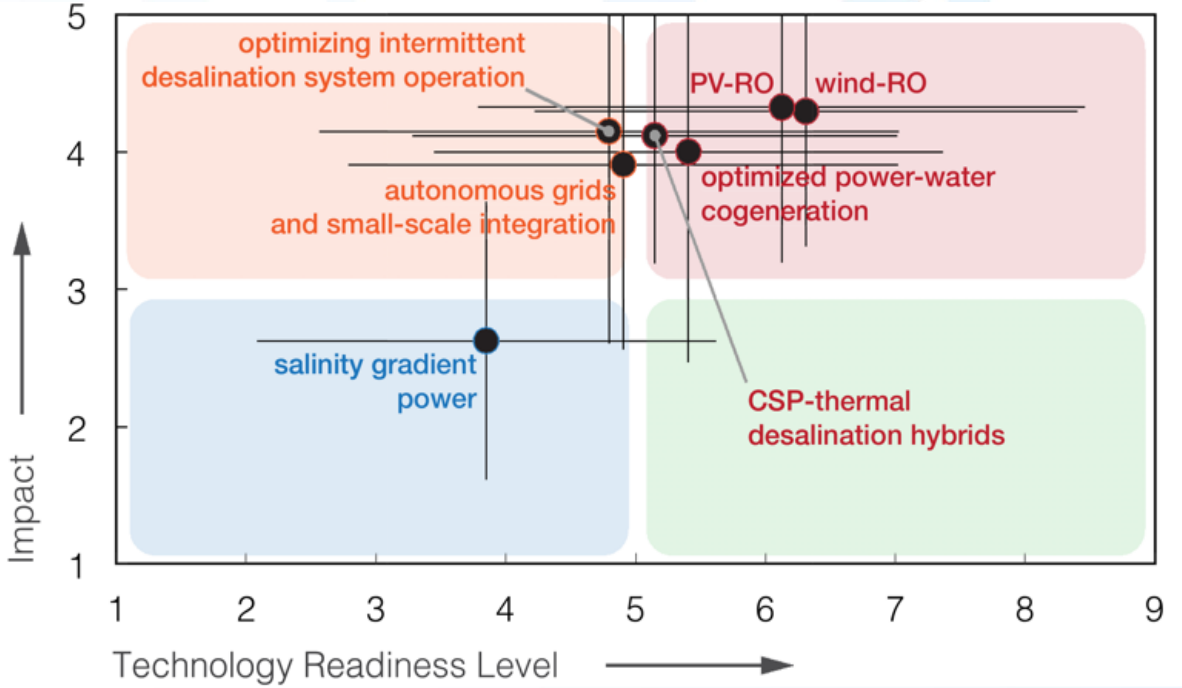


Source: GWI DesalData

TECNOLOGIES FOR GREENHOUSE GASES REDUCTION



GHG Reduction versus Technology Readiness Level for Desalination Technologies.

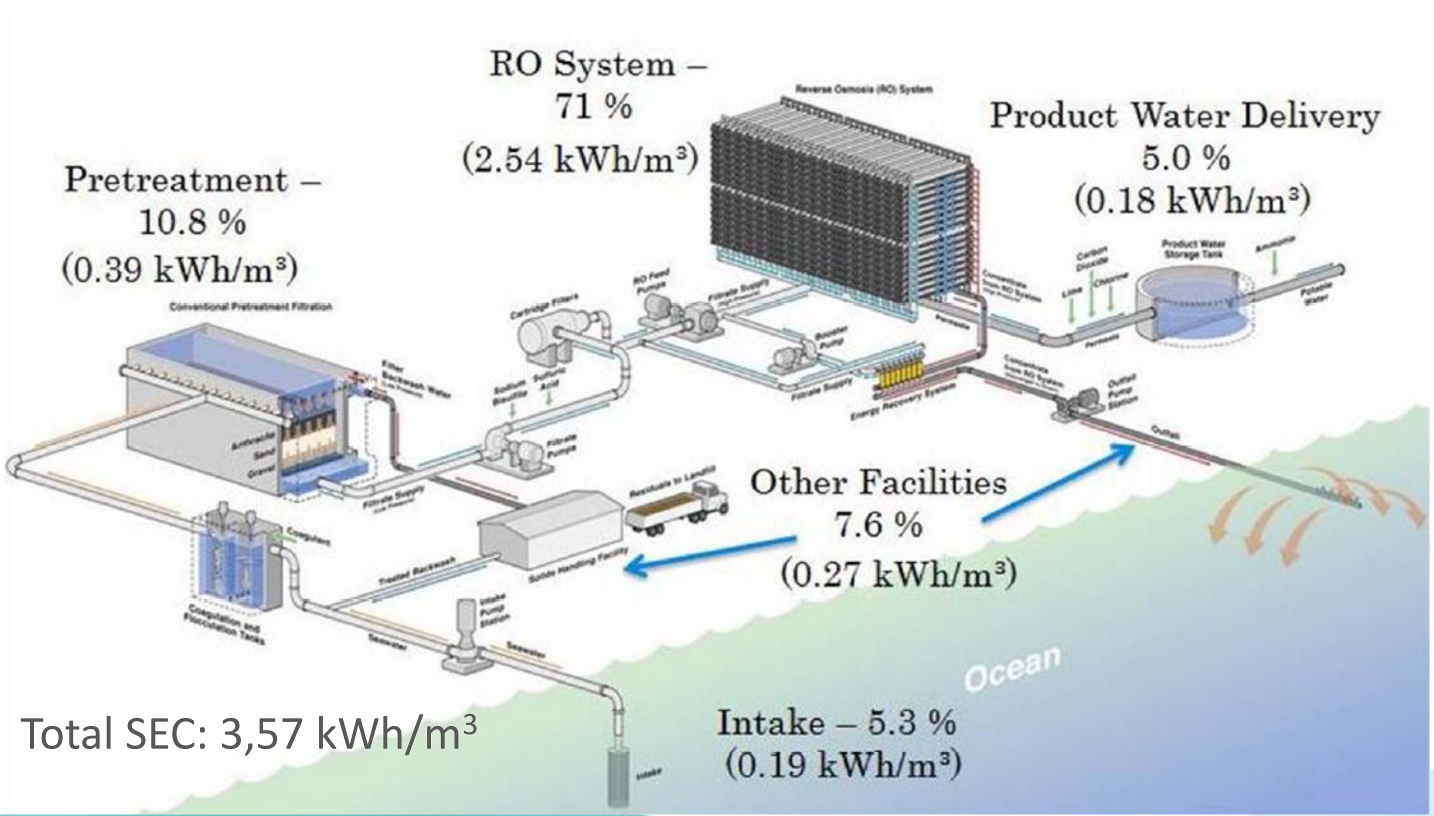


GHG Impact versus Technology Readiness Level for Several Low Carbon Desalination Systems.

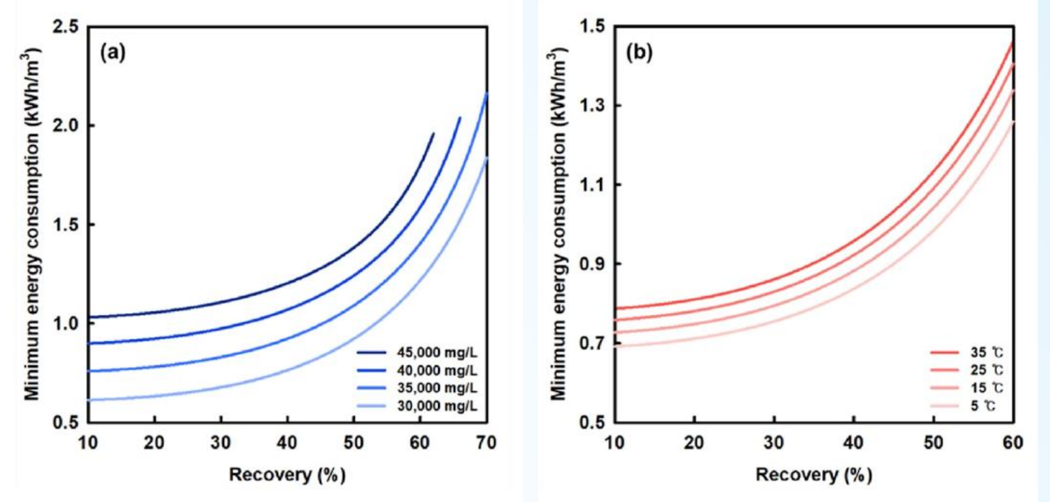
REFERENCES

- Low Carbon Desalination: Status and Research, Development and Demonstration Needs Report. Development, and Demonstration Needs. Report of a Workshop conducted at the Massachusetts Institute of Technology (2016).
- Lienhard, John H., Gregory P. Thiel, David M.Warsinger, and Leonardo D. Banchik eds .

ENERGY USE BREAKDOWN AND POSSIBILITIES TO REDUCE SEC



Total SEC: 3,57 kWh/m^3



RO system ≈ 71% of the total SEC.

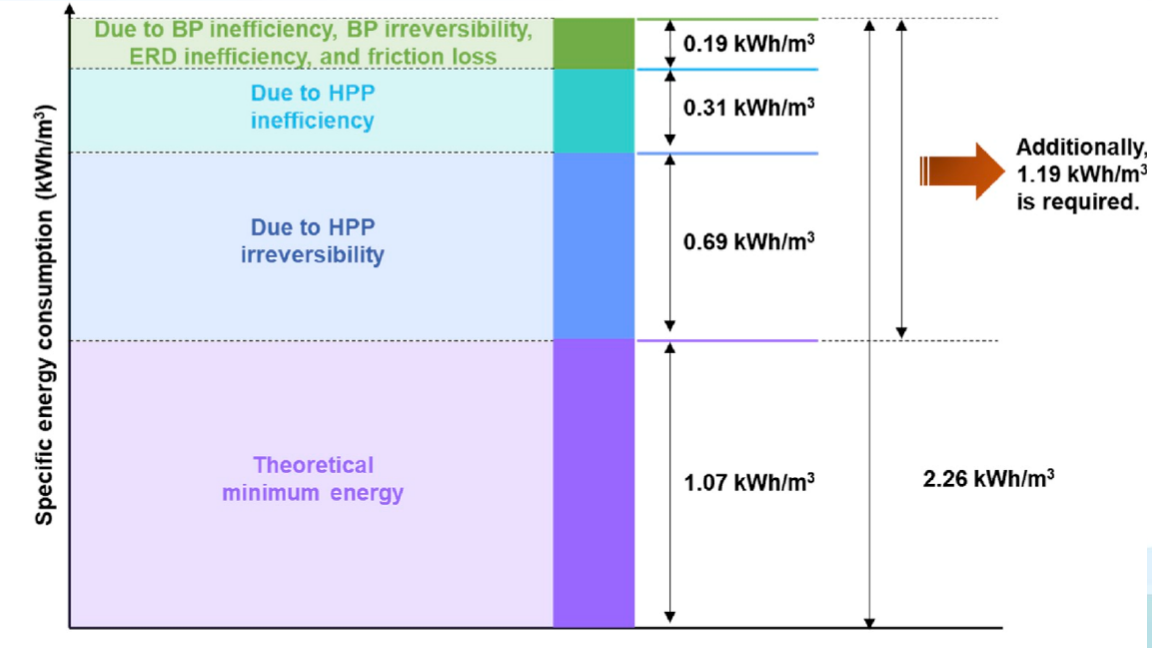
For 50% recovery, theoretical minimum SEC = 1.1 kWh/m^3

Minimum SEC increases with:

- salinity.
- recovery.
- Temperature.

ENERGY USE BREAKDOWN AND POSSIBILITIES TO REDUCE SEC

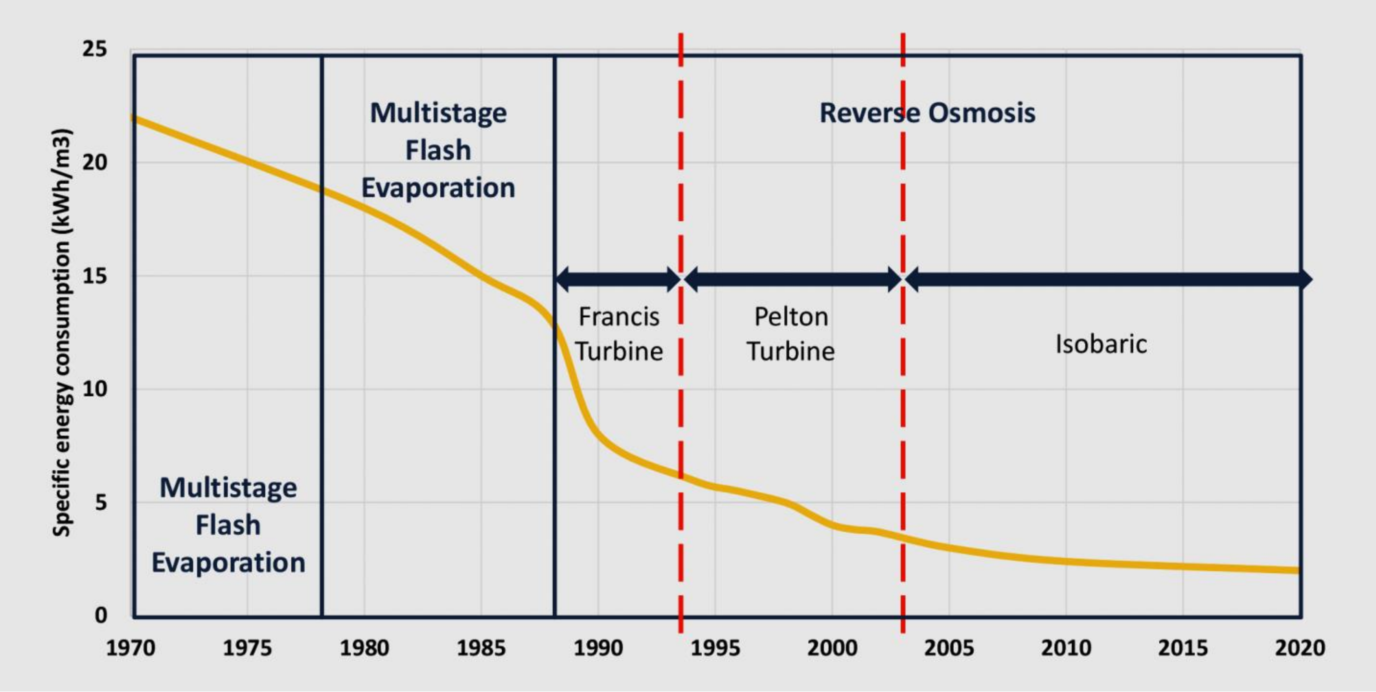
- Minimize irreversibility in HPP (maximum available margin = 0.69 kWh/m^3). Multi-stage, batch and semi-batch.
- Decrease osmotic pressure (maximum available margin = 1.07 kWh/m^3). Osmosis assisted process.
- Reduce HPP, BP and ERD inefficiencies (maximum available margin = 0.31 + 0.19 kWh/m^3).
- Recover osmotic pressure from RO concentrate (maximum available margin = 0.21 – 0.56 kWh/m^3).

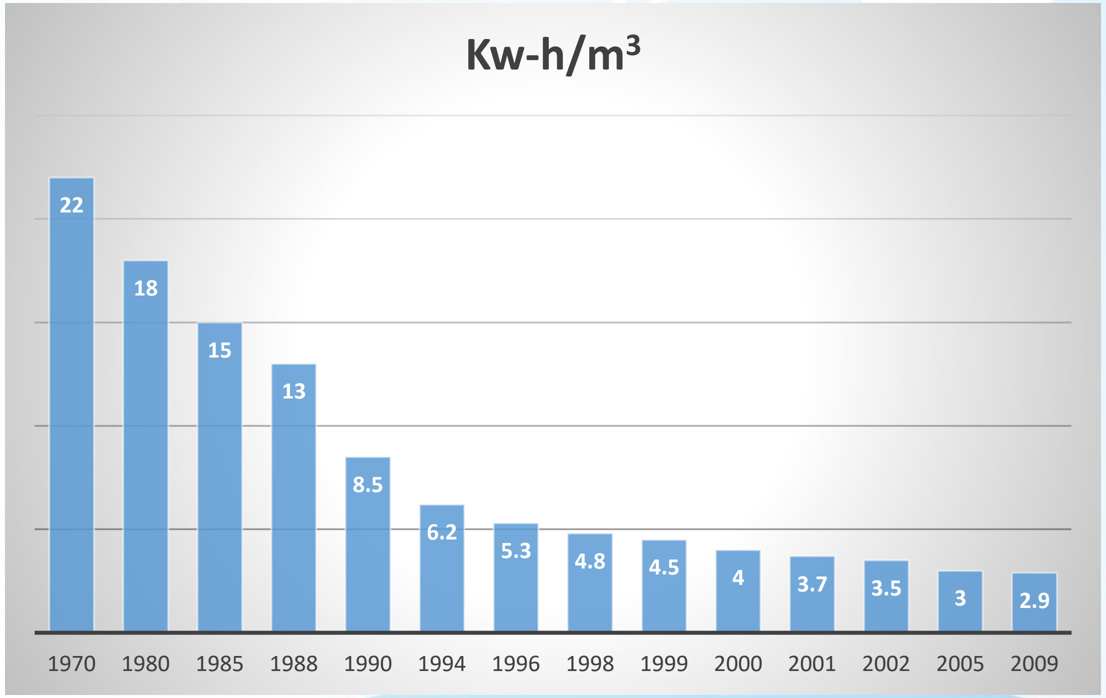


Theminimum value of 2.26 kWh/m3 is obtained under the following conditions:

Parameter	Value
Pump efficiency	85%
ERD efficiency	95%
Feed concentration	35,000 mg/L
Feed temperature	25ºC
Feed flowrate	20,000 m3/d
Number of Ro module in series	7
Total recovery	50%
RO module	FILMTEC SW30XLE-400

ENERGY RECOVERY DEVICES (ERD)

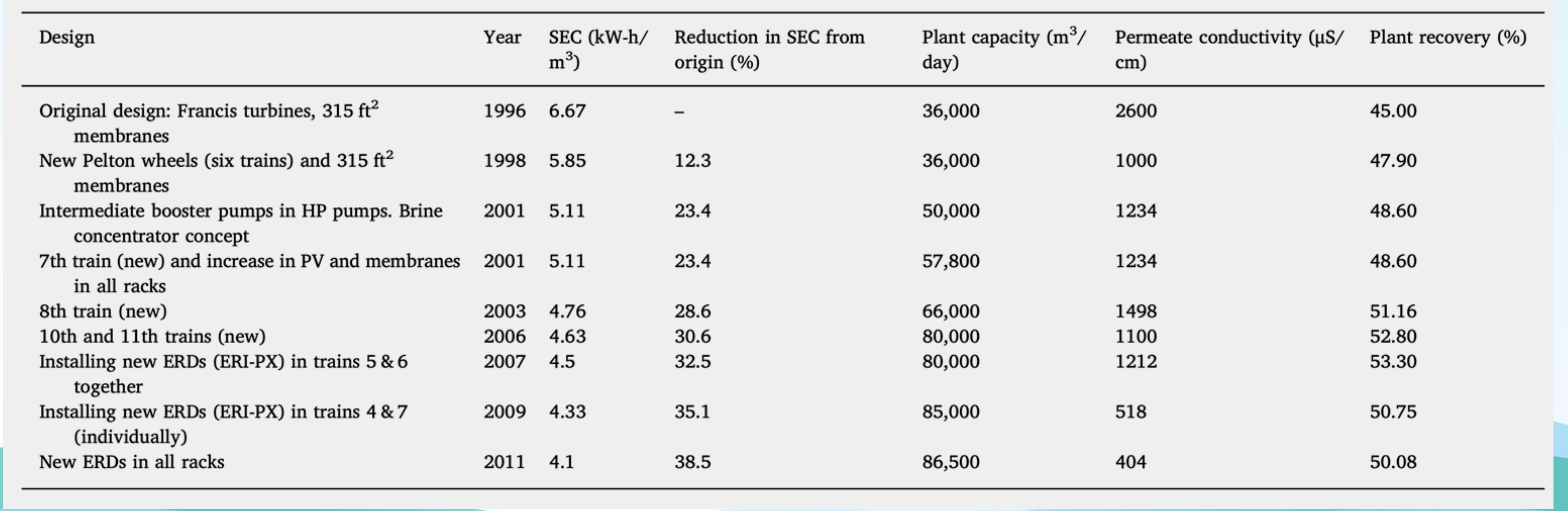




Evolution of average SEC in Spanish seawater desalination plants (AEDyR 2009).

