

NASDAQ:ERII

Reducing Energy Costs for Industry Wastewater Treatment



Oct. 2023 | Energy Recovery Inc.

AGENDA

- **Who is Energy Recovery, Inc.**
- **ZLD Process and Brine Concentration**
- **Introduction to ERI Energy Recovery Device**
- **ERD Solution to LPRO/SWRO/UHPRO**
- **Case Studies**

Who is Energy Recovery, Inc.



Energy Recovery Snapshot

- For more than 20 years, Energy Recovery has created technologies that solve complex challenges for industrial fluid flow markets
- We design and manufacture solutions that reduce waste, improve operational efficiency, and drive significant cost-savings for our customers in Water and Oil & Gas
- Our worldwide sales and technical service organization provides on-site support for our products



Energy Recovery Snapshot



HEADQUARTERS/CERAMICS
San Leandro (San Francisco), California, USA



REGIONAL OFFICES
Spain, USA, UAE & China

Why Energy Recovery?



Our technologies lower production costs of clean water and oil & gas, enabling more affordable access to these critical resources



Our Water solutions are in desalination facilities on seven continents, reducing carbon emissions and helping to combat water scarcity around the globe



Our PX[®] Pressure Exchanger[®] energy recovery device revolutionized seawater reverse osmosis desalination, reducing energy costs by up to 60%*, helping to make desalination affordable worldwide



We are working actively to expand our pressure exchanger technology to other markets, including industrial wastewater

**Energy Recovery estimate*

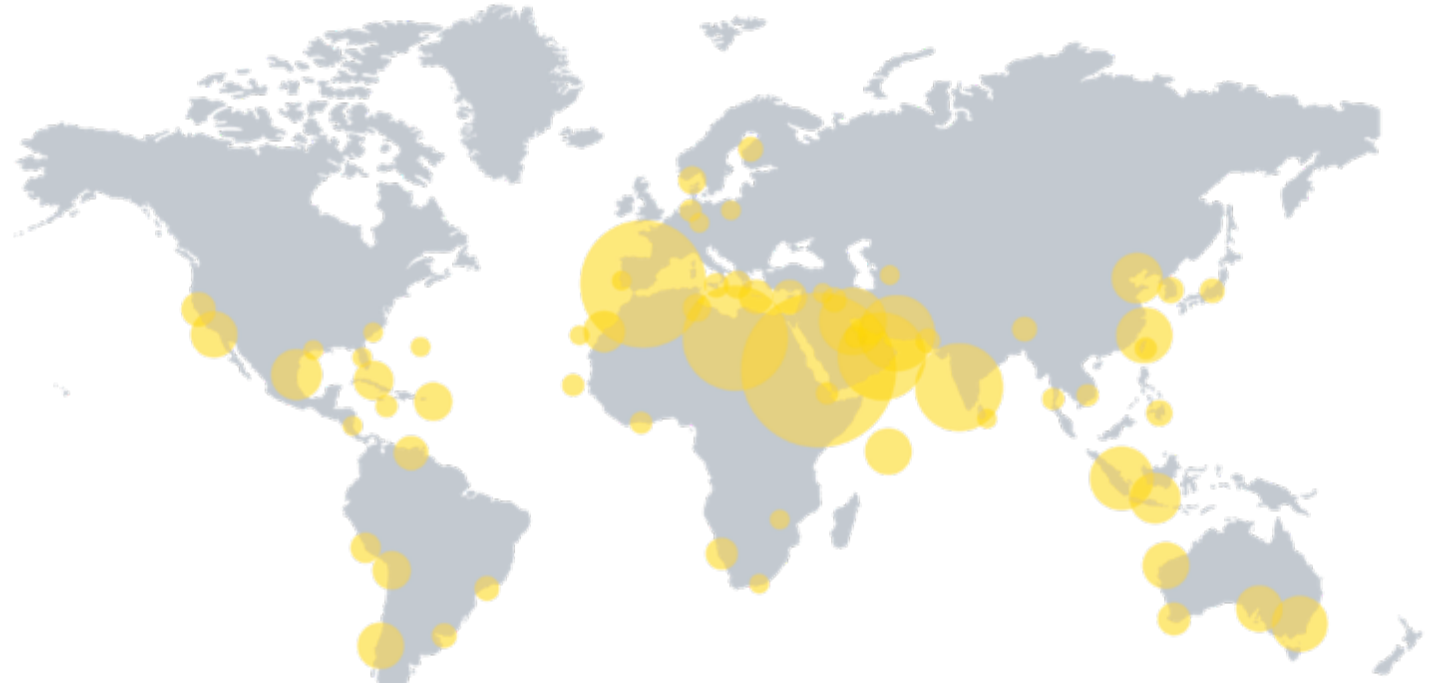
2021 Highlights 2021年亮点

 **30 TWh** *Saved in Electricity Consumption**

 **14.5M** *Metric Tons of Carbon Emissions Avoided**

 **\$3.9B** *Energy Expenses Saved by Customers**

 **112k kWh** *Solar Electricity Generated Internally*



Global Installations of Energy Recovery Water Products

*Annual data based on Energy Recovery estimates (internally assured).