SWRO PLANTS RETROFITING

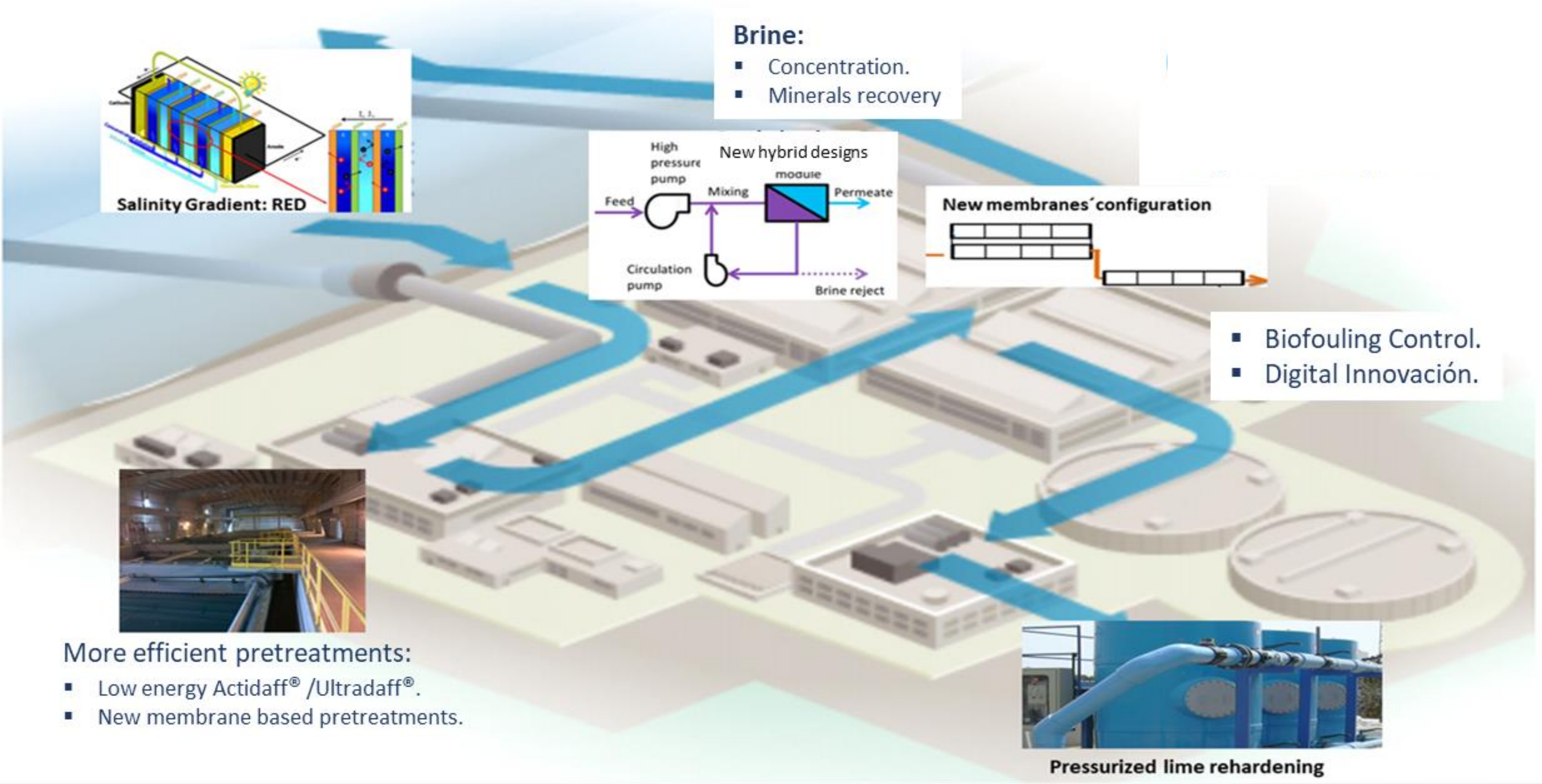
Historical development of the energy consumption at Las Palmas III SWRO (Spain) (Desalination 427(2018)1-9)



Design	Year	SEC (kW-h/m^3)	Reduction in SEC from origin (%)	Plant capacity (m^3/day)	Permeate conductivity (μS/cm)	Plant recovery (%)
Original design: Francis turbines, 315 ft^2 membranes	1996	6.67	–	36,000	2600	45.00
New Pelton wheels (six trains) and 315 ft^2 membranes	1998	5.85	12.3	36,000	1000	47.90
Intermediate booster pumps in HP pumps. Brine concentrator concept	2001	5.11	23.4	50,000	1234	48.60
7th train (new) and increase in PV and membranes in all racks	2001	5.11	23.4	57,800	1234	48.60
8th train (new)	2003	4.76	28.6	66,000	1498	51.16
10th and 11th trains (new)	2006	4.63	30.6	80,000	1100	52.80
Installing new ERDs (ERI-PX) in trains 5 & 6 together	2007	4.5	32.5	80,000	1212	53.30
Installing new ERDs (ERI-PX) in trains 4 & 7 (individually)	2009	4.33	35.1	85,000	518	50.75
New ERDs in all racks	2011	4.1	38.5	86,500	404	50.08

Desalination 427(2018)1-9

WHAT WE DO IN INNOVATION?



Brine:
- Concentration.
- Minerals recovery

Salinity Gradient: RED

New membranes´configuration

- Biofouling Control.
- Digital Innovación.

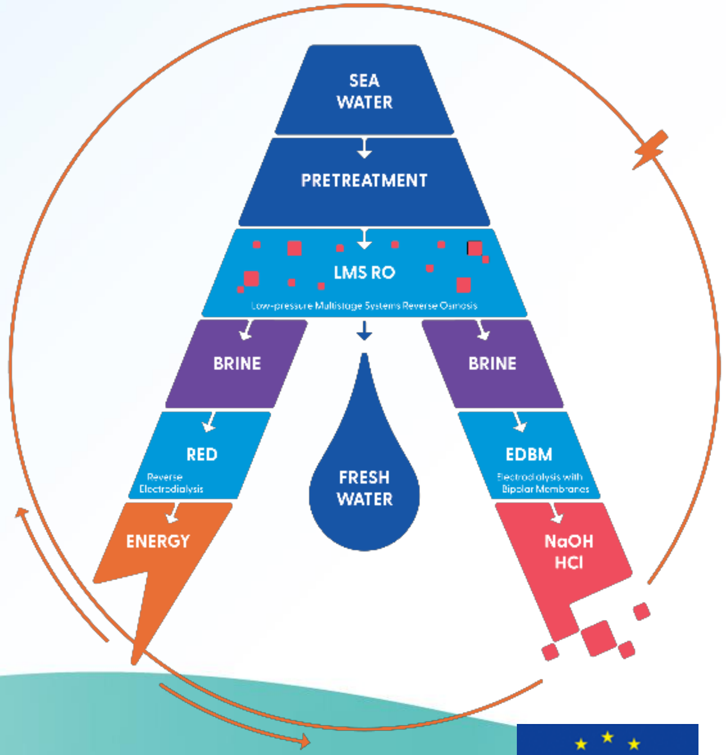
More efficient pretreatments:
- Low energy Actidaff® /Ultradaff®.
- New membrane based pretreatments.

Pressurized lime rehardening

LIFE | DREAMER

- To **increase the water recovery** of desalination systems up 60%.
- To **reduce 50% the internal use of chemicals** used in desalination (specifically, reagents for remineralisation and those for RO membrane fouling prevention). **Currently remin capacity: Ca 6-15 ppm & Mg 20 ppm**
- To **reduce the specific energy consumption** (and associated greenhouse gas emissions) of desalination 10% thanks to the increased water recovery and the optimized operation of the treatment and recovery systems.
- Valorisation of P. Biofouling potential reduction.

INDESAL

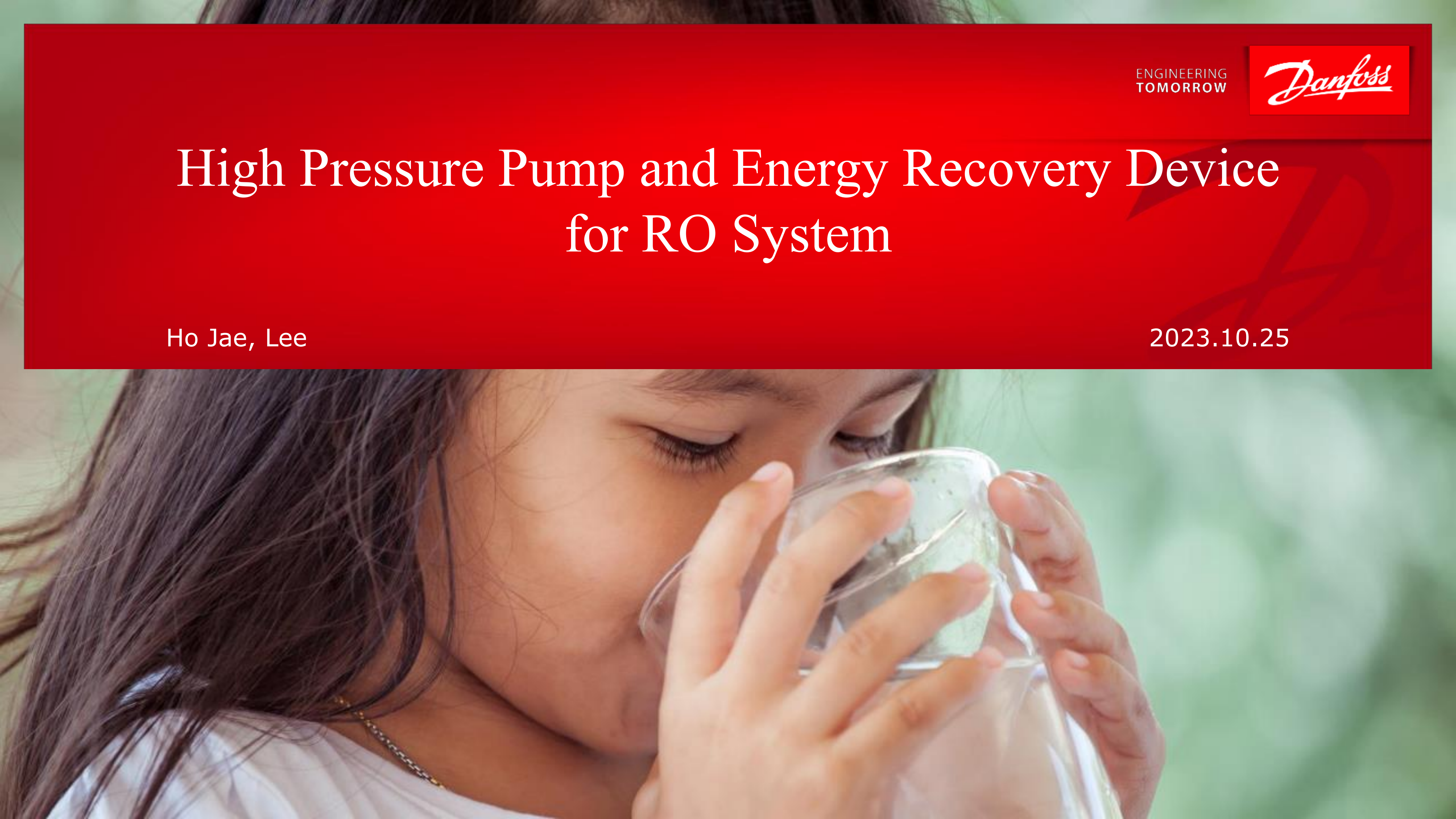


Generating renewable energy from brines through the Reverse Electrodialysis (RED), decreasing energy requirements of the desalination process (up to ~0.1kWh/m3).

Obtaining high quality fresh water via the highly energy efficient low pressure multistage Reverse Osmosis (LMS RO) process with reduced energy consumption (up to ~0.2kWh/m3).

Recovering resources from brines using Electrodialysis with Bipolar Membranes **(EDBM)**, reducing resource use by producing all the required NaOH and HCl for RO cleaning and pH adjustment.

Thank you!



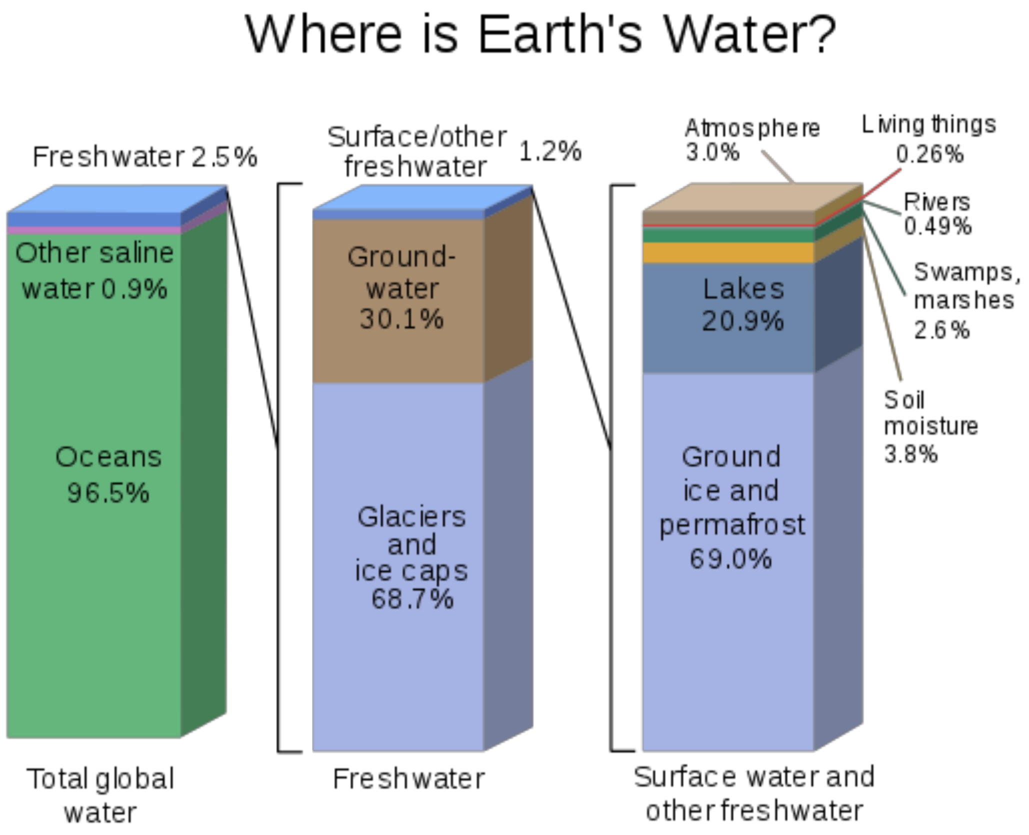
ENGINEERING
TOMORROW

High Pressure Pump and Energy Recovery Device for RO System

Ho Jae, Lee

2023.10.25

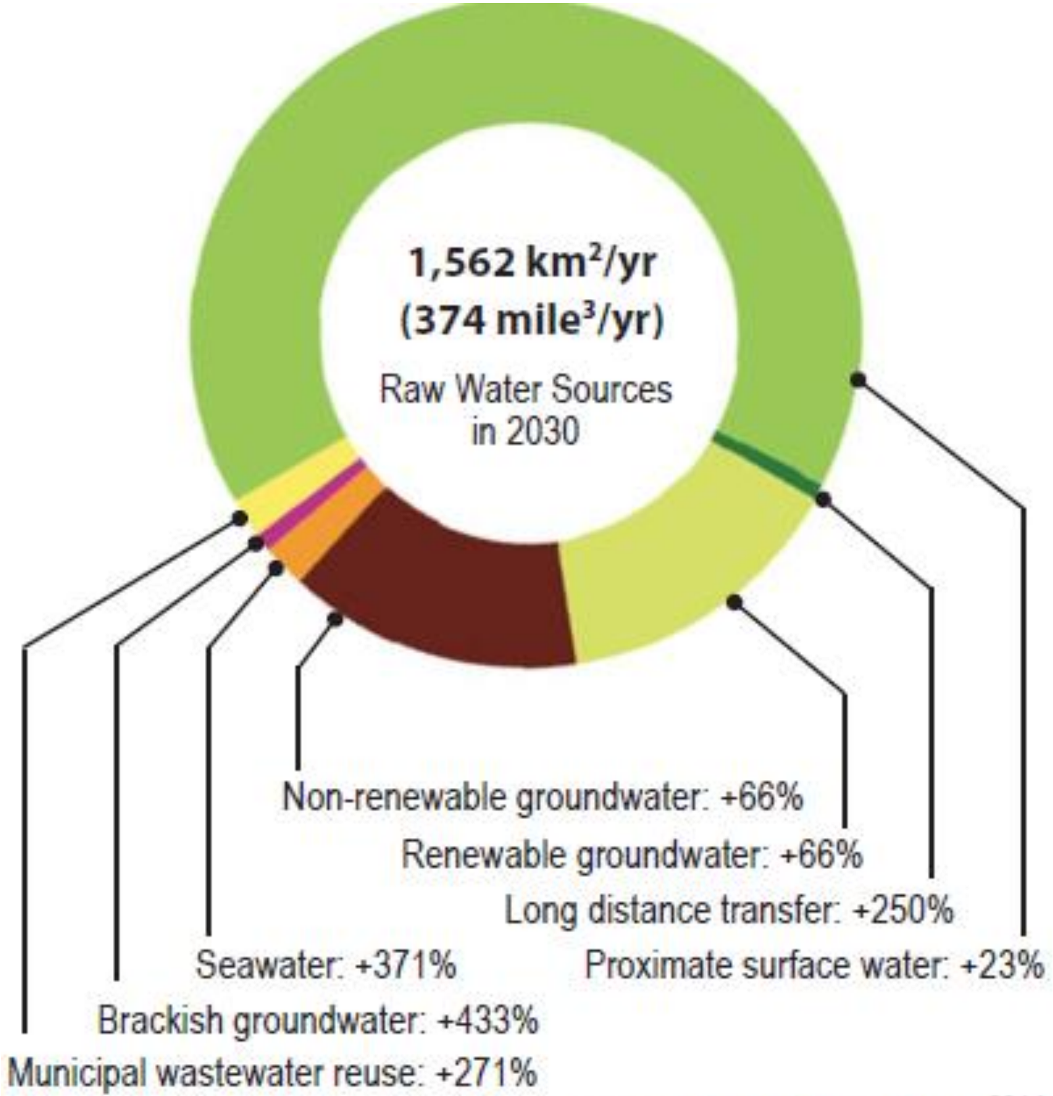
Water sources



A graphical distribution of the locations of water on Earth. Only 3% of the Earth's water is fresh water. Most of it is in icecaps and glaciers (69%) and groundwater (30%), while all lakes, rivers and swamps combined only account for a small fraction (0.3%) of the Earth's total freshwater reserves.

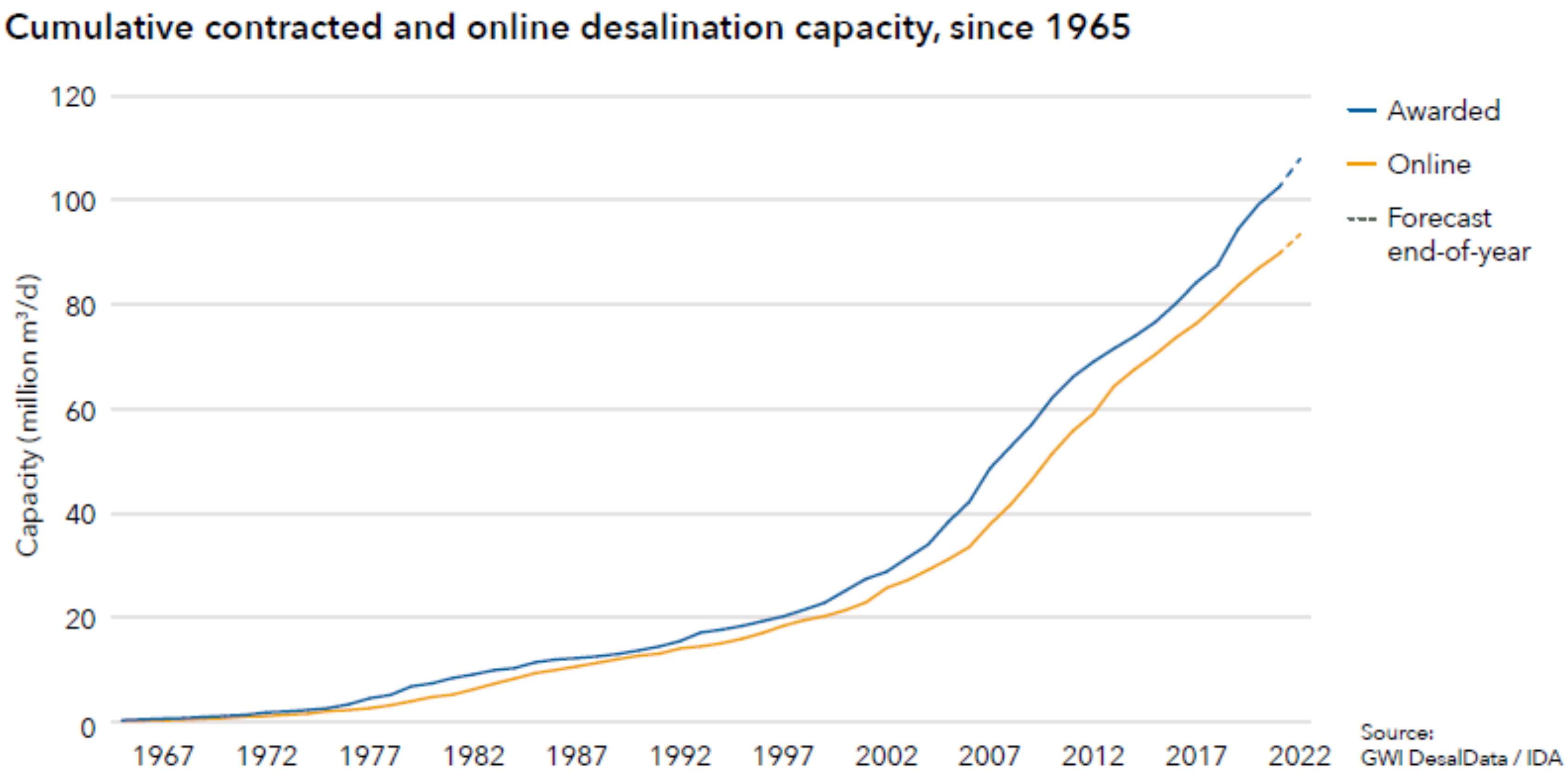
- Wikipedia

Water sources



source: GWI Global Water Markets 2014

Desalination Market Growth



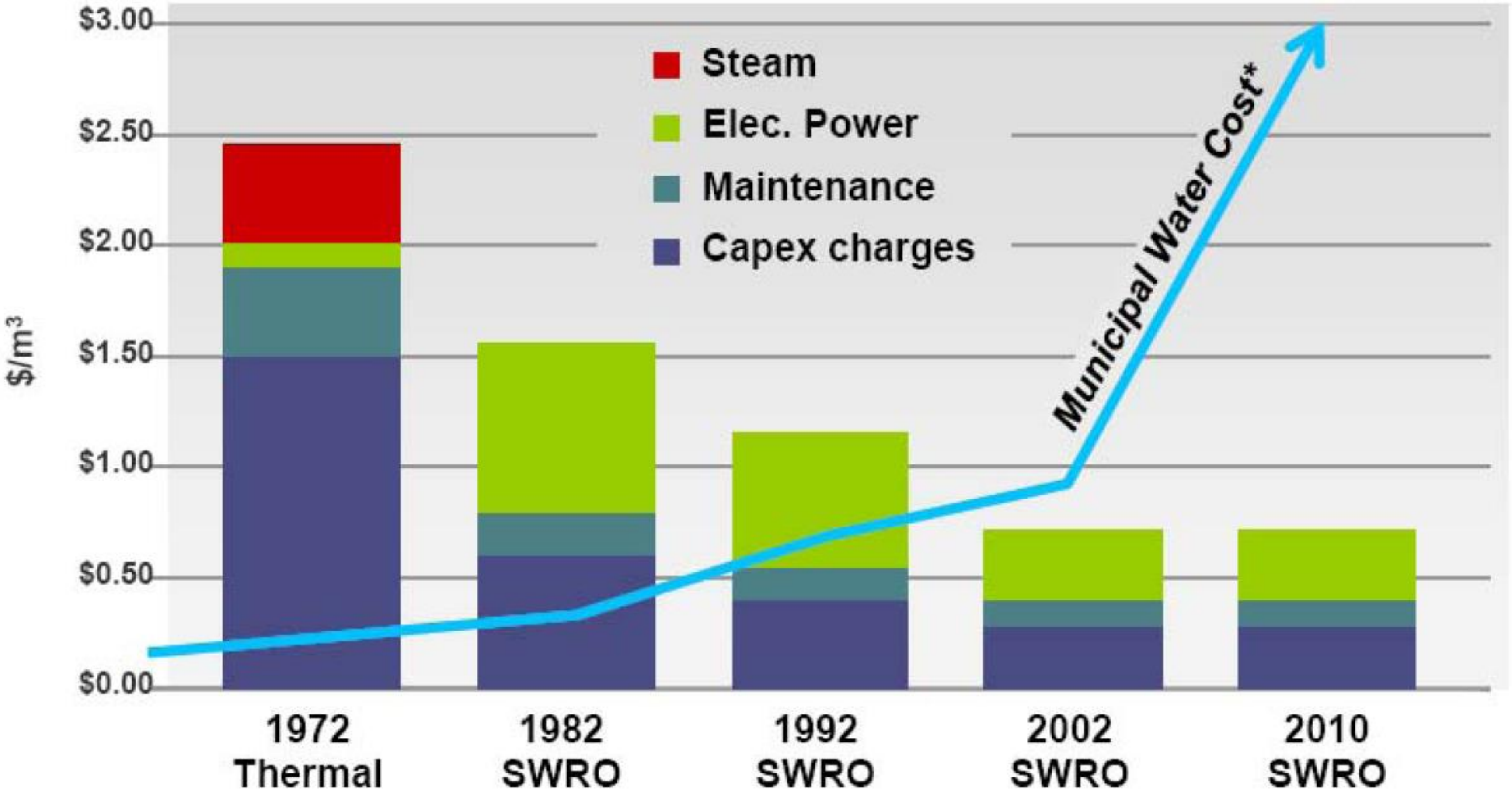
Source: GWI DesalData / IDA

Terminology

Total Water Cost : calculated by dividing the sum of the amortized capital costs and annual operating costs by the average annual water production, [$/m3]

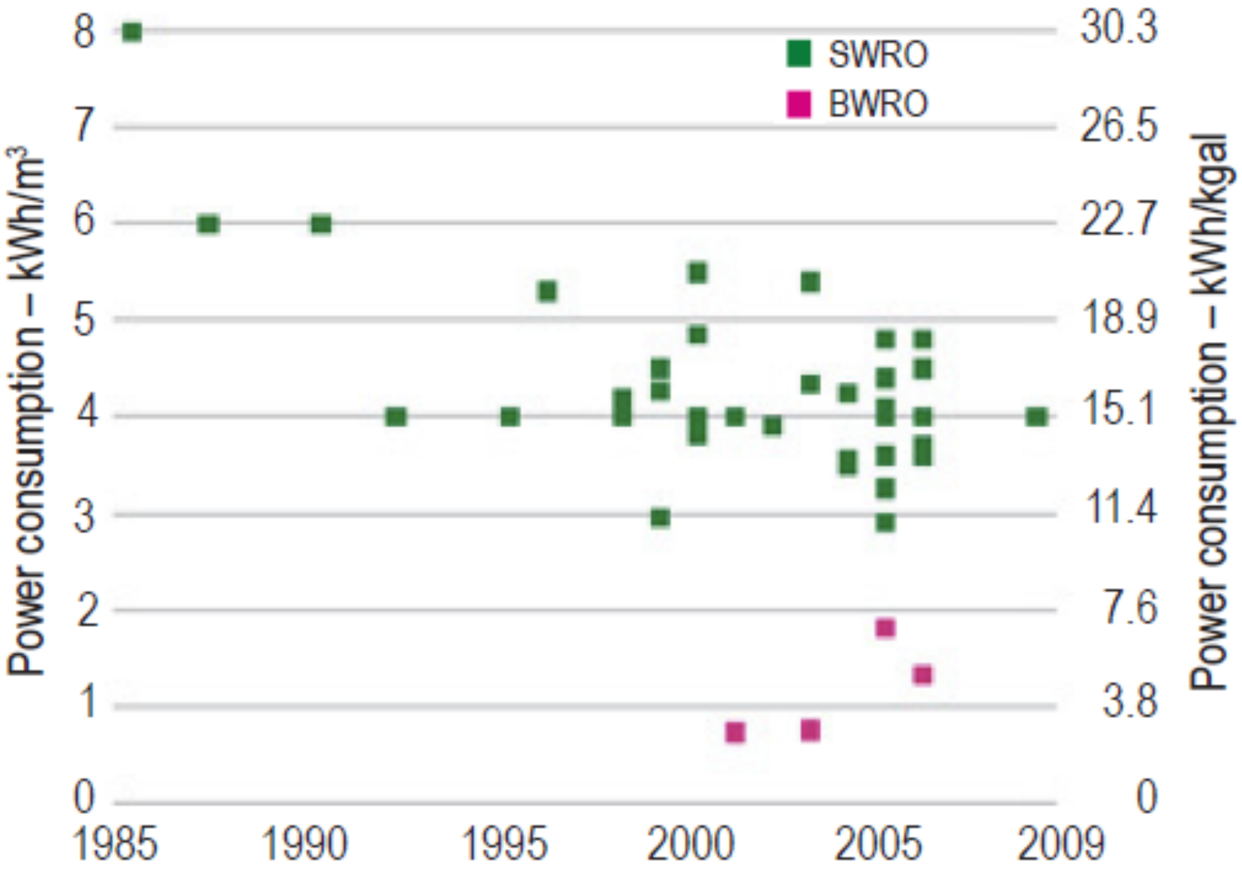
Specific Power Consumption : calculated by dividing the total energy consumption for the plant by the total water production, [kWh/m3]

SWRO Cost Trend



Source : Ibid

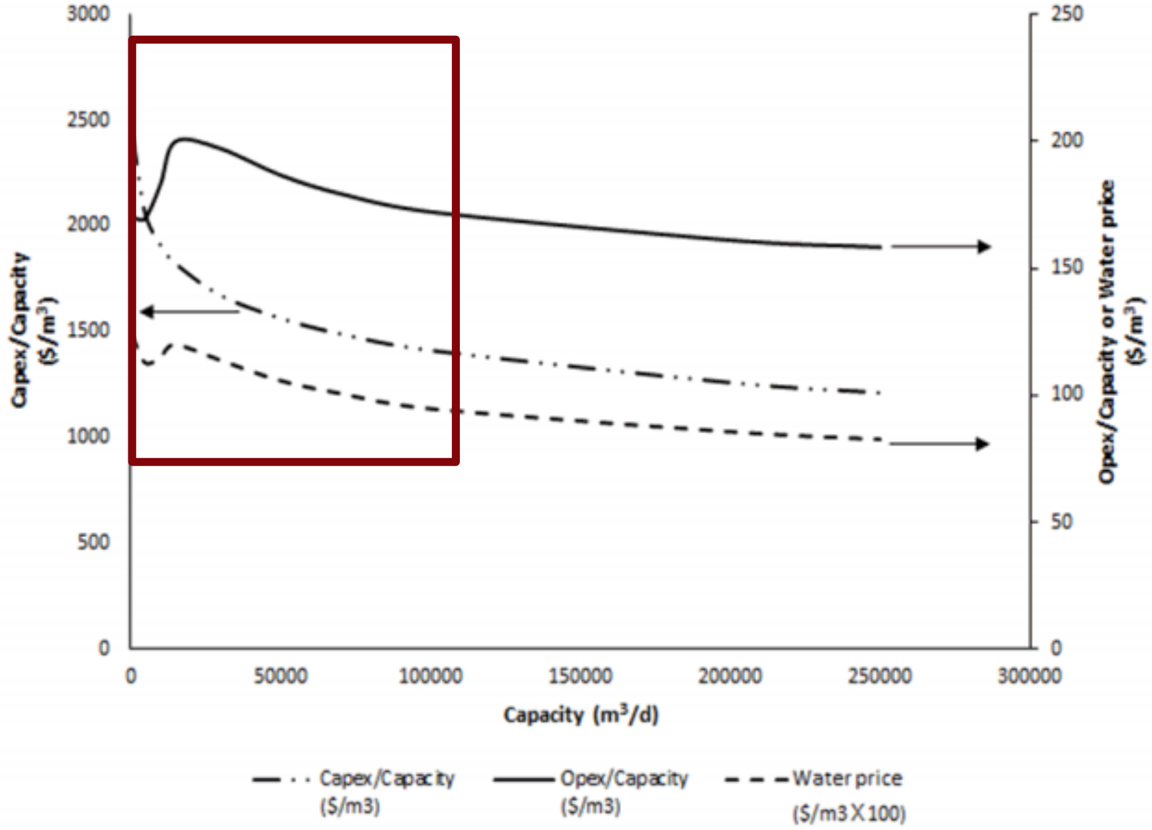
Energy Consumption Trends



Energy Consumption Trends in Reverse Osmosis

Source: GWI's Desalination Markets 2010

Capex and Opex for SWRO systems



Source : Estimation of Water Production Cost from Seawater Reverse Osmosis (SWRO) Plant in Korea by Moon-Hyun Hwang, Doseon Han, In S. Kim
J Korean Soc Environ Eng. 2017;39(4):169-179. Published online April 30, 2017
DOI: https://doi.org/10.4491/KSEE.2017.39.4.169
Journal of Korean Society of Environmental Engineers, Volume 39;2017

Analysis is based on 35,000 mg/L, Temp 15~30 ℃, 2nd pass 50%, SEC 3.5kWh/m3, Electricity price 0.08 $/kWh, Interest rate 6%

Market Trends

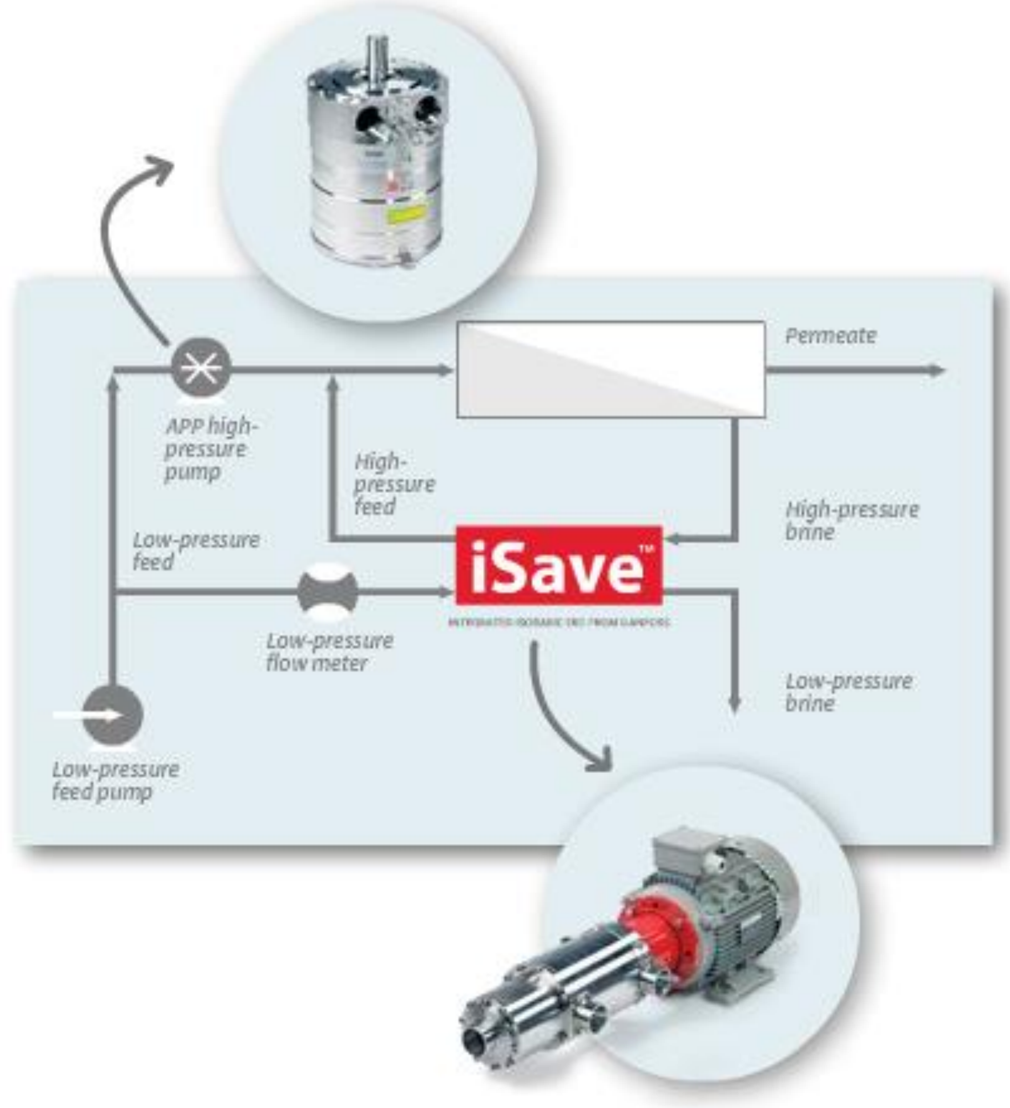
Ongoing enhancements in **energy efficiency** continue to be a key focus for the desalination industry (IDA News Dec. 2013)
Energy prices are critical to BOO project
Federal Governments have focus on lowering the CO_2 emission
A growing number of large plants, now use **solar energy** as part of their power supply

Pre-designed RO skids and Multi-module design:
Custom-made RO design requires a lot of manpower in the design
and purchasing phases
The trend is to build medium sized 1,000-10,000 CMD RO-plants
by using **pre-designed RO-skids**.
The RO-skids are built with standard components rather than custom made components.
For the higher capacity, **multi-module design** to cover 100,000 CMD.