ESG at Energy Recovery



- First Environmental, Social, Governance (ESG) report issued Sept 2020
 - Aligned with SASB and GRI sustainability reporting frameworks; select United Nations Sustainable Development Goals
- Our products address climate change, sustainable industrialization, energy efficiency, water scarcity
- Reflects our ongoing commitment to becoming a more sustainable, resilient business

To download the full report, please visit

[here](#)

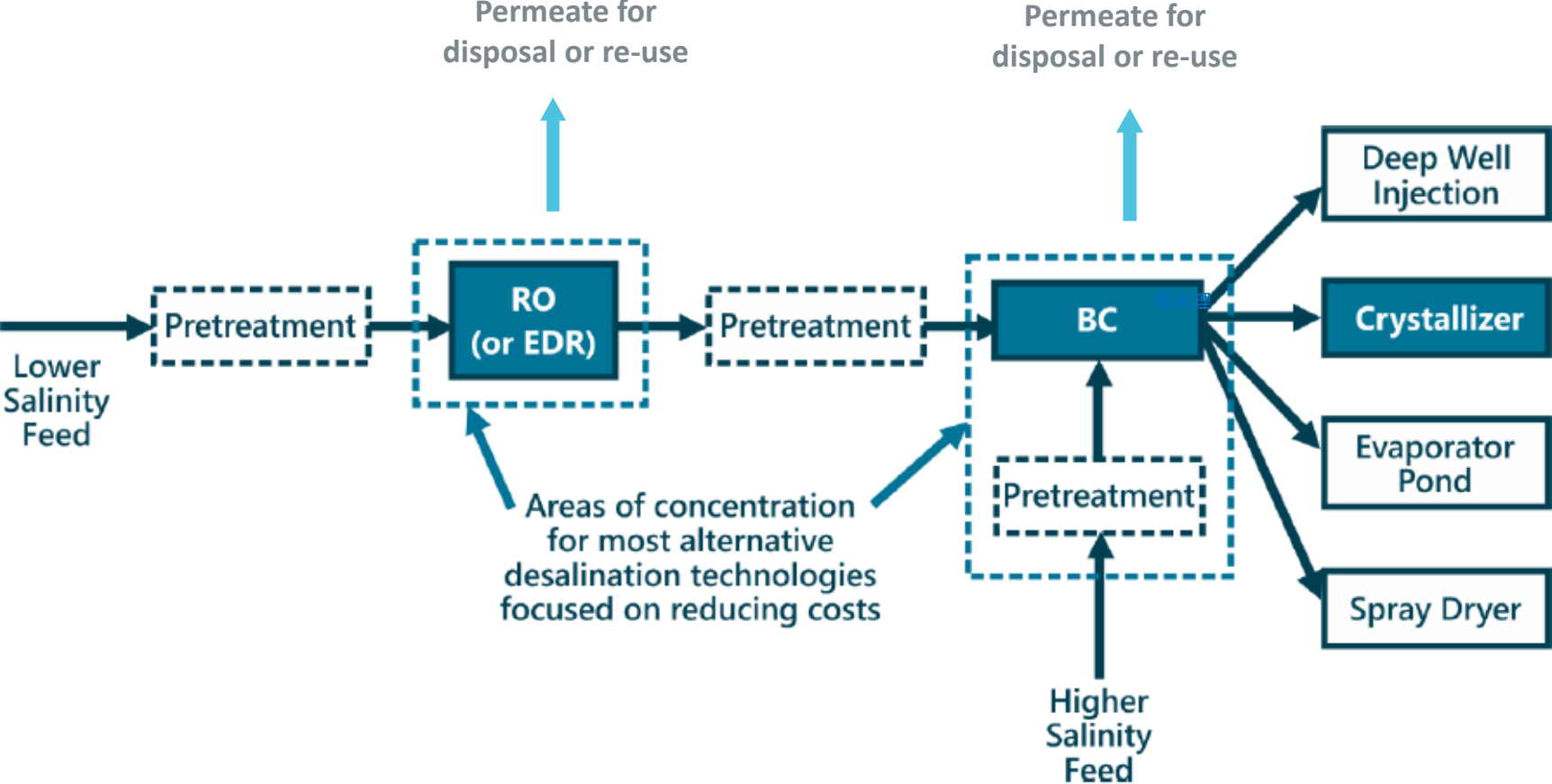
ZLD PROCESS AND BRINE CONCENTRATION