Scale of economy, **Mega project**

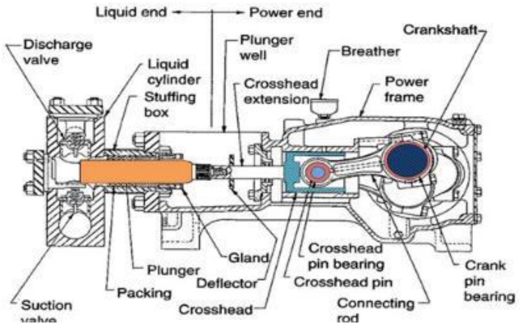
Diverse Energy Recovery Devices like as **Active ERD**

HPP and ERD

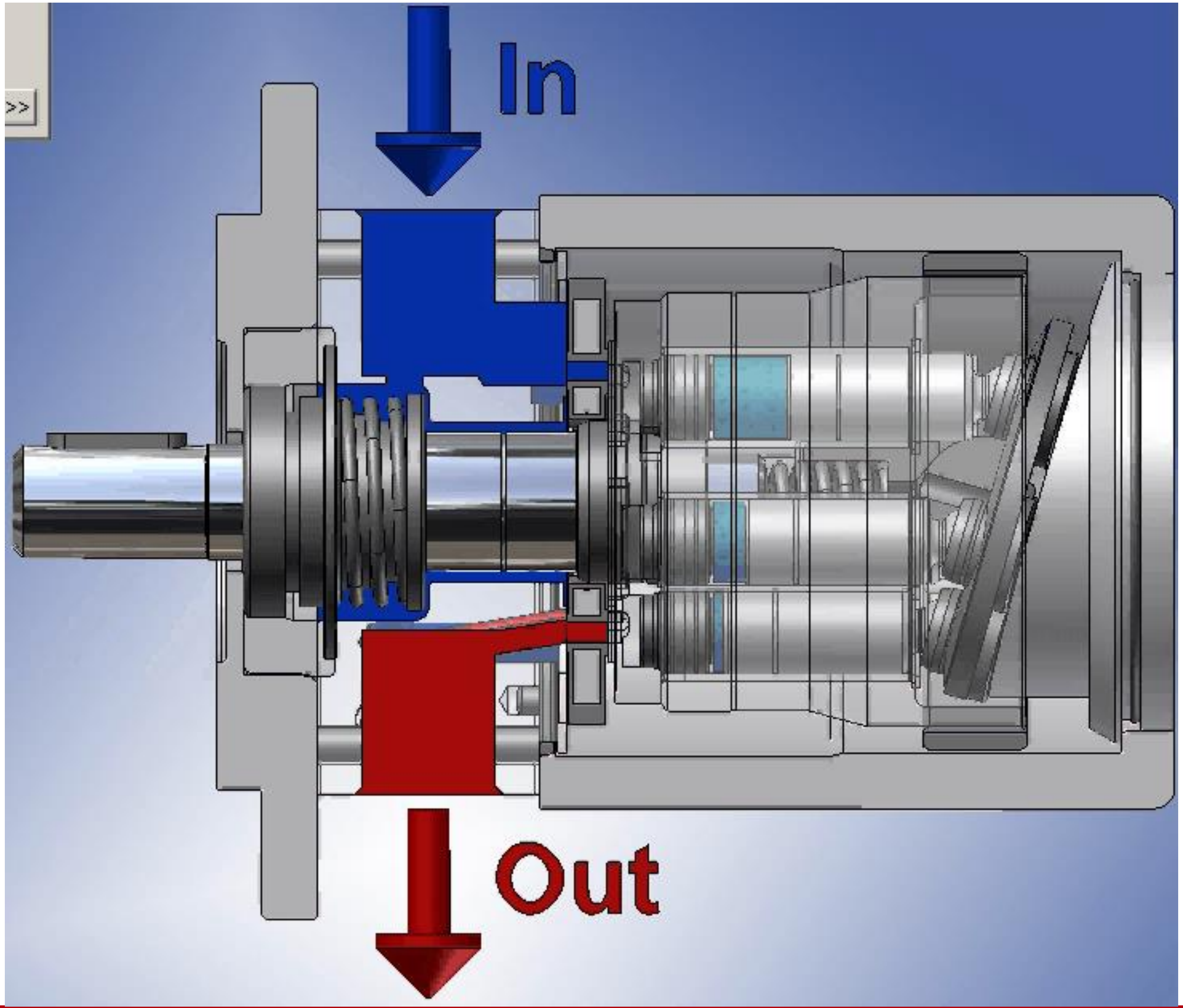

Permeate
APP high-pressure pump
High-pressure feed
High-pressure brine
Low-pressure feed
iSave™
Low-pressure flow meter
Low-pressure brine
Low-pressure feed pump

High Pressure Pumps – centrifugal type

High Pressure Pumps – positive displacement type, plunger pump

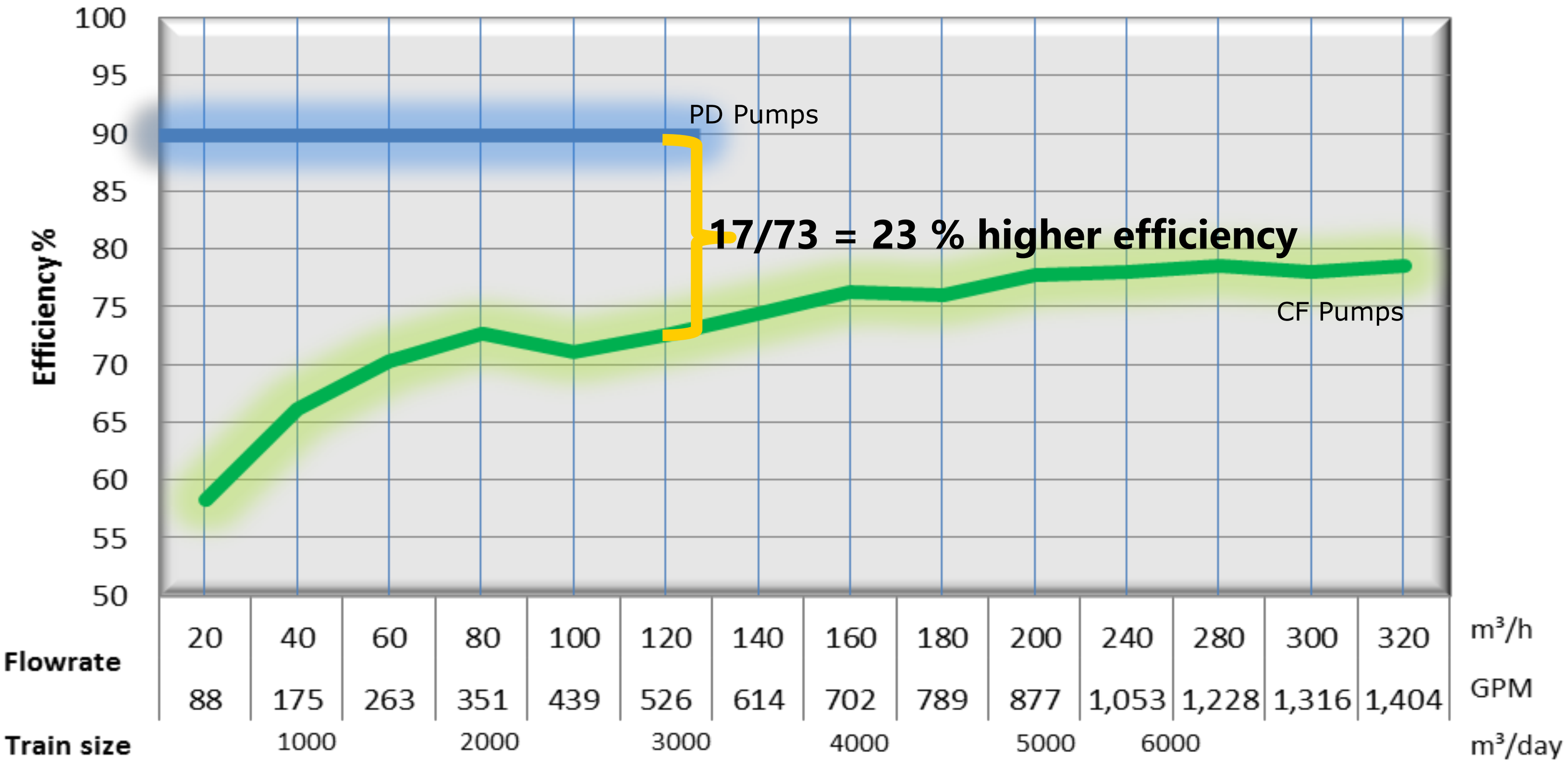


High Pressure Pumps – PD type, axial piston pump



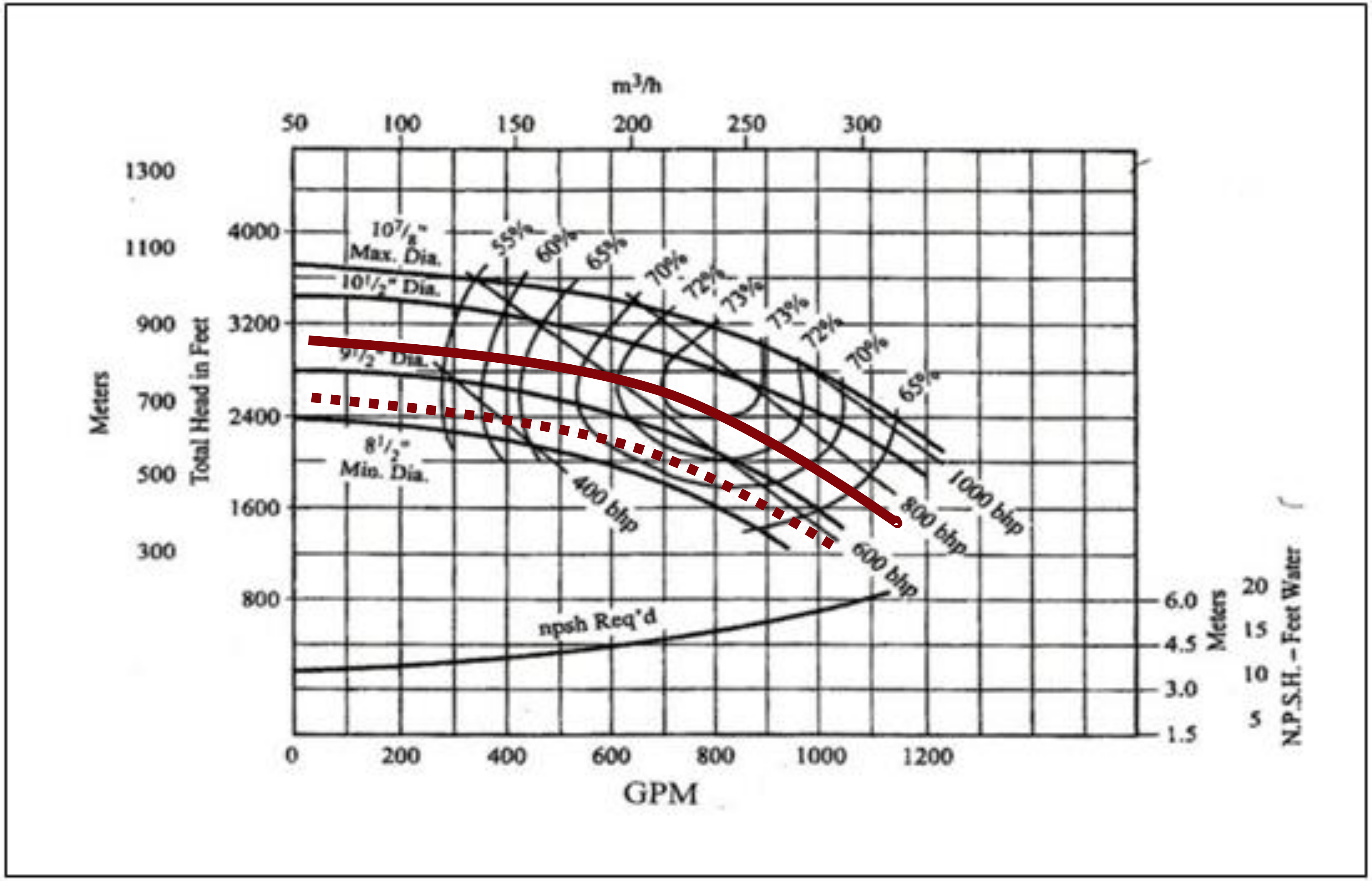
Dilemma, PD vs CF

- The efficiency of centrifugal pumps is too low
- High efficient positive displacement pumps are limited in flow



The blue line is based on values from a PD pump with pressure at 60 bar/870 psi.
The green line is an average of values from well known centrifugal pump suppliers.

Pump efficiency – centrifugal



Danfoss High Pressure Axial piston pumps

Efficiency rates up to **92%**
Future eff. could reach 95%

Consistently **high efficiency** for **all operating conditions**

Constant flow regardless of pressure variations

Parallel installation
- Standard/modular equipment
- Low voltage motors
- Higher flexibility

Simple operation

No oil lubrication

Fewer moving parts
Onsite maintenance

Compact footprint

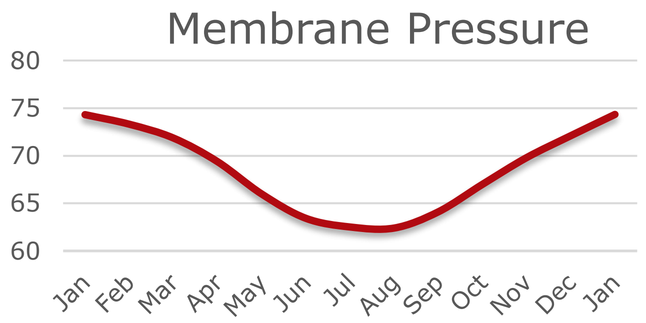
Design Condition vs. Real Oeration

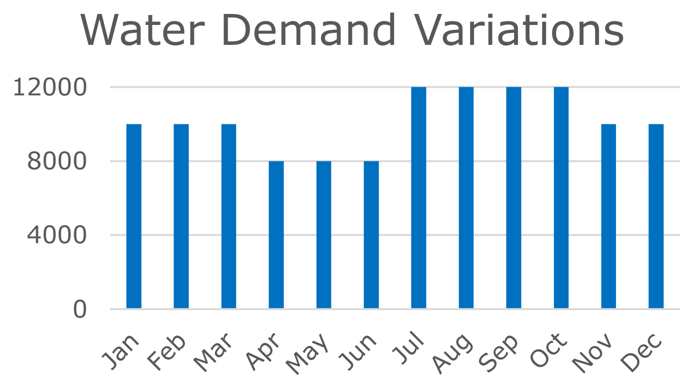
Standard systems calculations are based on static scenarios

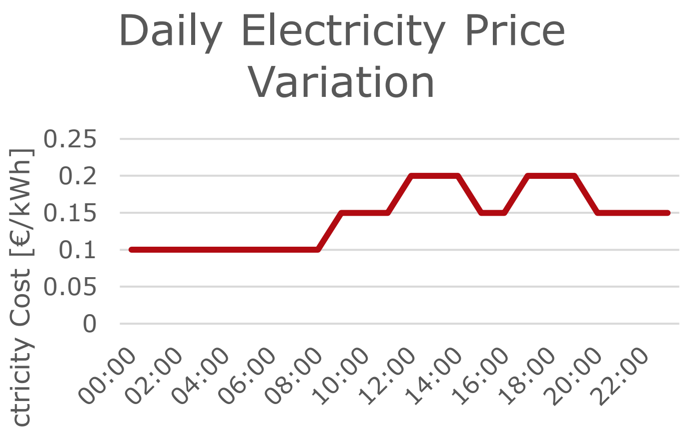
Constant…

- Electricity price
- Permeate production
- Recovery rate
- Best efficiency point
- pump energy efficiency

…But the world is NOT static!

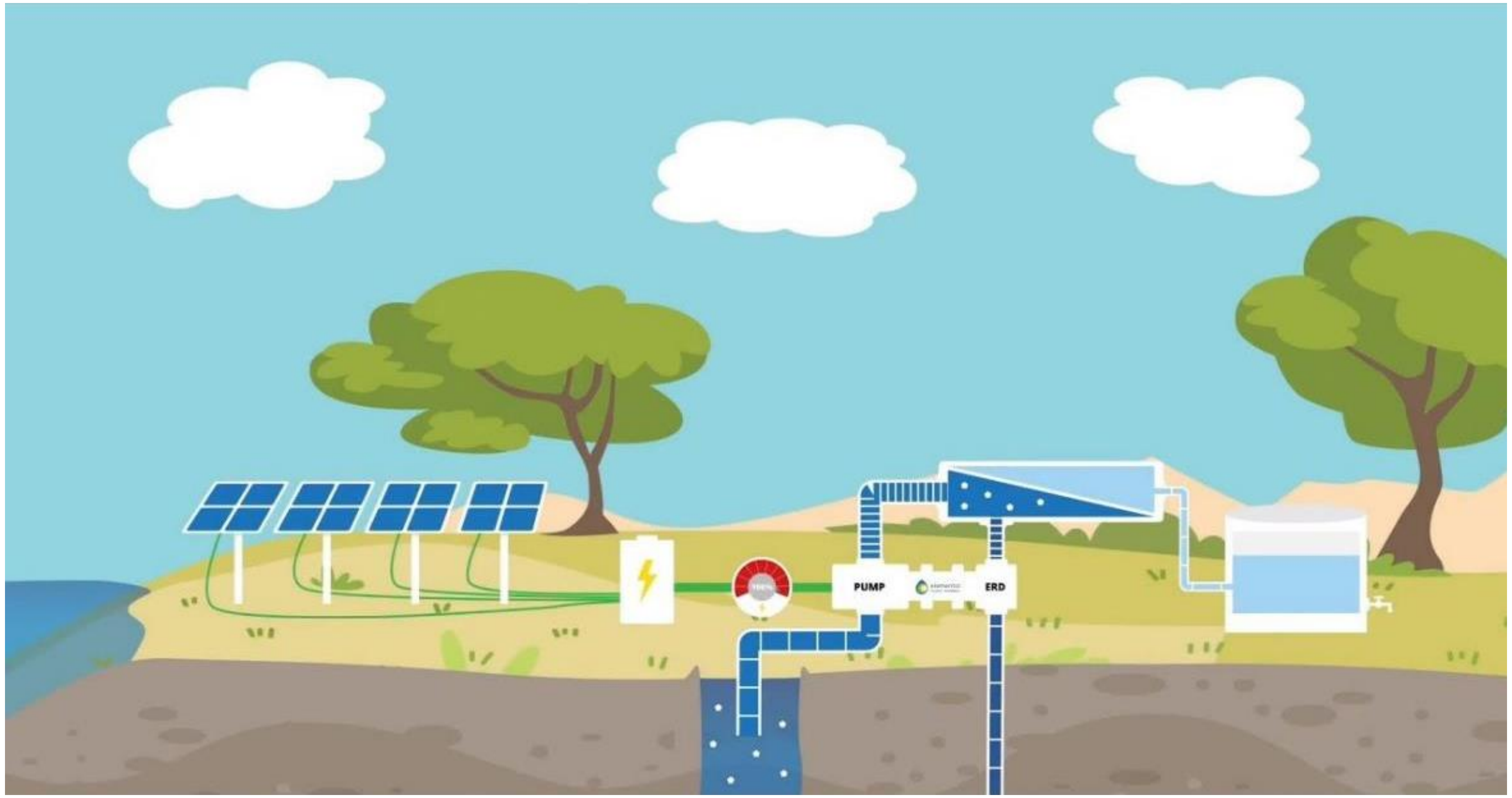






…and this will impact the total systems efficiency

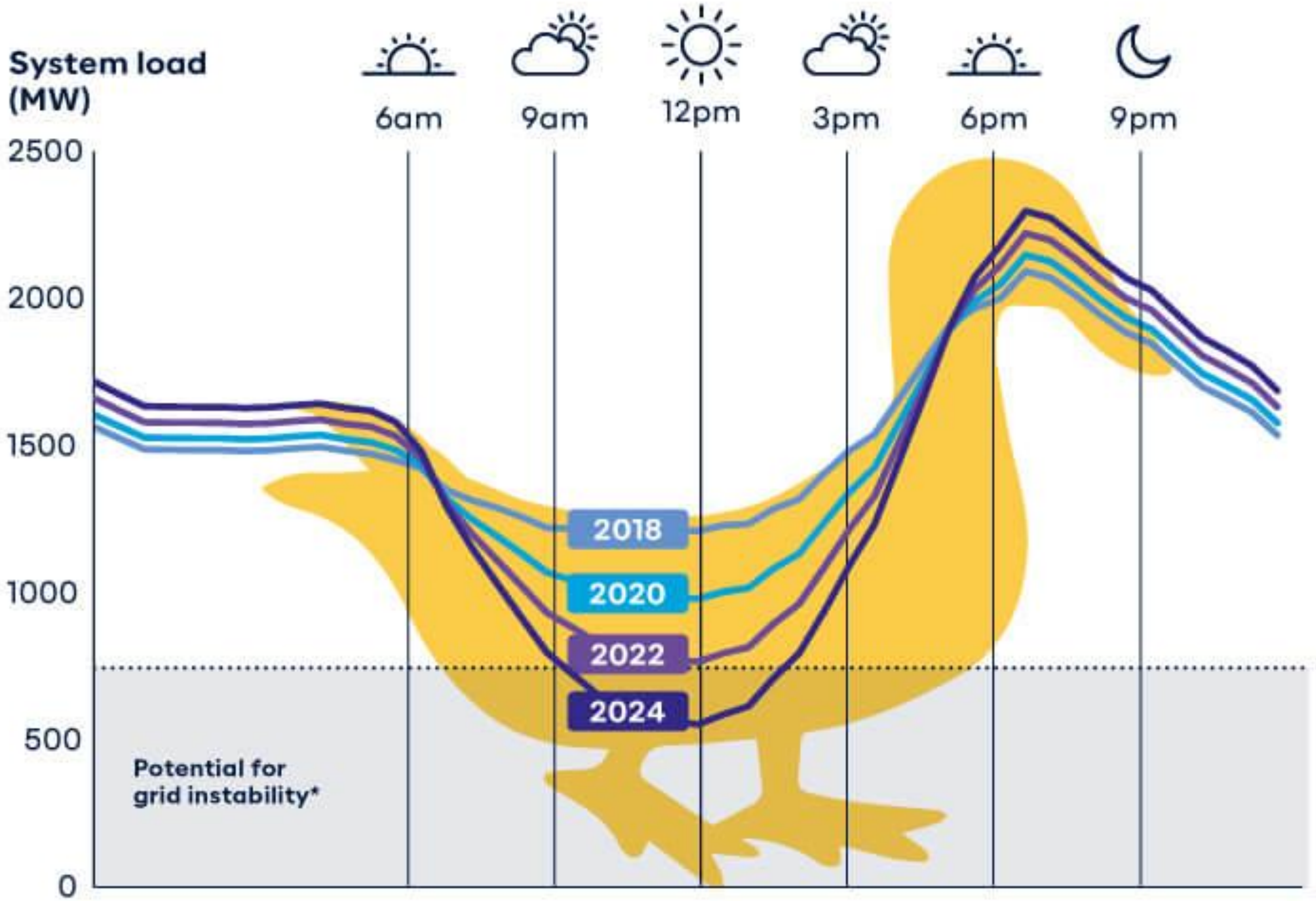
Renewable Energy



❑ Desalination using solar panels utilizes renewable energy from the sun.

❑ Solar panels capture sunlight and convert it into electricity to power the desalination process.

Variations in operation - The World Changes

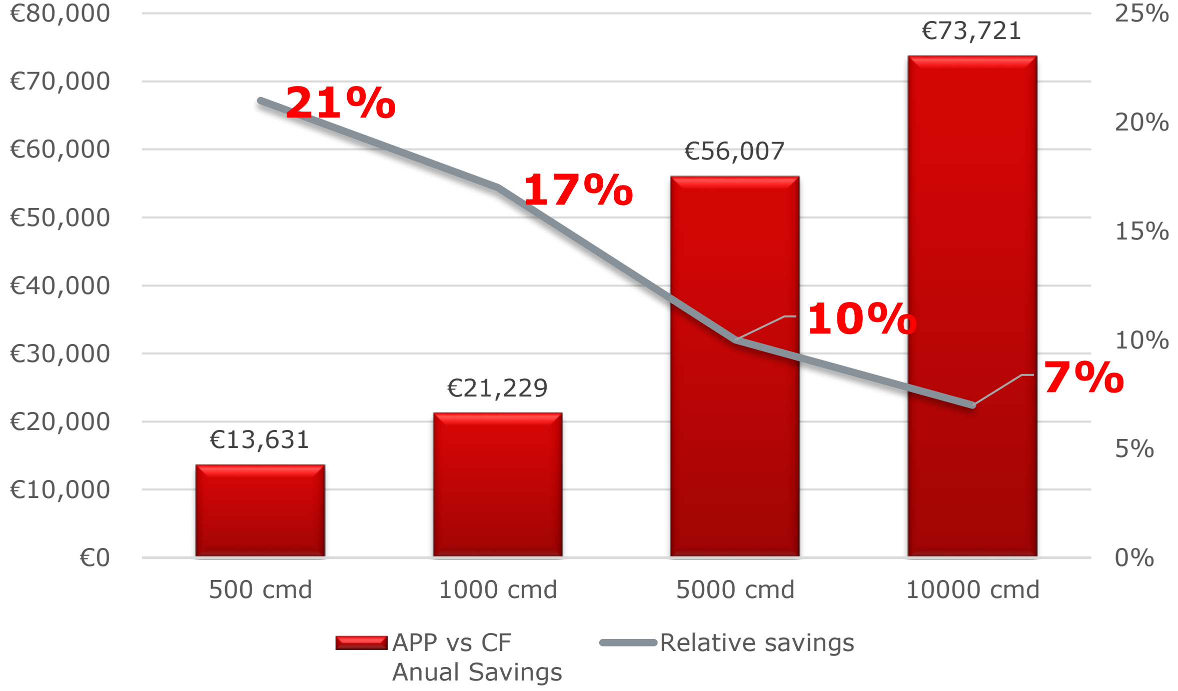


- The Duck Curve refers to a graphical representation of electricity demand from the grid on days when solar energy production is high and demand in the grid is low

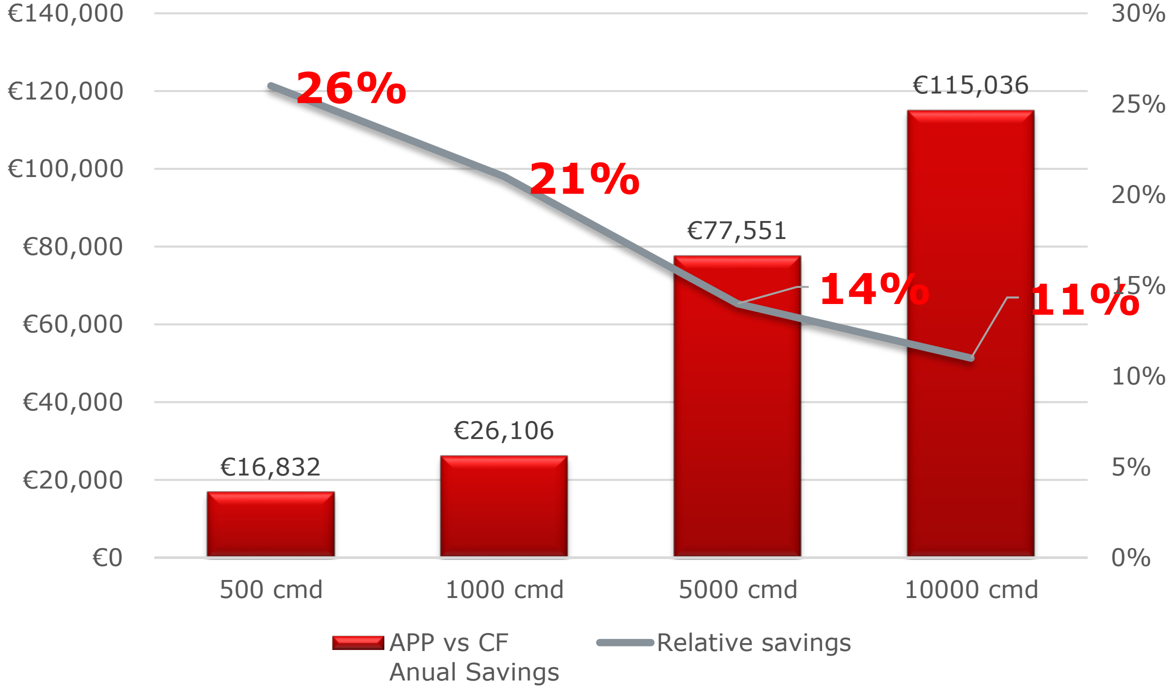
- the grid attempts to cope with extreme changes in demand across different parts of the day.

Opex – PD vs. CF

1st Scenario-full load operation



2nd Scenario-partial load operation



Conclusions for pumps

Accelerating Carbon Neutrality in Desalination

- Focus on optimizing energy efficiency and adopting low carbon solutions.
- AP pump-based SWRO plants contribute to climate-friendly operation.
- Align water production with renewable energy for potential grid balancing benefits.

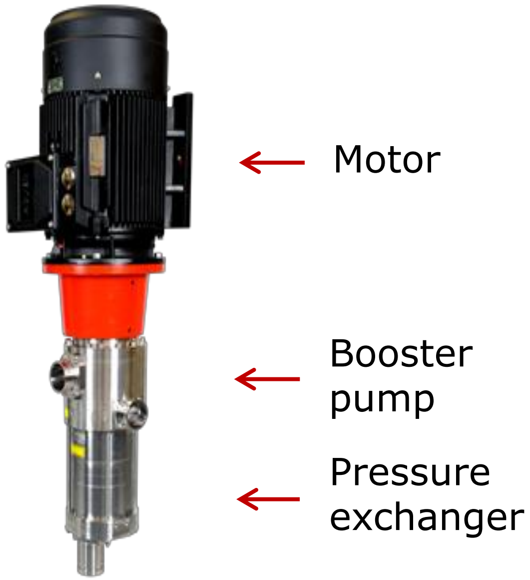
Advantages of AP Pump Technology

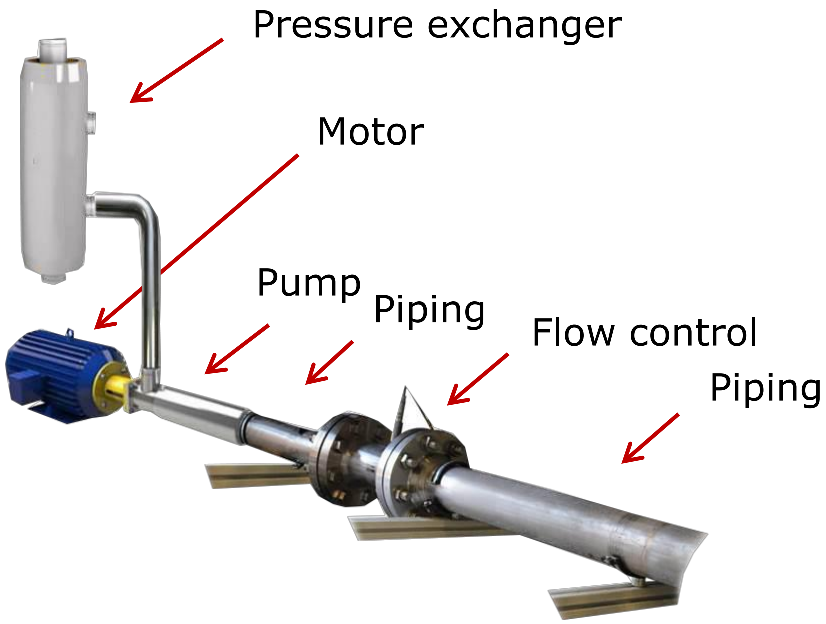
- Significant energy savings (up to 92%) compared to centrifugal pumps.
- No regulating valve required, improving system efficiency.
- Increased energy efficiency under changing operating conditions.

Practical Benefits

- Standard AP pump designs minimize spare parts and maintenance costs.
- Smaller, low voltage motors and VFDs optimize system operation.
- Modular system ensures uninterrupted water supply during pump maintenance

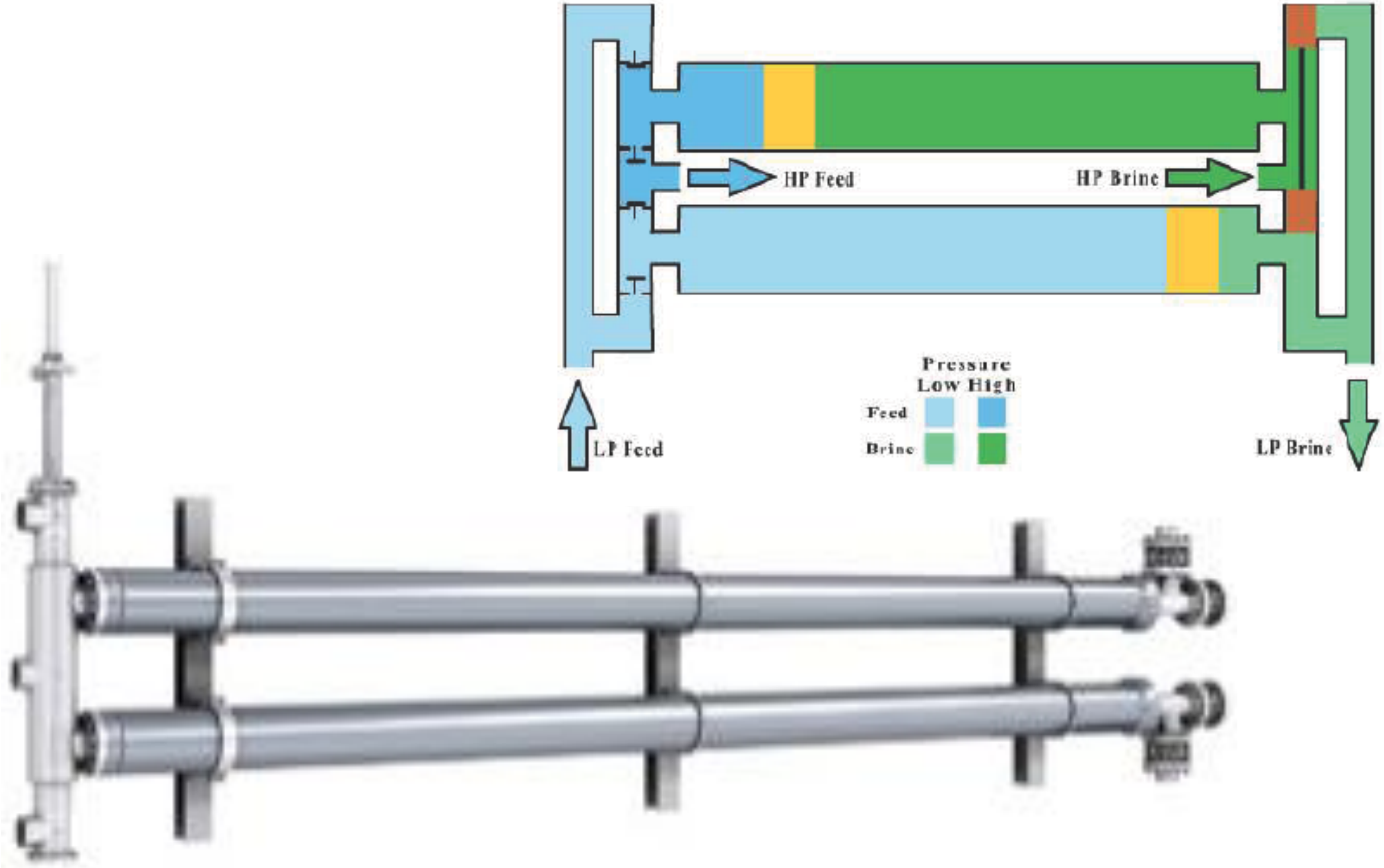
Energy Recovery Devices - Isobaric Pressure Exchanger



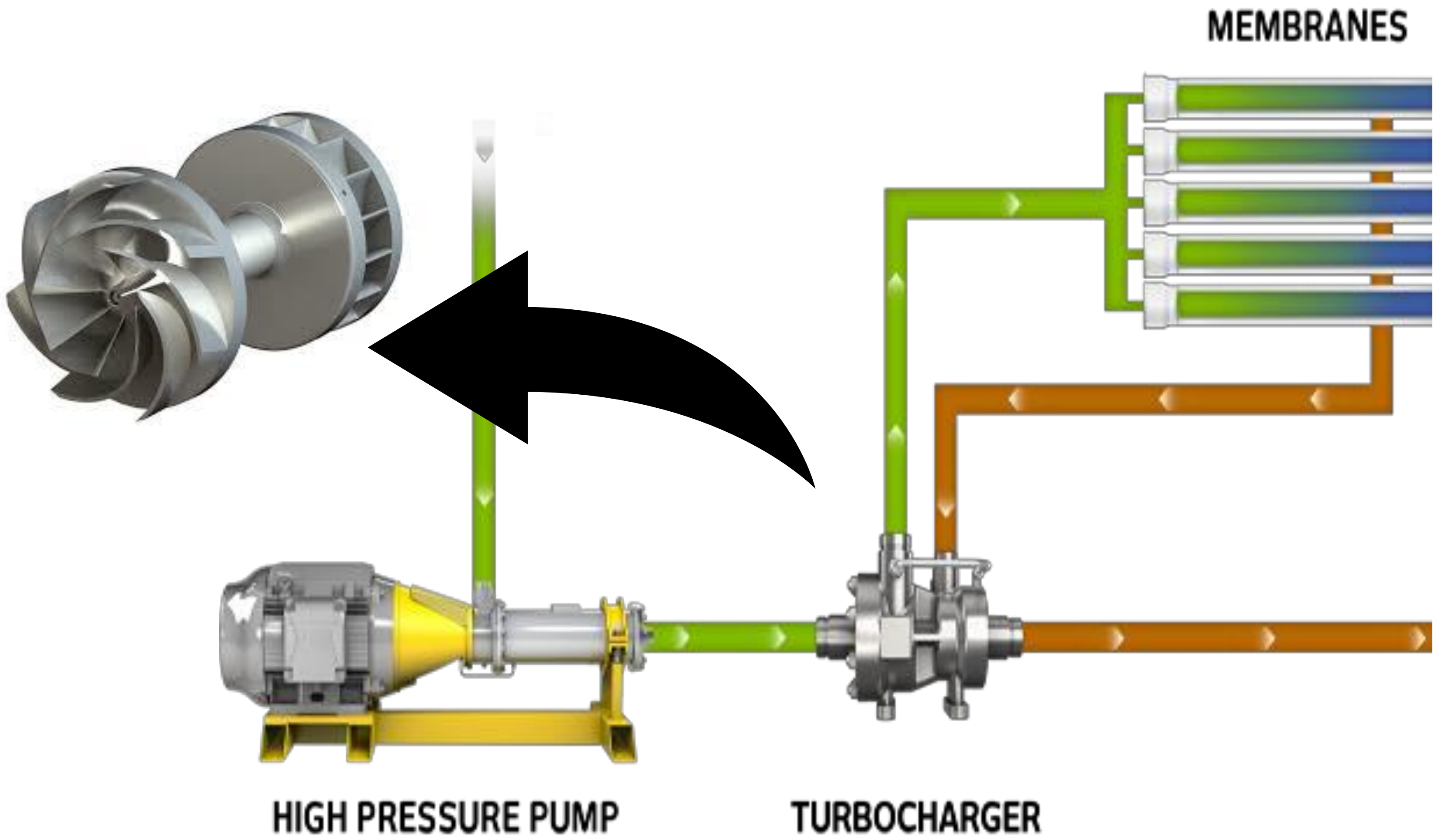


The isobaric ERD from Danfoss is fully integrated with its own booster pump and electric motor – it **saves** you not only **energy**, but also **space** and **costs** for **components**

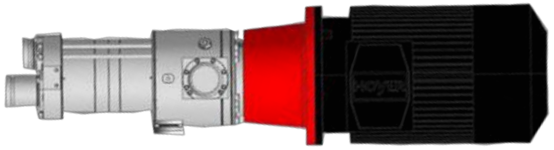
Energy Recovery Devices – long cylinder



Energy Recovery Devices - Turbocharger



The Danfoss iSave ERD Range



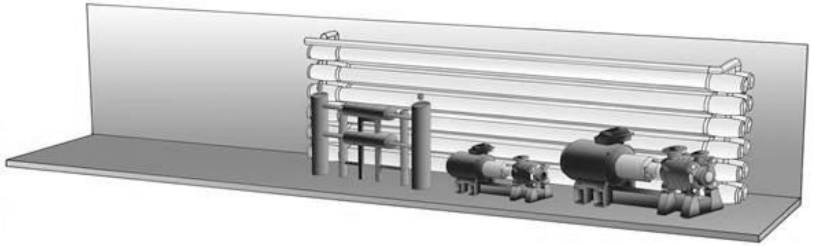
		iSave 21	**iSave 40**	**iSave 50**	**iSave 70**
Flow	m^3/h Gpm	7-21 31-92	21-41 92-180	42-52 184-228	50-70 220-308
Efficiency iSave, motor, VFD	%	88-91	89-92	92-94	91-93
Delta P Max. differential pressure HP in – HP out	Barg	3 43	5 72	5 72	5 72
Weight	kg Lb	65 143	123 271	164 362	164 362
Footprint	m^2 $Foot^2$	0.38 4.09	0.17-0.54 1.83-5.81	0.44 4.71	0.44 4.71
Connections		2″ Vic.	3″ Vic.	3″ Vic.	3″ Vic.