RO vs Thermal

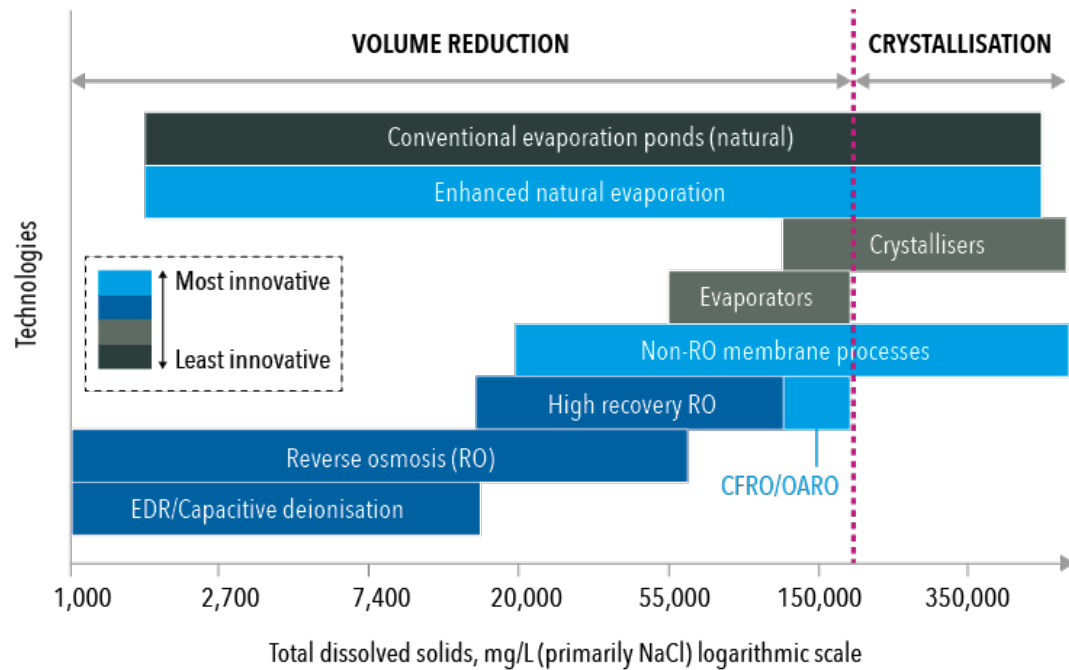


MLD/ZLD Process overview

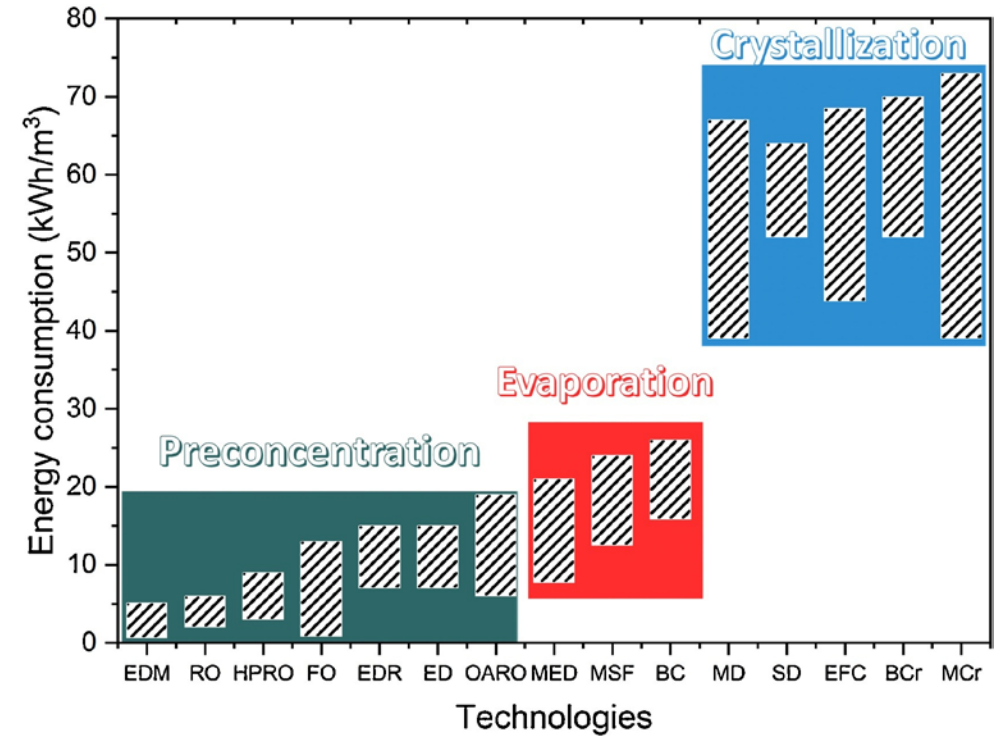
Water treatment process in which the plant discharges no liquid effluent into surface waters and contaminants are reduced to solid waste



Brine concentration technologies



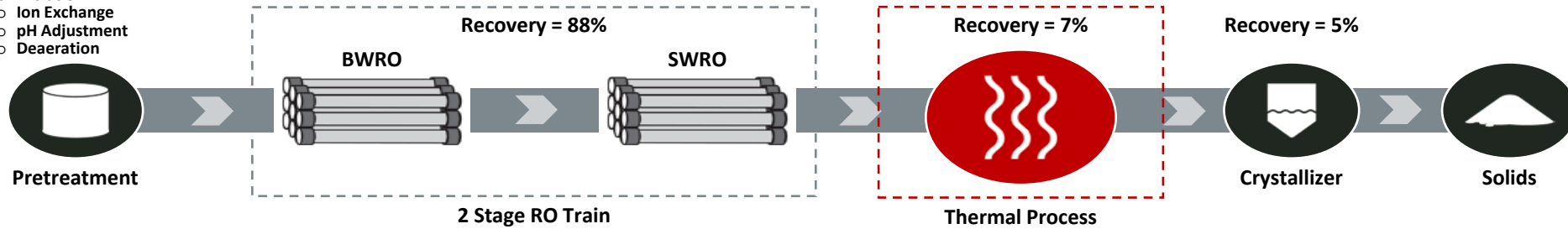
Source: <https://www.globalwaterintel.com/global-water-intelligence-magazine/20/6/market-map/ro-systems-make-their-case-for-brine-concentration-applications>