- Materials: Peek, Duplex and Super Duplex
- Frequency converters always required

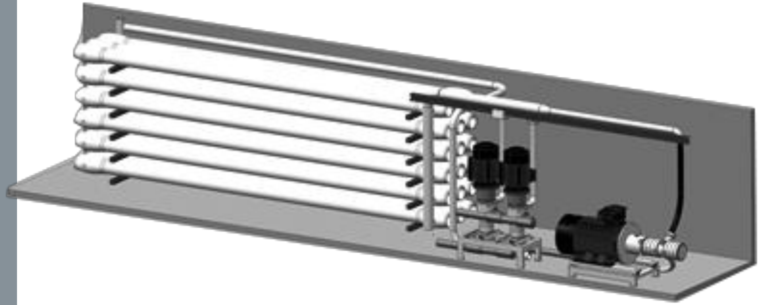
Modular Design of RO train

Pump	ERD			Train size	
		No. of pumps	No. of ERDs	CMD	GPM
APP 38	iSave 50	1-2	1-2	750-1700	150-300
APP 43	iSave 50	1-2	1-2	950-2000	175-350
APP 53	iSave 70	1	1	1050-1200	195-220
APP 65	iSave 70	1	1	1250-1350	230-250
APP 65	iSave 50	1	2	1400-1500	255-275
APP 78	iSave 50	1	2	1600-1800	295-330
APP 86	iSave 50	1	2	1850-2000	340-365
APP 86	iSave 70	1	2	1850-2000	340-365
APP 53	iSave 70	2	2	2100-2400	385-440
APP 78	iSave 70	2	2-3	2500-3600	460-660
APP 92 New	iSave 70	2-5	3-8	3700-10000	680-1835

Multiple **APP pumps** and **iSave ERDs**



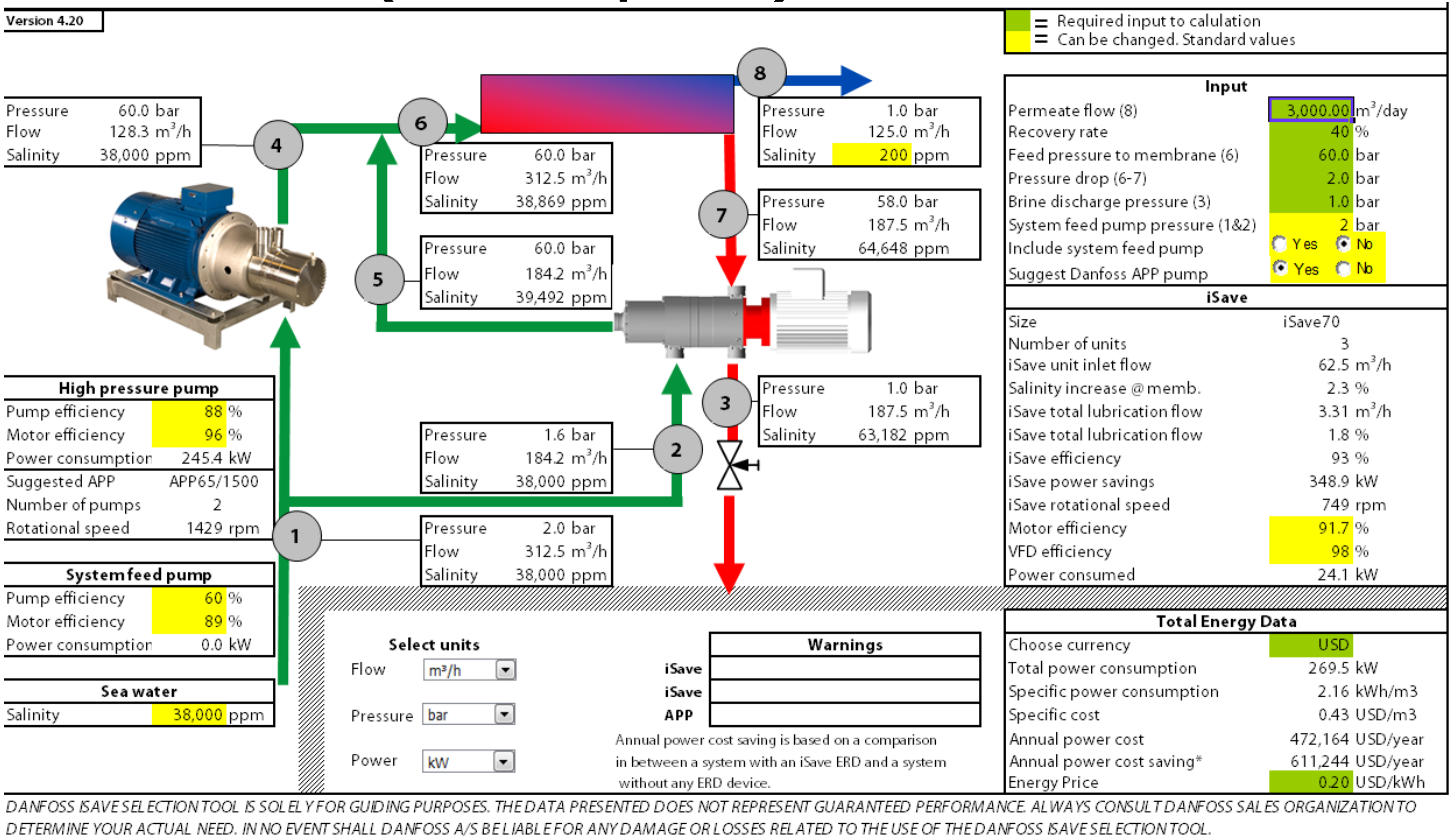
Traditional centrifugal pump and isobaric solution
1,200-2,000 m³/day at 40-50% recovery rate



APP pump and isobaric solution:
1,200-2,000 m³/day at 40-50% recovery rate

The **APP pumps** and **iSave ERDs** are very compact - Two or more sets of them fit into the same space required by traditional solutions

Selection Tool(examples)



Version 4.20

🟩 = Required input to calulation
🟨 = Can be changed. Standard values

	④	⑥	⑧	⑦	⑤	③	②	①
Pressure	60.0 bar	60.0 bar	1.0 bar	58.0 bar	60.0 bar	1.0 bar	1.6 bar	2.0 bar
Flow	128.3 m^3/h	312.5 m^3/h	125.0 m^3/h	187.5 m^3/h	184.2 m^3/h	187.5 m^3/h	184.2 m^3/h	312.5 m^3/h
Salinity	38,000 ppm	38,869 ppm	200 ppm	64,648 ppm	39,492 ppm	63,182 ppm	38,000 ppm	38,000 ppm

High pressure pump	
Pump efficiency	88 %
Motor efficiency	96 %
Power consumption	245.4 kW
Suggested APP	APP65/1500
Number of pumps	2
Rotational speed	1429 rpm

System feed pump	
Pump efficiency	60 %
Motor efficiency	89 %
Power consumption	0.0 kW

Sea water	
Salinity	38,000 ppm

Input	
Permeate flow (8)	3,000.00 m^3/day
Recovery rate	40 %
Feed pressure to membrane (6)	60.0 bar
Pressure drop (6-7)	2.0 bar
Brine discharge pressure (3)	1.0 bar
System feed pump pressure (1&2)	2 bar
Include system feed pump	○ Yes ● No
Suggest Danfoss APP pump	● Yes ○ No

iSave	
Size	iSave70
Number of units	3
iSave unit inlet flow	62.5 m^3/h
Salinity increase @ memb.	2.3 %
iSave total lubrication flow	3.31 m^3/h
iSave total lubrication flow	1.8 %
iSave efficiency	93 %
iSave power savings	348.9 kW
iSave rotational speed	749 rpm
Motor efficiency	91.7 %
VFD efficiency	98 %
Power consumed	24.1 kW

Total Energy Data	
Choose currency	USD
Total power consumption	269.5 kW
Specific power consumption	2.16 kWh/m3
Specific cost	0.43 USD/m3
Annual power cost	472,164 USD/year
Annual power cost saving*	611,244 USD/year
Energy Price	0.20 USD/kWh

Select units	
Flow	m³/h
Pressure	bar
Power	kW

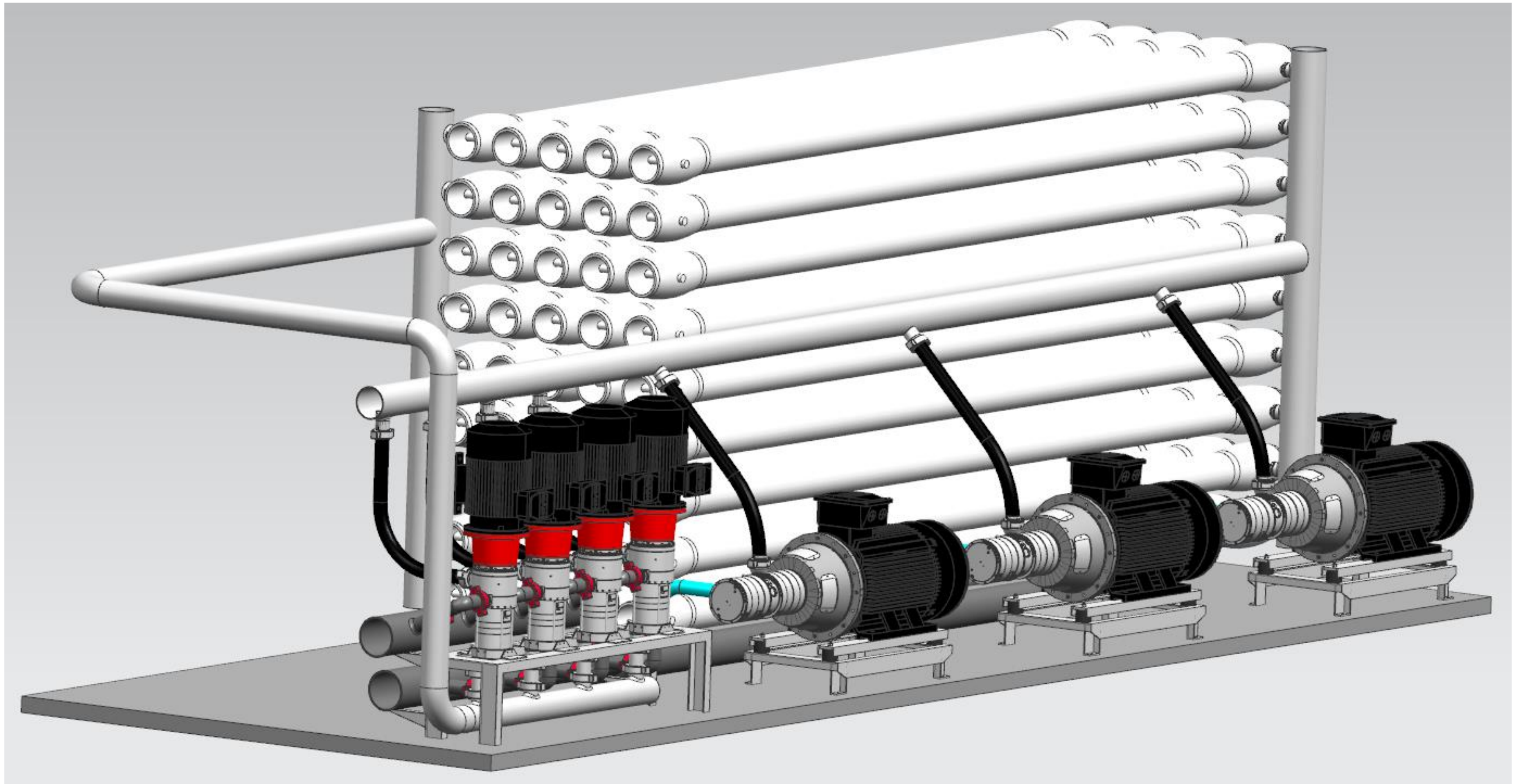
Warnings	
iSave	
iSave	
APP	

Annual power cost saving is based on a comparison in between a system with an iSave ERD and a system without any ERD device.

DANFOSS ISAVE SELECTION TOOL IS SOLELY FOR GUIDING PURPOSES. THE DATA PRESENTED DOES NOT REPRESENT GUARANTEED PERFORMANCE. ALWAYS CONSULT DANFOSS SALES ORGANIZATION TO DETERMINE YOUR ACTUAL NEED. IN NO EVENT SHALL DANFOSS A/S BE LIABLE FOR ANY DAMAGE OR LOSSES RELATED TO THE USE OF THE DANFOSS ISAVE SELECTION TOOL.

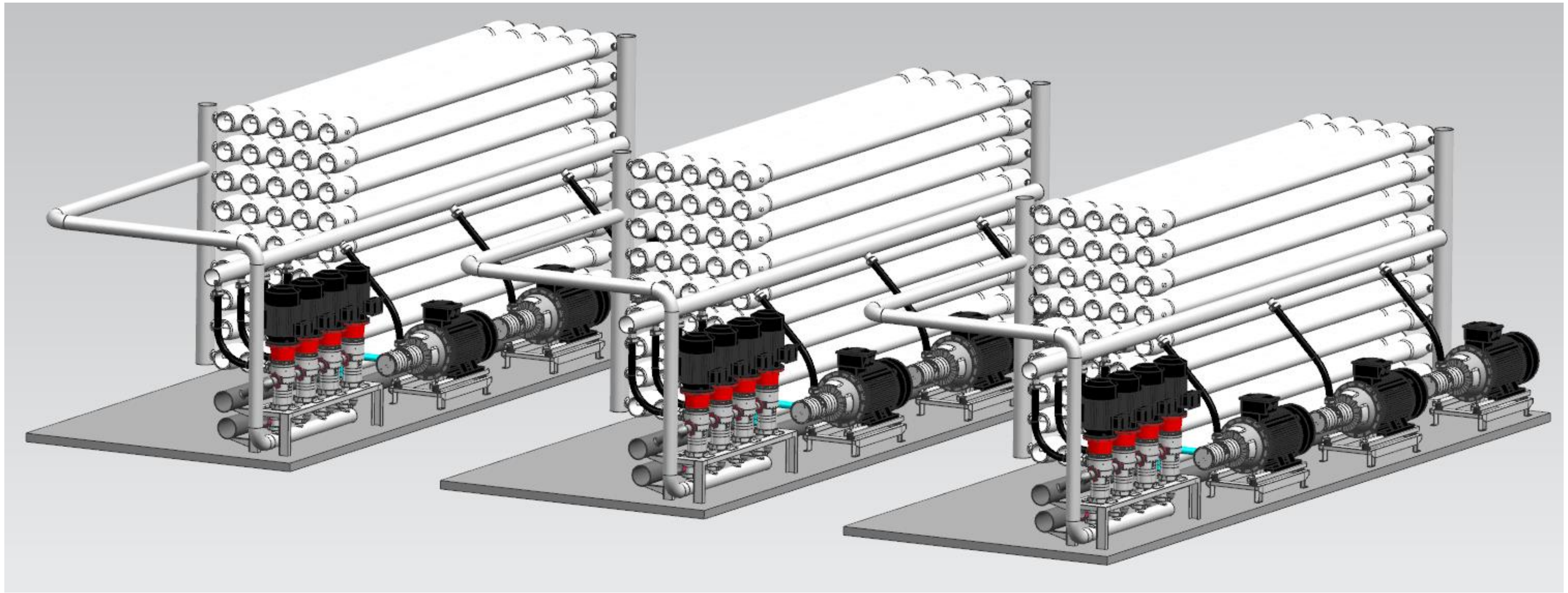
Train size of **5,333 m³/day**

3 APP 78 pumps and 4 iSave 70 ERDs

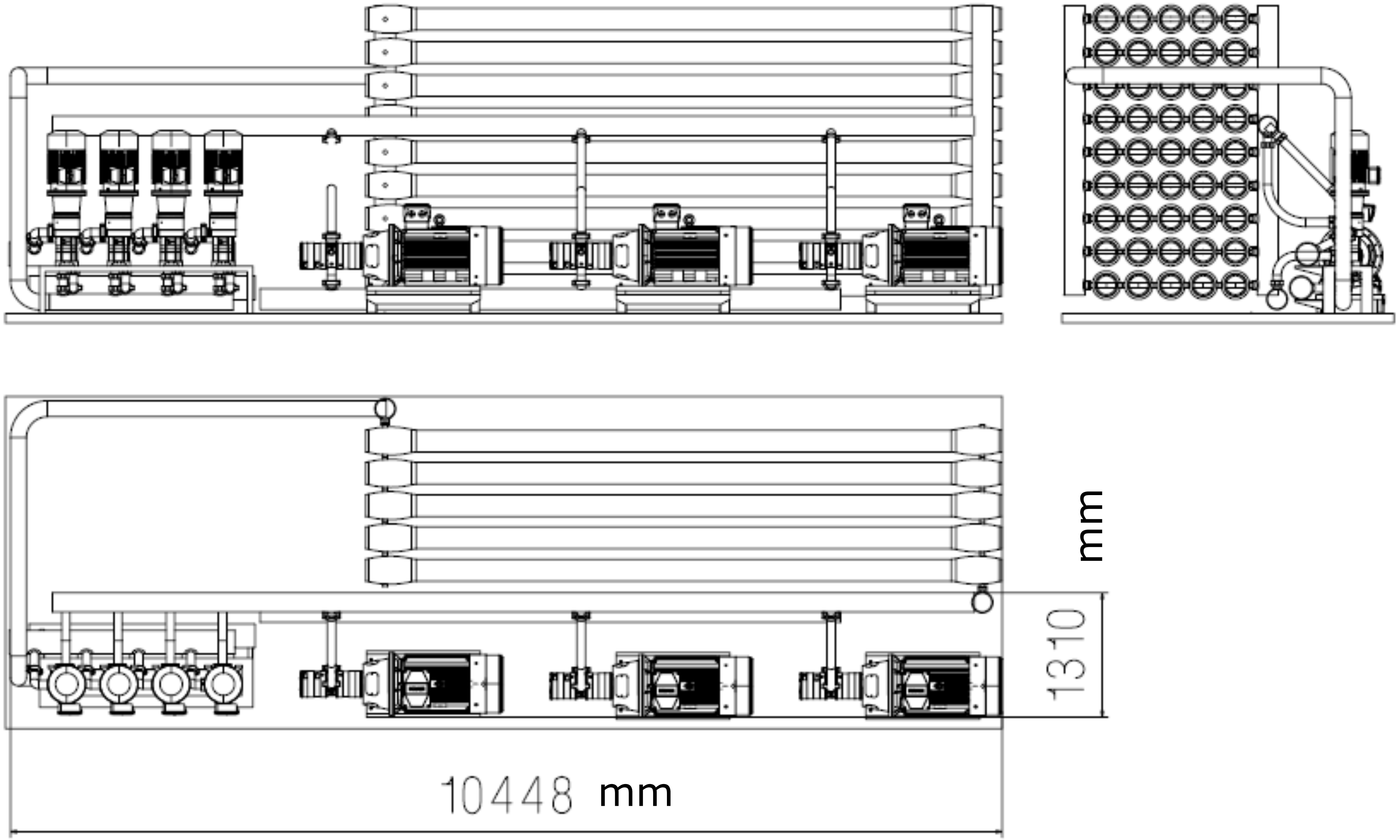


How to build a **16,000 m³/day plant**

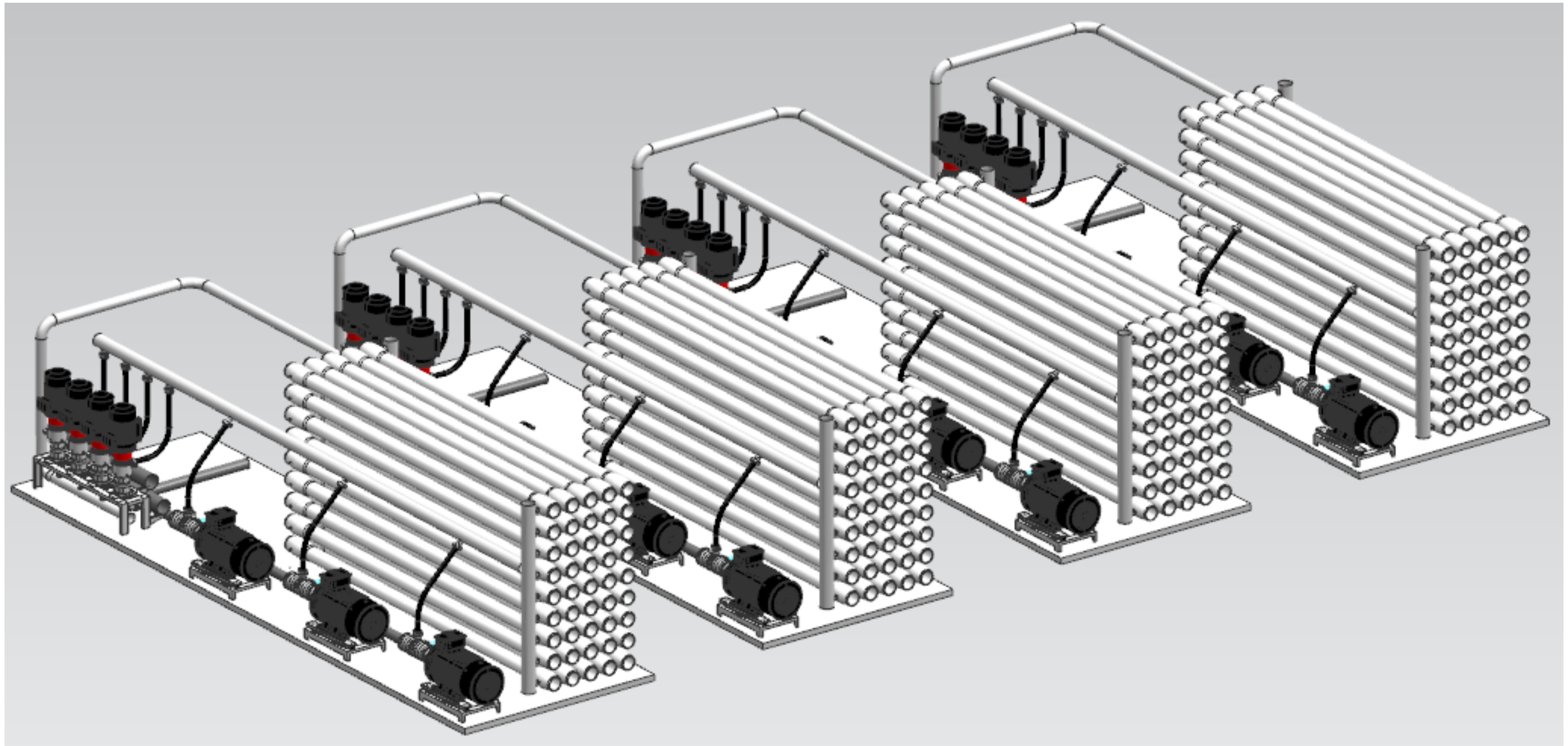
based on train sizes of 5,333 m³/day



Train size of **5,333 m³/day**



How to build a **20,000 m^3/day plant**



SWRO plant in Italy – SARLUX, 12,000 CMD

- Landbased SWRO plant, **4 trains**, commissioned in 2017
- Producing 12,000 m^3/day with **8 APP 78** high-pressure pumps and **10 iSave 70** energy recovery devices in parallel

One train:
2 APP 86 High-pressure pumps
3 iSave 70 Energy recovery devices

Up to Medium size SWRO - Conclusions

Positive displacement pumps and isobaric ERDs offer:

- ✓ The lowest possible energy consumption in a SWRO plant
- ✓ Multiple pumps and ERDs in a train secure higher uptime.
- ✓ Multiple high-efficient trains offer wide range of capacity with high uptime.
- ✓ With standardized mass production items, easy for designing, procurement, after sales service and maintenance.
- ✓ Minimize the site work and transportation by factory assembly.
- ✓ Competitive price and short delivery time.

=>The optimal solution for medium sized SWRO system!

=>For bigger capacity, MPE 70

Danfoss – ERD technology

iSave: Active Isobaric ERD + booster pump

- **2008** – iSave technology patented
- **2009** – 1st field installation

MPE 70: Active Isobaric ERD

- **2021** – MPE 70 patented based on our existing technology
- **2021** – 1st field installation

15 years of experience
> 3,000 worldwide references:

Landbased

Mobile and containerized

Marine and offshore

MPE 70 – Features and benefits

Electric motor

- Avoid unintended brine bypass and salinity increase
- Simple and controlled start-up

Monitoring

- Smarter operation: Monitor and control the performance of each unit
- Remote control
- Suitable for machine learning

Overflushing

- Mixing and SEC reduction
- Operation under control

Biofouling

- No rotor stop
- No need for disassembly
- Superduplex material

High flexibility

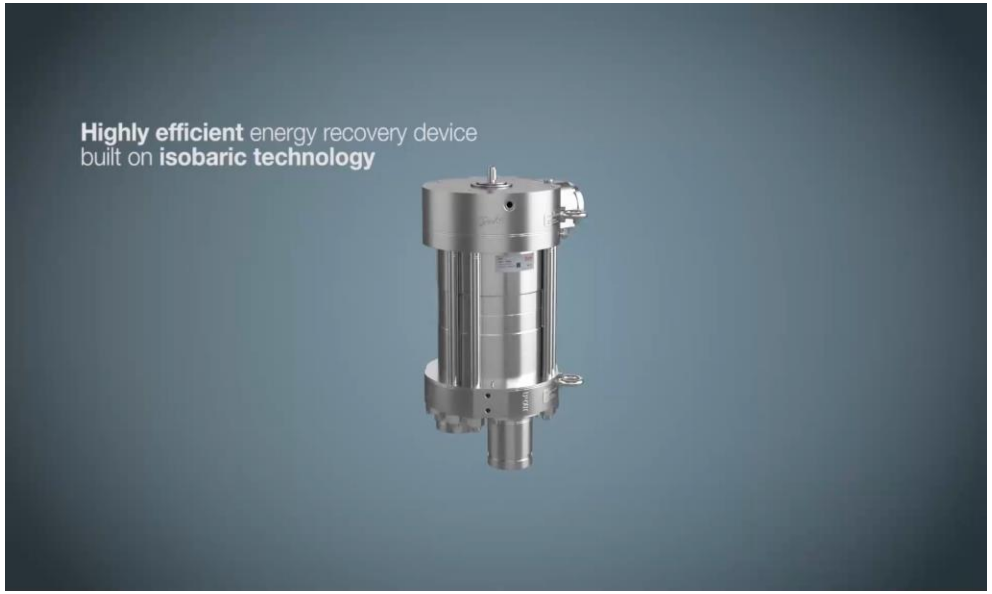
- No need for redundancy
- Overflow capability

Safe operation

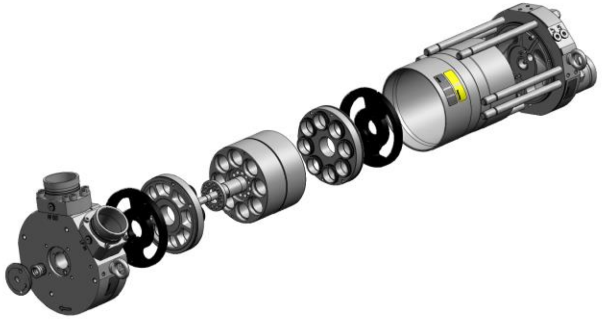
- Speed under control
- Non-electric flow control valve
- No unpredictable breakdowns

MPE 70 – Technical data

Flow capacity (m3/h)	70
Flow capacity temporary (m3/h)	90
Pressure (barg)	Up to 83
Salinity increase (5% overflushing)	1%
Differential pressure - Hp side (bar)	0,3 - 0,6
Differential pressure - Lp side (bar)	0,4 - 0,7
Lubrication at max flow & 60bar (m3/h)	0,8
Material	Superduplex wetted parts
Speed (rpm)	600 - 900

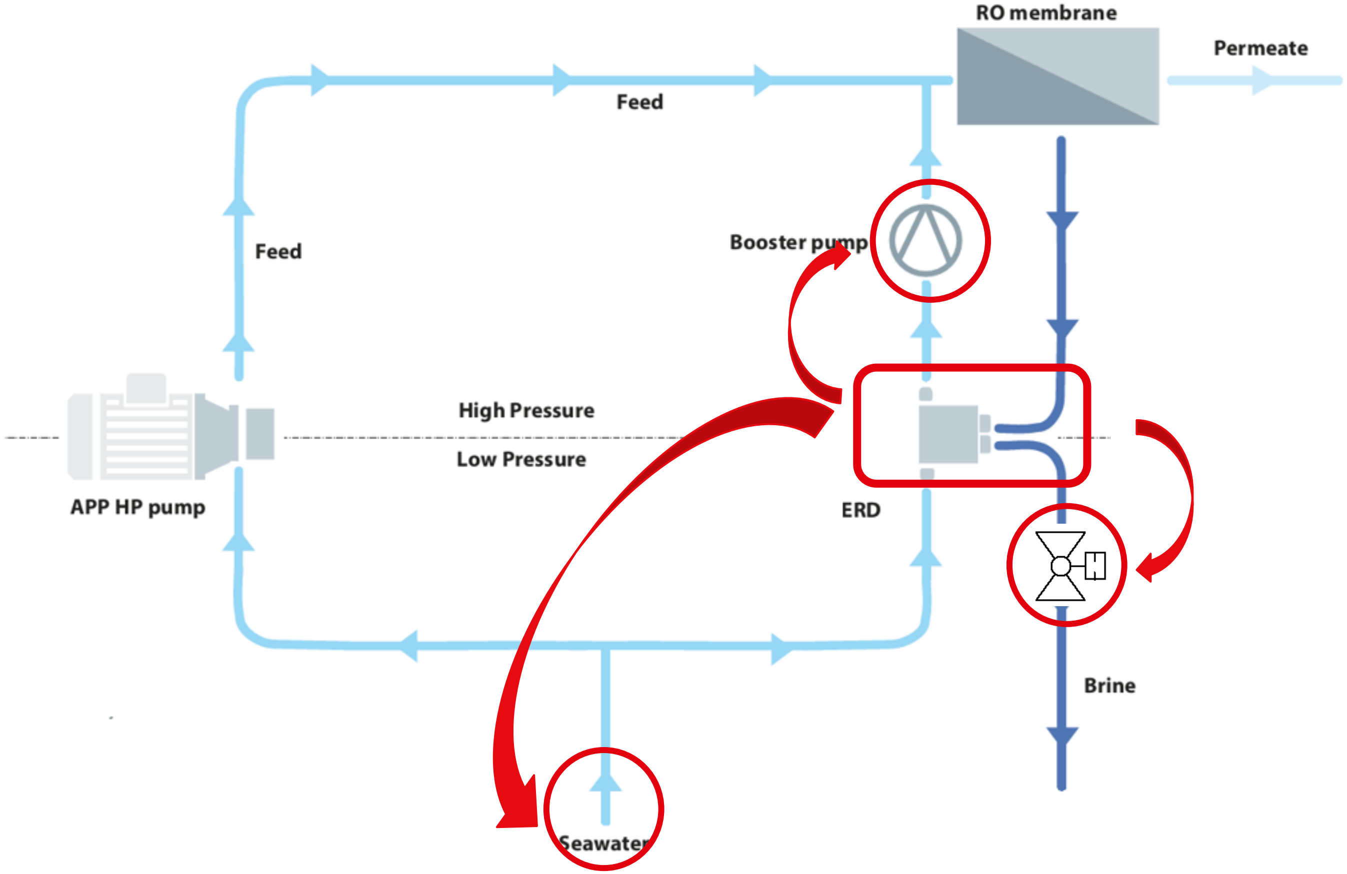


Highly efficient energy recovery device
built on **isobaric technology**



Passive ERDs in larger SWRO plants

Standard SWRO configuration includes a passive ERD device.



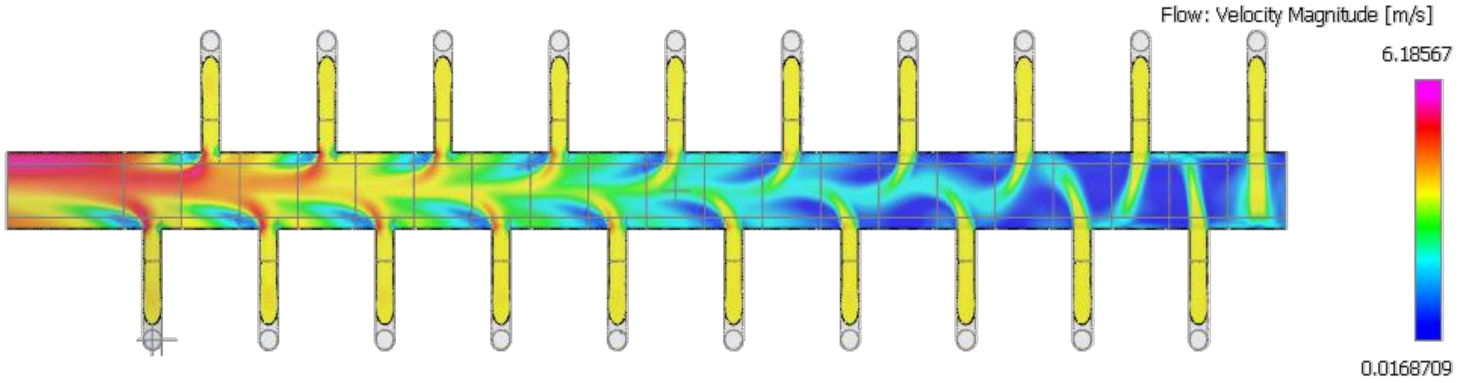
Passive ERDs relays their performance and safety in **external devices**

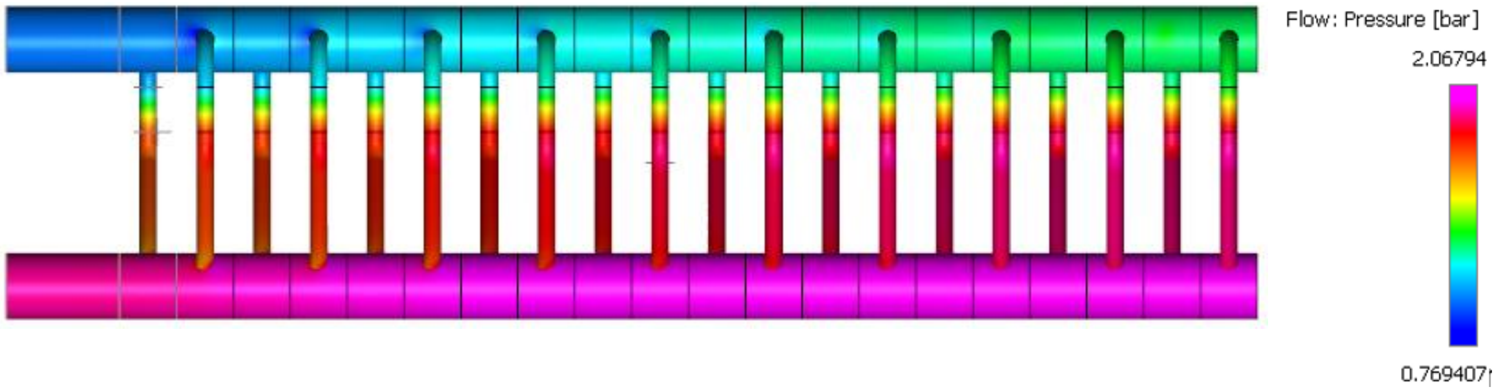
Passive ERDs in larger SWRO plants

Different flow operation

Salinity differences

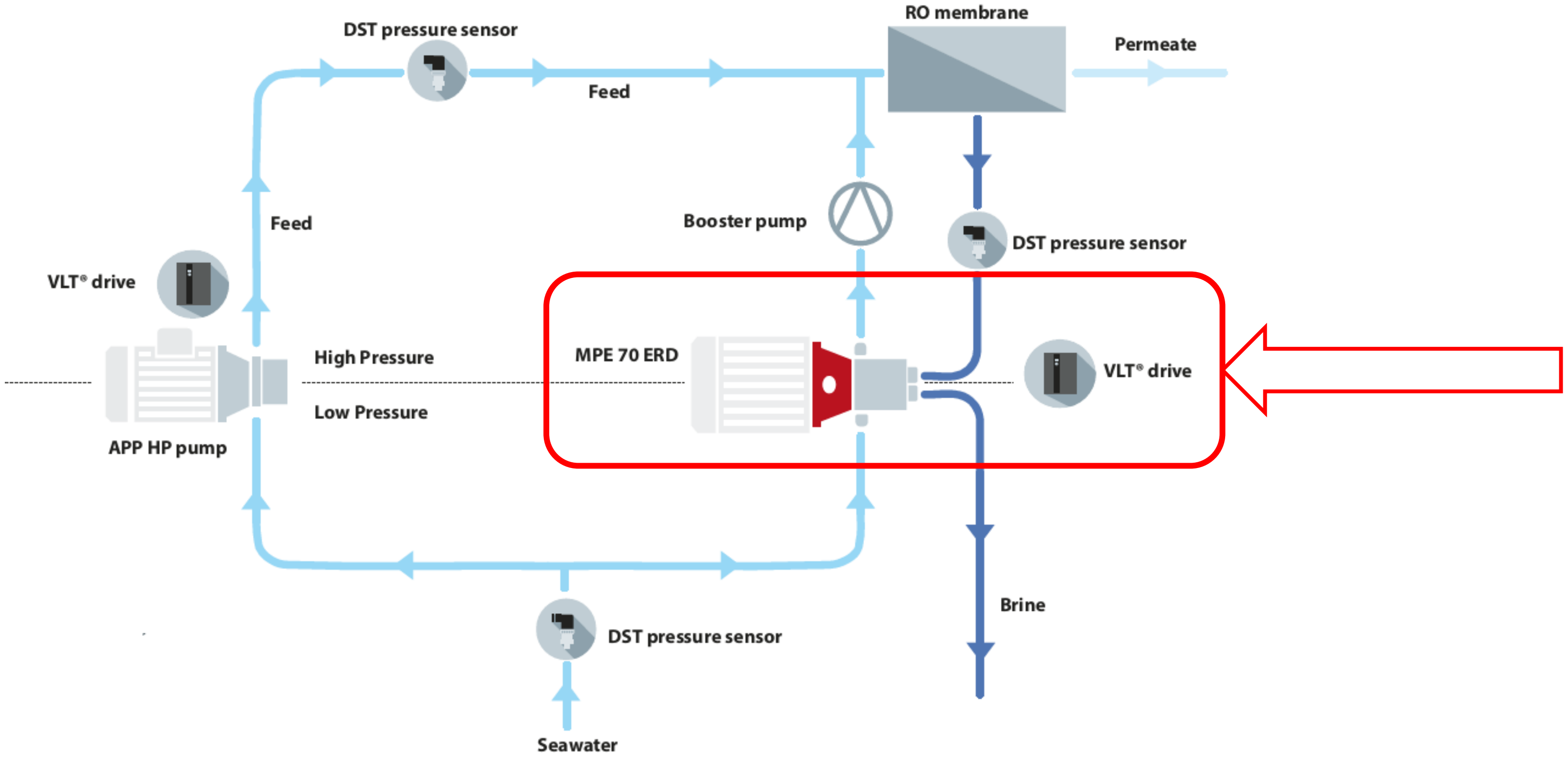
Different pressure losses





- ✓ Passive ERDs can not operate in the same way having different environment
- ✓ Every single unit operates at a different flow
- ✓ First units are working with laminar flow despite the last units where the flow is much more turbulent