UHPRO Value proposition for ZLD

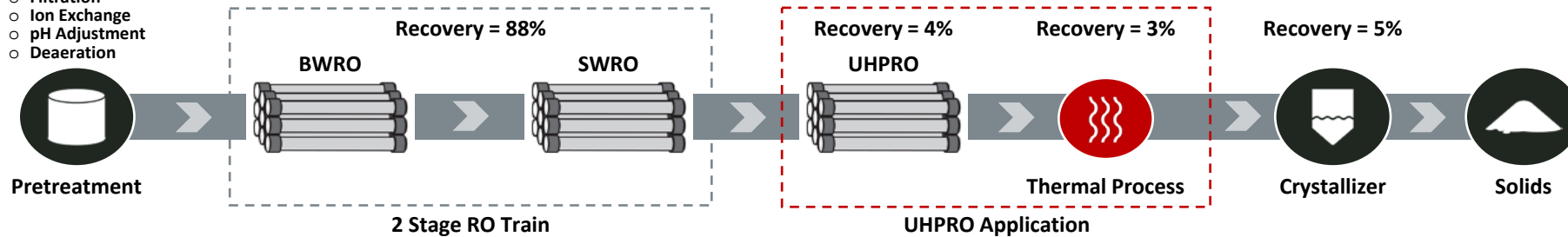
Thermal

- Softening
- Filtration
- Ion Exchange
- pH Adjustment
- Deaeration



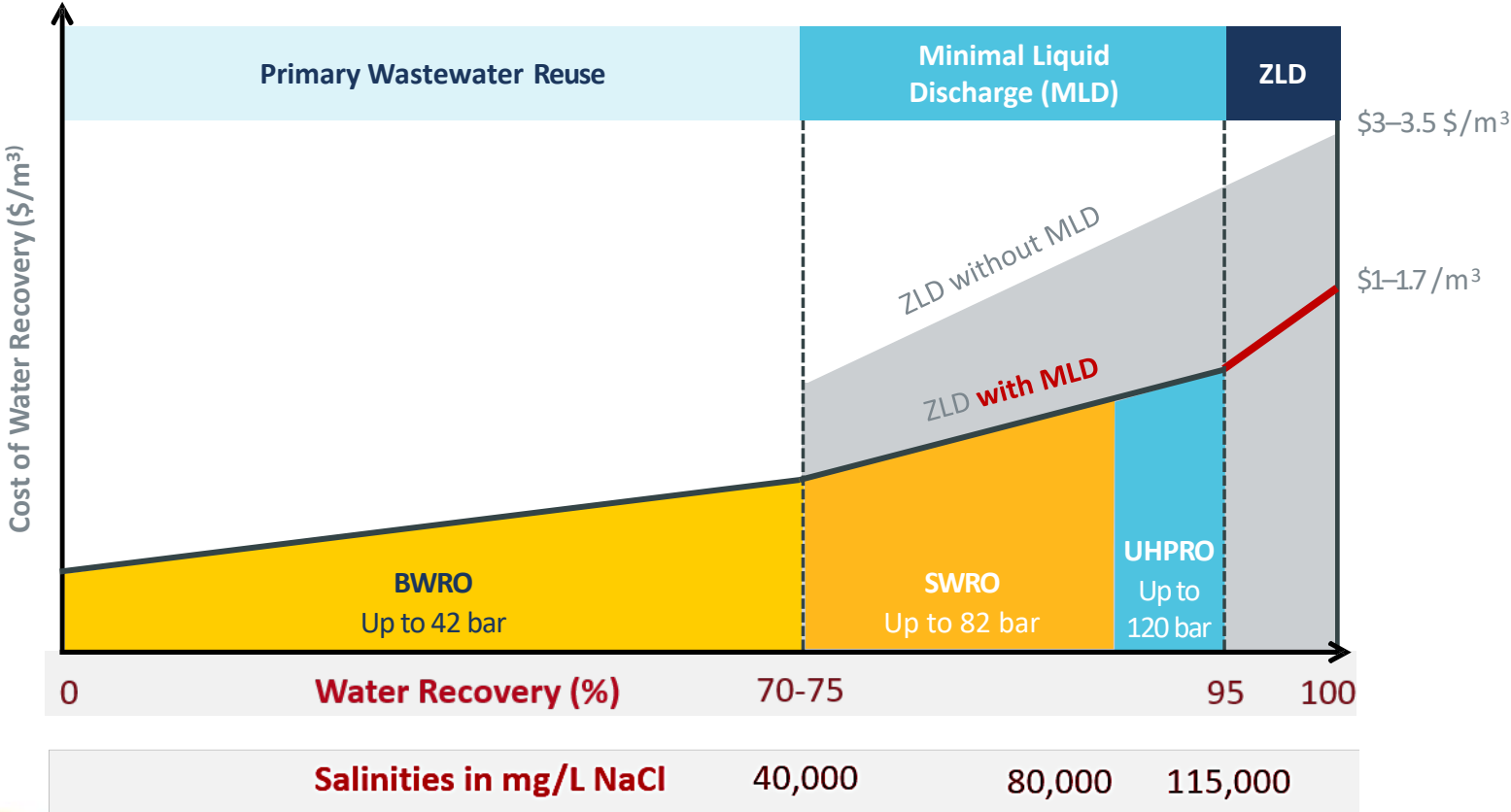
UHPRO + Reduced Thermal

- Softening
- Filtration
- Ion Exchange
- pH Adjustment
- Deaeration



- Maximizing water recovery and brine concentration through the RO process
- Minimizing the use of thermal process that is more energy intensive

MLD Value Proposition



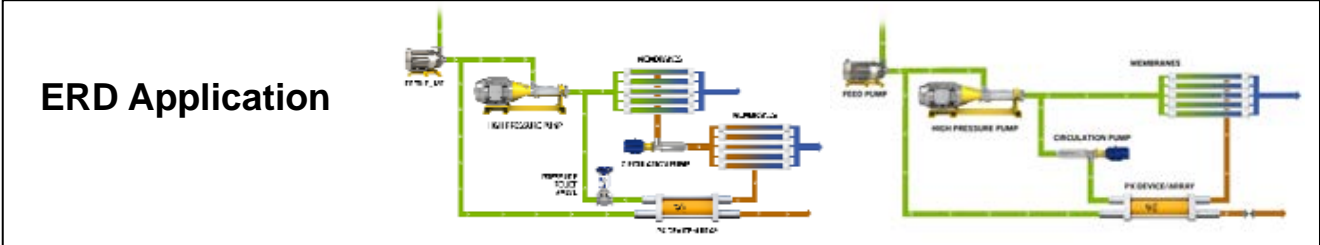
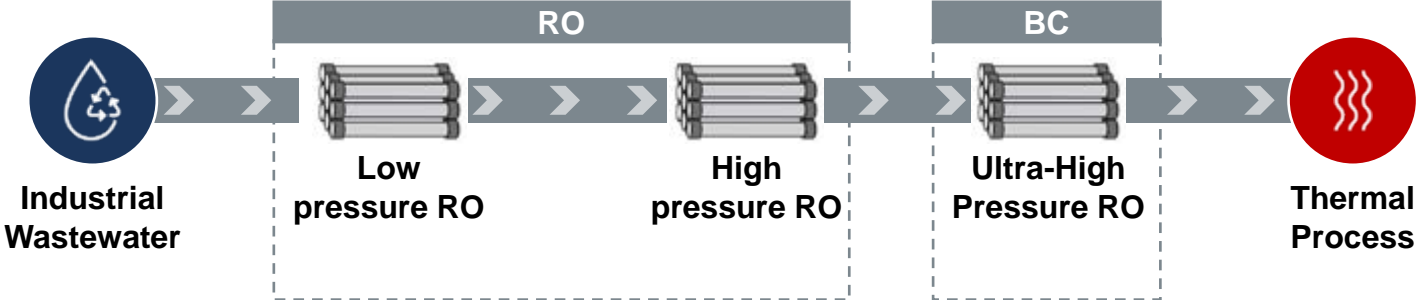
- Minimal Liquid Discharge (MLD) utilizes proven separation and energy recovery technologies that enable a breakthrough process; recapturing resources that would otherwise go untapped at a cost savings that allows businesses to thrive
- Employ a compatible solution that enables capture of more than 95% of liquid discharge and save 60% of the cost

Introduction to ERI Energy Recovery Device



Energy Recovery – ERD PRODUCT LINE

Energy Recovery Devices (ERD) for All Membranes in the MLD/ZLD Treatment Train



Our water desalination solutions

Energy Recovery Devices

PX Pressure Exchanger



- Most widely used ERD in SWRO
- Unmatched efficiencies for desalination up to 98%
- Highest uptime in the market (99.8%)
- Designed for up to 25+ years of useful life

AT Turbocharger

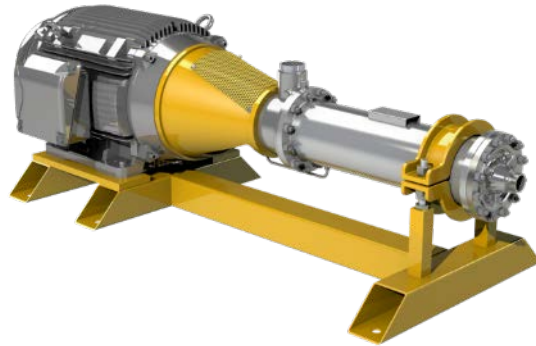


- Efficiencies up to 80%
- Volute insert technology for best efficiency range
- Lower initial capital costs

Our water desalination solutions

Pump Products

AquaBold High Pressure Pump



- Water lubricated bearing for long life and low maintenance
- Cast, duplex stainless-steel hydraulics for higher quality and uptime

Vertical and Horizontal Circulation Pumps



- Specialized pumps pair with PX application
- Designed for long life with low maintenance
- Reliable performance in high suction pressure operating environments

Our water desalination solutions

Frame Support

PX Power Train

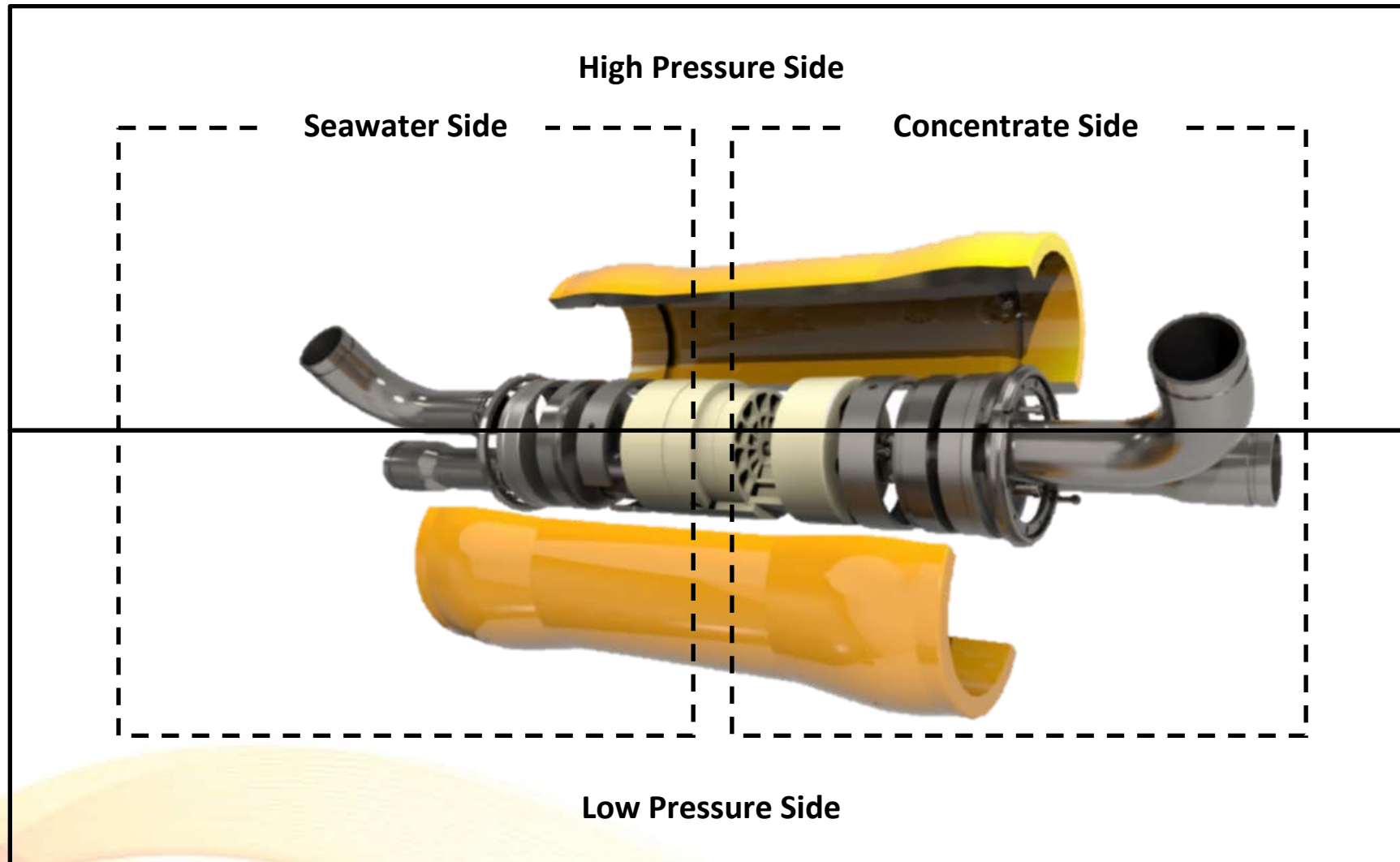
- Combines PX with frame support and ancillary equipment into a compact, high-performance ERD array package
- Designed according to Energy Recovery guidelines to ensure optimal PX operation
- Pre-designed ERD and frame support for ease of installation
- Train production capacity ranges from 3,000 to 13,000 cubic meters per day (CMD)