Benefits of the **new active ERD – MPE 70**



Active device that allows to operate independently of external equipment

MPE 70 – Field installation and references

Total: 33 units

6 different plants & Customers

1. Acciona - Arucas Moya SWRO plant
2. Saudi Arabia SWRO plant
3. North Africa SWRO plant
4. 1st Egypt SWRO plant
5. 2nd Egypt SWRO plant
6. Asia WW plant

Arucas Moya SWRO – Field operation results

- ✓ Plant size: 15.000 m^3/d
- ✓ Plant name: Arucas Moya
- ✓ MPE 70 first site installation
- ✓ Operator: acciona
- ✓ Location: Canary Island, Spain
- ✓ Plant start-up: 1995

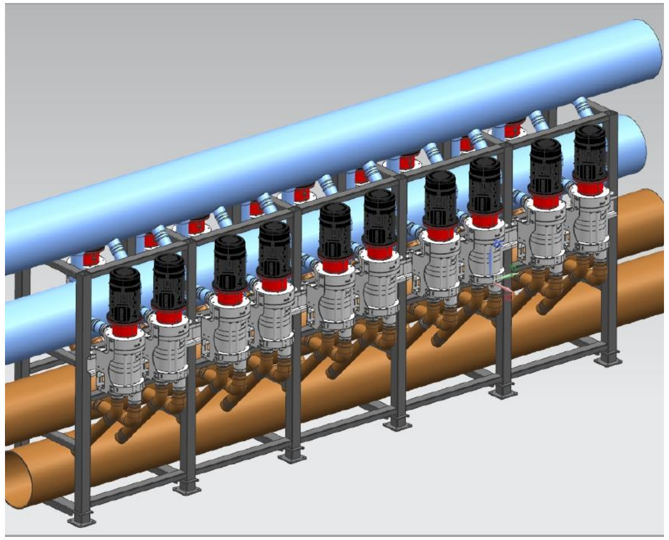
Arucas Moya SWRO – Field operation results

- ✓ MPE 70 start-up: Dec 2021 → 1,5 years of operation
- ✓ Scope: 7 x MPE 70
- ✓ Performance data collected frequently

Flow per unit (m3/h)	54
Mixing	**1,9%**
Salinity increase at membranes	**1,0%**
Flushing	4,7%
ERD efficiency	97,1%
Differential pressure Hp side (bar)	0,4
Differential pressure Lp side (bar)	0,7

Large SWRO - Conclusions

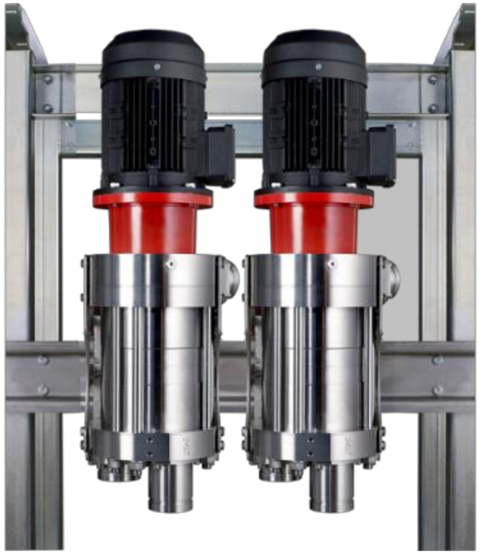
MPE 70 – Active Isobaric energy recovery device



- ✓ Robust and proven design based on our existing technology
- ✓ Unprecedented Mixing levels (as low as 1,9%)
- ✓ Monitor and control each individual unit → Optimal performance
- ✓ Continue operation despite biofouling
- ✓ MPE 70 → 33 units in 6 plants; 7 units working for 1,5 years
- ✓ Extensive ERD experience: 15 years and more than 3000 installations worldwide

Thanks for your attention! Any question?

2. SWRO in Saudi Arabia – Field installation



- ✓ Plant size: 2.000 m^3/d
- ✓ Scope: 2 x MPE 70 + 1 x HPP on an existing rack
- ✓ Location: Saudi Arabia
- ✓ Plant commissioning: Sep 2022
- ✓ Site Performance values – MPE 70:

Flow per unit (m3/h)	57
Pressure (bar)	83
Speed	715

3. SWRO in North Africa – Field installation

- ✓ Plant size: 20.000 m^3/d
- ✓ Scope: 16 x MPE 70
- ✓ Plant start-up: May 2023
- ✓ Agreed performance Data:

Flow per unit (m3/h)	65
Mixing	**2,5%**
Salinity increase at membranes	**1,1%**
Flushing	5%
Differential pressure - Hp (bar)	0,5
Differential pressure - Lp (bar)	0,6

4. 1st SWRO in Egypt – Field installation

- ✓ Plant size: 10.000 m^3/d
- ✓ Scope: 6 x MPE 70
- ✓ Location: Egypt
- ✓ Expected plant start-up: June 2023
- ✓ Agreed performance Data:

Flow per unit (m3/h)	60
Pressure (bar)	68
DeltaP_Hpside (bar)	0,4
DeltaP_Lpside (bar)	0,7

5. 2nd SWRO in Egypt – Field installation

- ✓ Plant size: 2.700 m^3/d
- ✓ Scope: 2 x MPE 70
- ✓ Location: Egypt
- ✓ Expected plant start-up: Sep 2023

6. WW in Asia – Field installation

- ✓ Plant size: 2.500 m^3/d
- ✓ Scope: 2 x MPE 70
- ✓ Expected plant commissioning: Sep 2023
- ✓ Agreed performance Data:

HP out Flow (m3/h)	60
Pressure (bar)	66

Danfoss APP Pump

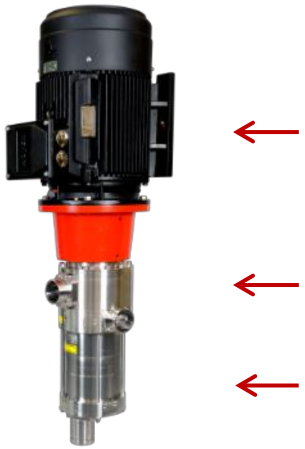
From 0.15 to 92 m^3/h

Pump size	Flow range		Pressure	
	m^3/h	gpm	barg	psig
APP 0.6 – 1.0	0.15 – 1.0	0.7 – 4.4	20 - 80	290 - 1160
APP 1.5 – 3.5	1.6 - 3.5	7.04 – 15.4	20 - 80	290 - 1160
APP 5.1.- 10.2	4.9 -10.3	21.6 – 45.3	20 - 80	290 - 1160
APP 11 – 13	11.0 – 13.5	48.4 – 59.4	10 - 80	145 - 1160
APP 16 - 22	15.8 – 21.8	69.9 – 96.0	10 - 80	145 - 1160
APP 21 - 46	21.1 – 44.6	92.9 – 202.5	10 - 80	145 – 1160
APP 53 – 92 NEW	24 - 92	105.7 -405.1	30 – 80(70)	435 – 1160(1015)

Calculation of comparable **Efficiency**

includes Pressure Exchanger, Pump and Motor

iSave



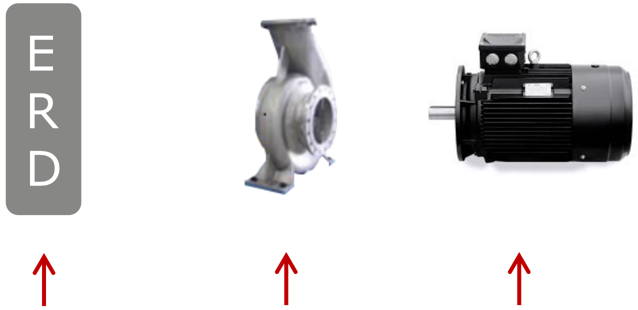
Motor

Booster pump

Pressure exchanger

Total efficiency **up to 94%**

NN isobaric ERD



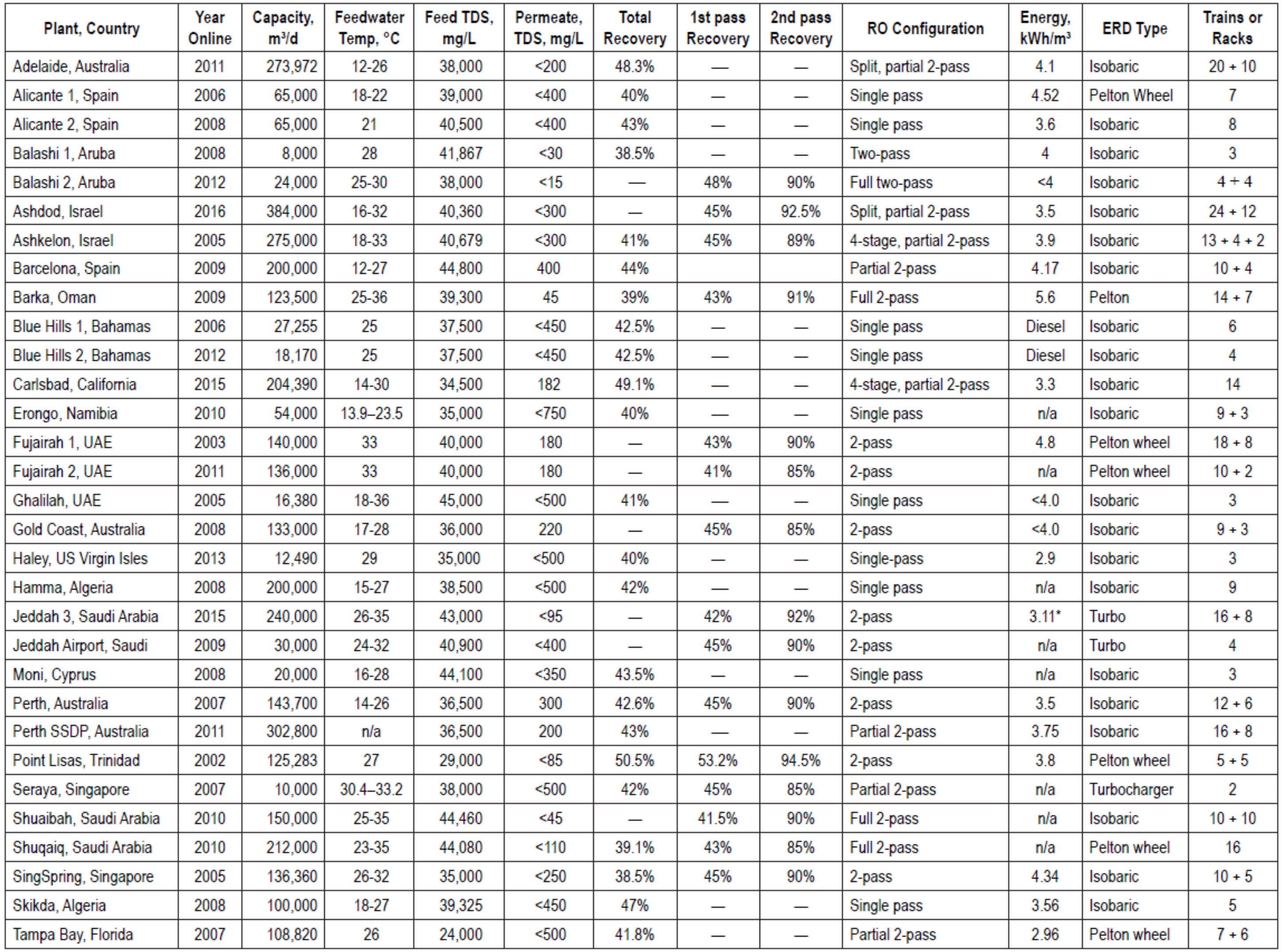
Pressure exchanger

Booster pump

Motor

Total efficiency **up to 94%**

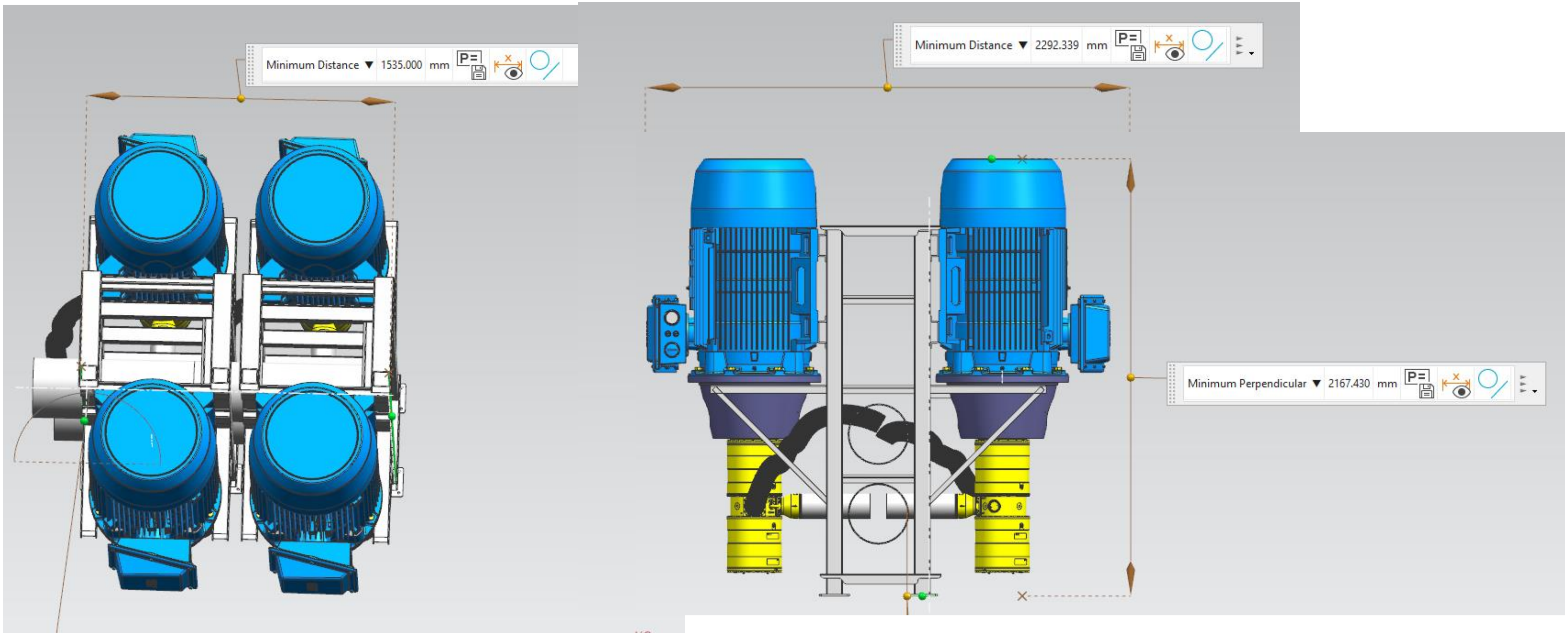
Energy Consumption Trends



Plant, Country	Year Online	Capacity, m^3/d	Feedwater Temp, °C	Feed TDS, mg/L	Permeate, TDS, mg/L	Total Recovery	1st pass Recovery	2nd pass Recovery	RO Configuration	Energy, kWh/m^3	ERD Type	Trains or Racks
Adelaide, Australia	2011	273,972	12-26	38,000	<200	48.3%	—	—	Split, partial 2-pass	4.1	Isobaric	20 + 10
Alicante 1, Spain	2006	65,000	18-22	39,000	<400	40%	—	—	Single pass	4.52	Pelton Wheel	7
Alicante 2, Spain	2008	65,000	21	40,500	<400	43%	—	—	Single pass	3.6	Isobaric	8
Balashi 1, Aruba	2008	8,000	28	41,867	<30	38.5%	—	—	Two-pass	4	Isobaric	3
Balashi 2, Aruba	2012	24,000	25-30	38,000	<15	—	48%	90%	Full two-pass	<4	Isobaric	4 + 4
Ashdod, Israel	2016	384,000	16-32	40,360	<300	—	45%	92.5%	Split, partial 2-pass	3.5	Isobaric	24 + 12
Ashkelon, Israel	2005	275,000	18-33	40,679	<300	41%	45%	89%	4-stage, partial 2-pass	3.9	Isobaric	13 + 4 + 2
Barcelona, Spain	2009	200,000	12-27	44,800	400	44%			Partial 2-pass	4.17	Isobaric	10 + 4
Barka, Oman	2009	123,500	25-36	39,300	45	39%	43%	91%	Full 2-pass	5.6	Pelton	14 + 7
Blue Hills 1, Bahamas	2006	27,255	25	37,500	<450	42.5%	—	—	Single pass	Diesel	Isobaric	6
Blue Hills 2, Bahamas	2012	18,170	25	37,500	<450	42.5%	—	—	Single pass	Diesel	Isobaric	4
Carlsbad, California	2015	204,390	14-30	34,500	182	49.1%	—	—	4-stage, partial 2-pass	3.3	Isobaric	14
Erongo, Namibia	2010	54,000	13.9–23.5	35,000	<750	40%	—	—	Single pass	n/a	Isobaric	9 + 3
Fujairah 1, UAE	2003	140,000	33	40,000	180	—	43%	90%	2-pass	4.8	Pelton wheel	18 + 8
Fujairah 2, UAE	2011	136,000	33	40,000	180	—	41%	85%	2-pass	n/a	Pelton wheel	10 + 2
Ghalilah, UAE	2005	16,380	18-36	45,000	<500	41%	—	—	Single pass	<4.0	Isobaric	3
Gold Coast, Australia	2008	133,000	17-28	36,000	220	—	45%	85%	2-pass	<4.0	Isobaric	9 + 3
Haley, US Virgin Isles	2013	12,490	29	35,000	<500	40%	—	—	Single-pass	2.9	Isobaric	3
Hamma, Algeria	2008	200,000	15-27	38,500	<500	42%	—	—	Single pass	n/a	Isobaric	9
Jeddah 3, Saudi Arabia	2015	240,000	26-35	43,000	<95	—	42%	92%	2-pass	3.11*	Turbo	16 + 8
Jeddah Airport, Saudi	2009	30,000	24-32	40,900	<400	—	45%	90%	2-pass	n/a	Turbo	4
Moni, Cyprus	2008	20,000	16-28	44,100	<350	43.5%	—	—	Single pass	n/a	Isobaric	3
Perth, Australia	2007	143,700	14-26	36,500	300	42.6%	45%	90%	2-pass	3.5	Isobaric	12 + 6
Perth SSDP, Australia	2011	302,800	n/a	36,500	200	43%	—	—	Partial 2-pass	3.75	Isobaric	16 + 8
Point Lisas, Trinidad	2002	125,283	27	29,000	<85	50.5%	53.2%	94.5%	2-pass	3.8	Pelton wheel	5 + 5
Seraya, Singapore	2007	10,000	30.4–33.2	38,000	<500	42%	45%	85%	Partial 2-pass	n/a	Turbocharger	2
Shuaibah, Saudi Arabia	2010	150,000	25-35	44,460	<45	—	41.5%	90%	Full 2-pass	n/a	Isobaric	10 + 10
Shuqaiq, Saudi Arabia	2010	212,000	23-35	44,080	<110	39.1%	43%	85%	Full 2-pass	n/a	Pelton wheel	16
SingSpring, Singapore	2005	136,360	26-32	35,000	<250	38.5%	45%	90%	2-pass	4.34	Isobaric	10 + 5
Skikda, Algeria	2008	100,000	18-27	39,325	<450	47%	—	—	Single pass	3.56	Isobaric	5
Tampa Bay, Florida	2007	108,820	26	24,000	<500	41.8%	—	—	Partial 2-pass	2.96	Pelton wheel	7 + 6

Source: WATER DESALINATION REPORT – 31 July 2017 * does not includes pre-, post-treat

Bigger module 8,000 CMD



Minimum Distance ▼ 1535.000 mm

Minimum Distance ▼ 2292.339 mm

Minimum Perpendicular ▼ 2167.430 mm