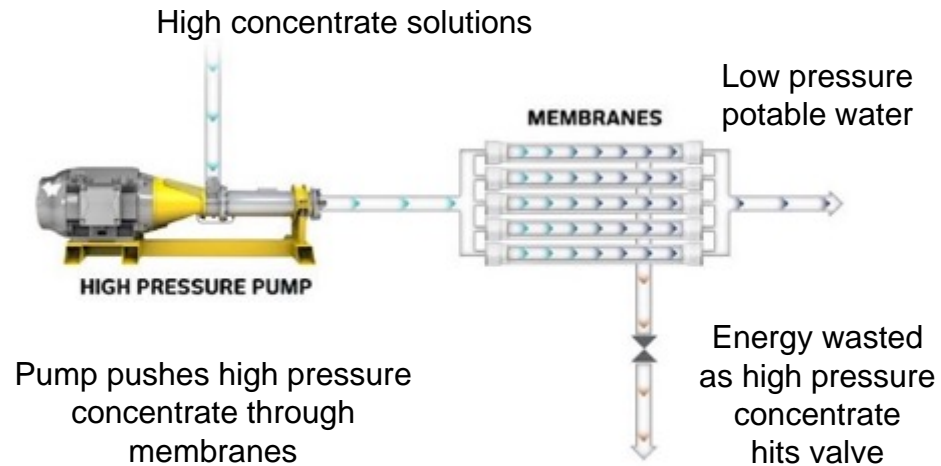
PX Product Line

A look inside the PX



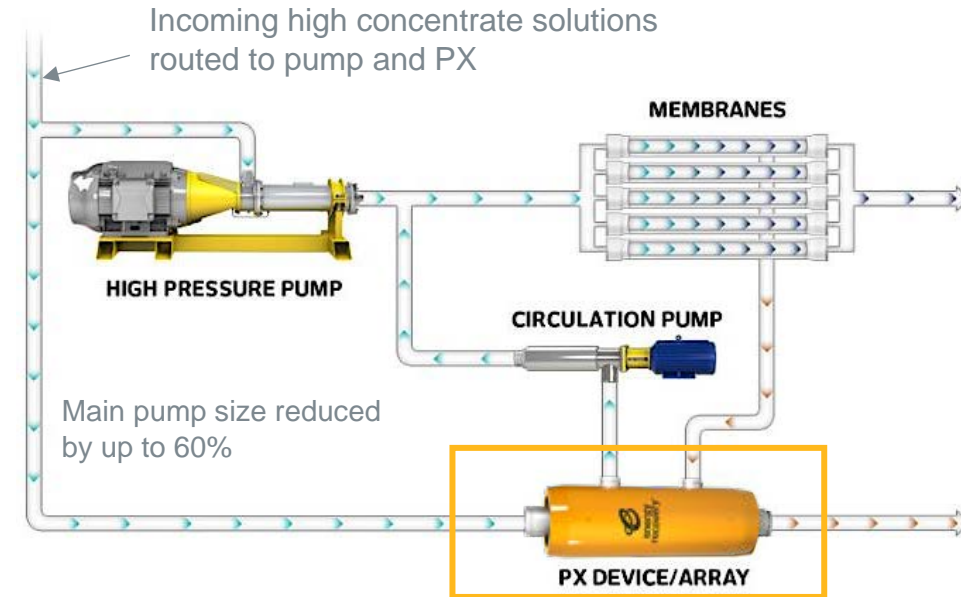
PX improves RO value proposition

Without Energy Recovery Devices (ERDs)
= Approx. 60% of Energy Wasted



- Pressure driven. High pressure demand is proportional to feed water salinity up to 1800 psi
- Brine comes out at high pressure/energy which is reduced using a flow control valve

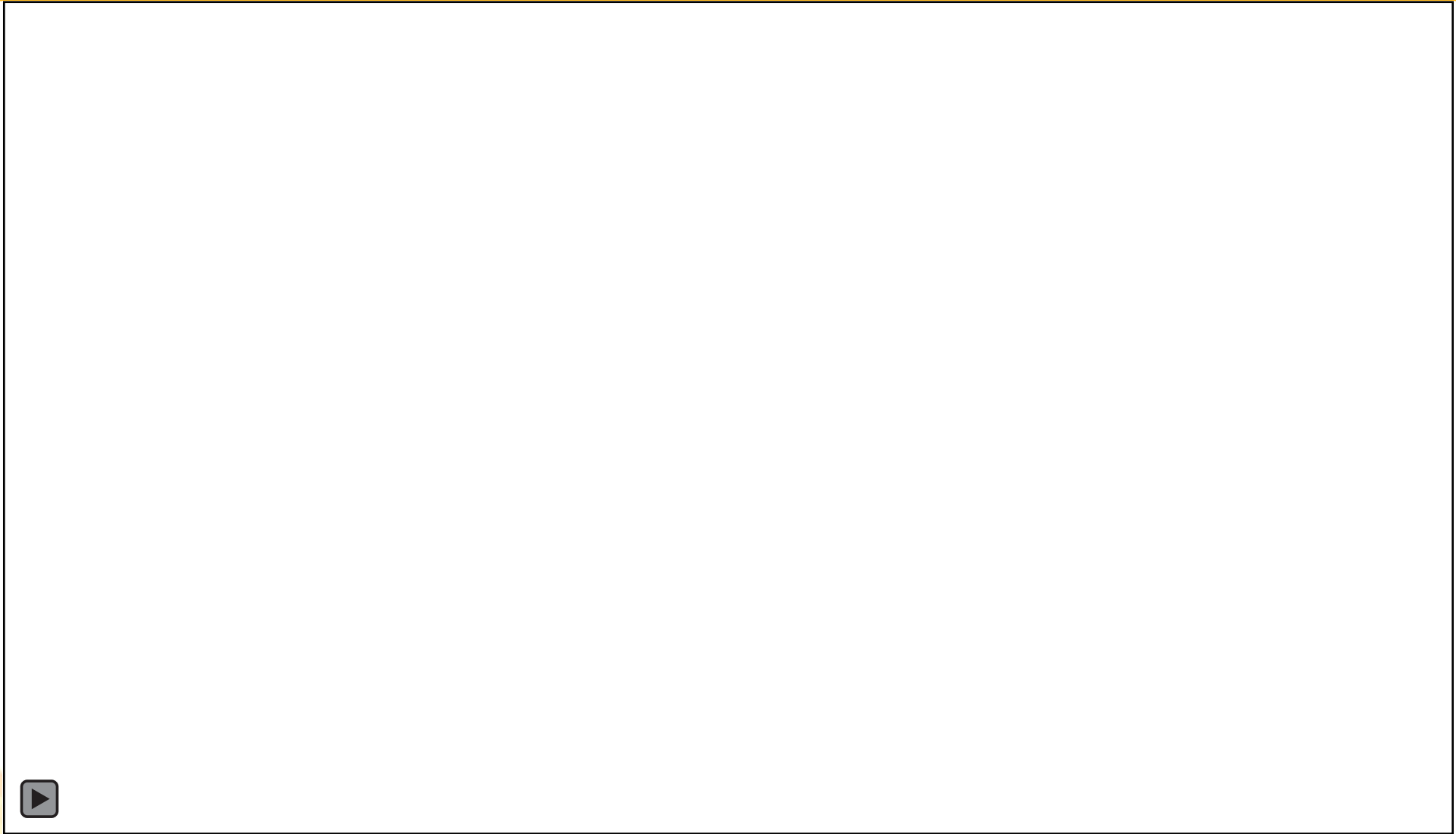
With PX Pressure Exchanger
= Energy Recycled, up to 60% Decrease in Energy Use



Introduction of Ultra PX in RO process allows:

- Up to 60% energy savings from recovering wasted energy
- Up to 65% reduction in high-pressure pump size which only needs to deliver a flow equal the product flow
- Ability to do brine recirculation

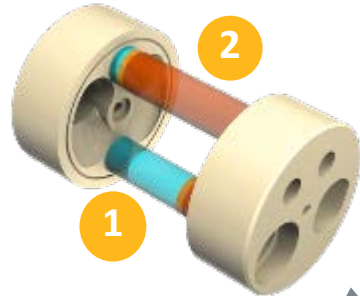
How pressure exchanger technology works



How pressure exchanger technology works

Sealed Phase

Two fluids on opposite sides of PX; rotor duct is sealed, isolating high, low pressure fluid streams



1. Low pressure driven fluid that will be pressurized and sent into system
2. High pressure motive fluid

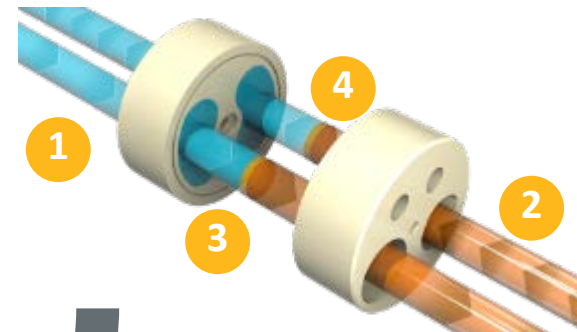
Rotor duct rotates to pressure exchange phase



Rotor duct rotates to sealed phase

Pressure Exchange Phase

1. Low pressure driven fluid enters the rotor duct
2. High pressure motive fluid enters the rotor duct



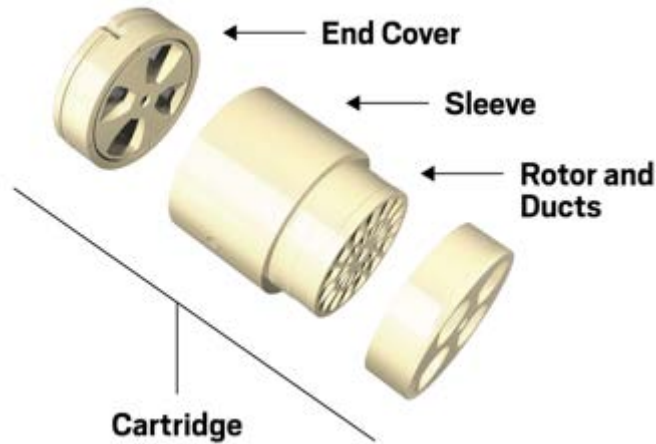
3. Low pressure driven fluid contacts motive fluid, expelling it at low pressure
4. High pressure motive fluid contacts driven fluid, expelling it at high pressure

Pressure is exchanged continuously as the rotor spins at high speed

Pressure Exchanger Technology Platform

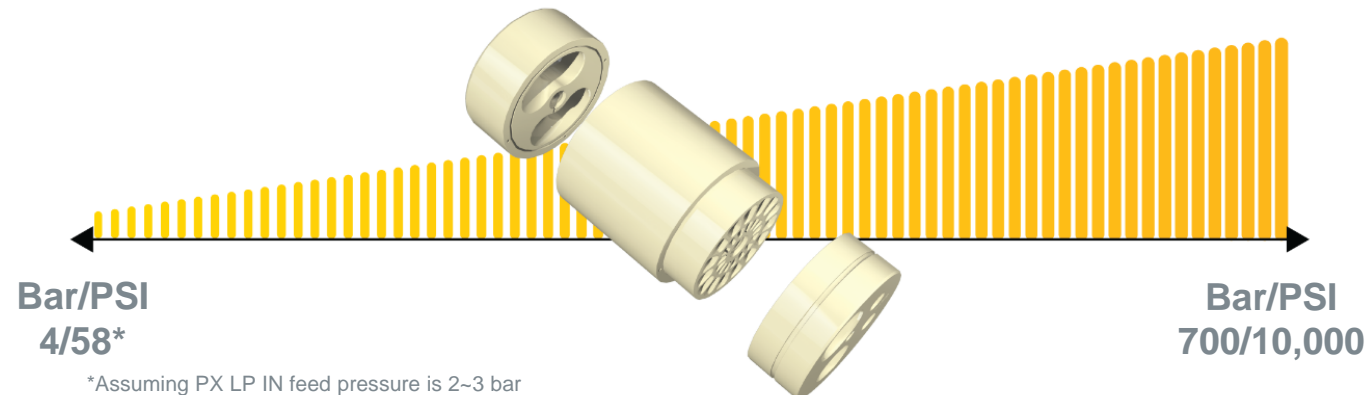
Anatomy of a Pressure Exchanger

Transfers energy from high-pressure to low-pressure fluids through continuously rotating ducts with only one moving part (the rotor)

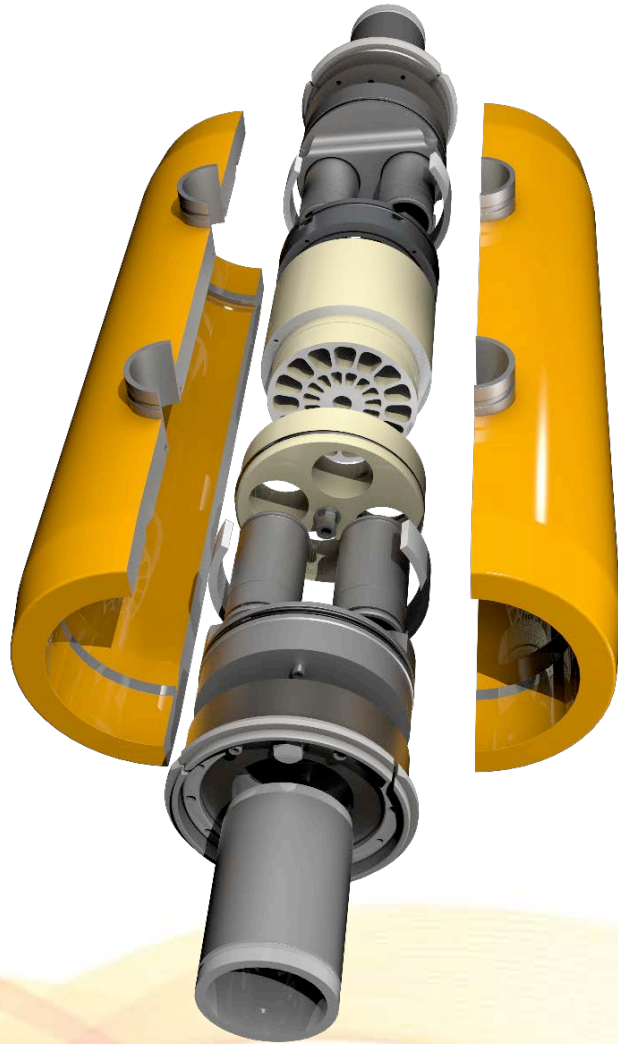


- We drive benefits by applying this technology to industrial fluid-flow systems:
 - Decreased energy use
 - Reduced operating costs
 - Lower emissions
- Pressure exchanger technology is versatile – can handle a range of pressures and fluids
- The PX for SWRO was the initial product application; we are now incubating new solutions on this technology platform

Pressure Exchanger Technology Operating Range



PX: Rugged and compact design



No controls, wires, or electrical connections

No valves

Rotor

- Only moving part
- Hydrodynamic bearing
- Automatic speed adjustment
- No material to material contact

State-of-the Art Materials

- Trade-secret ceramic formulation
- Extremely durable material (3X steel hardness)
- Never corrodes
- No fatigue

Lightweight/Small footprint

PX Technology Advantages

- **Highest Energy Recovery Efficiency at 98%**
 - \$2.0 billion per year in savings for our customers.
 - Consumes no electrical power so facilities can reduce their energy consumption by as much as 60%.
- **Uptime: 99.8% Availability Advantage**
 - Virtually no scheduled maintenance and proven long-life performance
 - Engineered with only one moving part from our patented ceramic technology, the PX is designed to be durable in the harshest of environments without failure- maximizing your facility's uptime.
- **Lowest Lifecycle Costs**
 - Highest return on investment
- **Durability – Designed for a lifetime**
 - Designed for plant lifetime (25+ years minimum)
 - Robust ceramic components that are corrosion-proof and abrasion-resistant
- **Modularity & Flexibility**
 - Scalable to accommodate different capacities
 - Flexible operations (recovery/flows)

PX Pressure Exchanger Product Line for SWRO/LPRO

PX (PX 30/.../Q400)



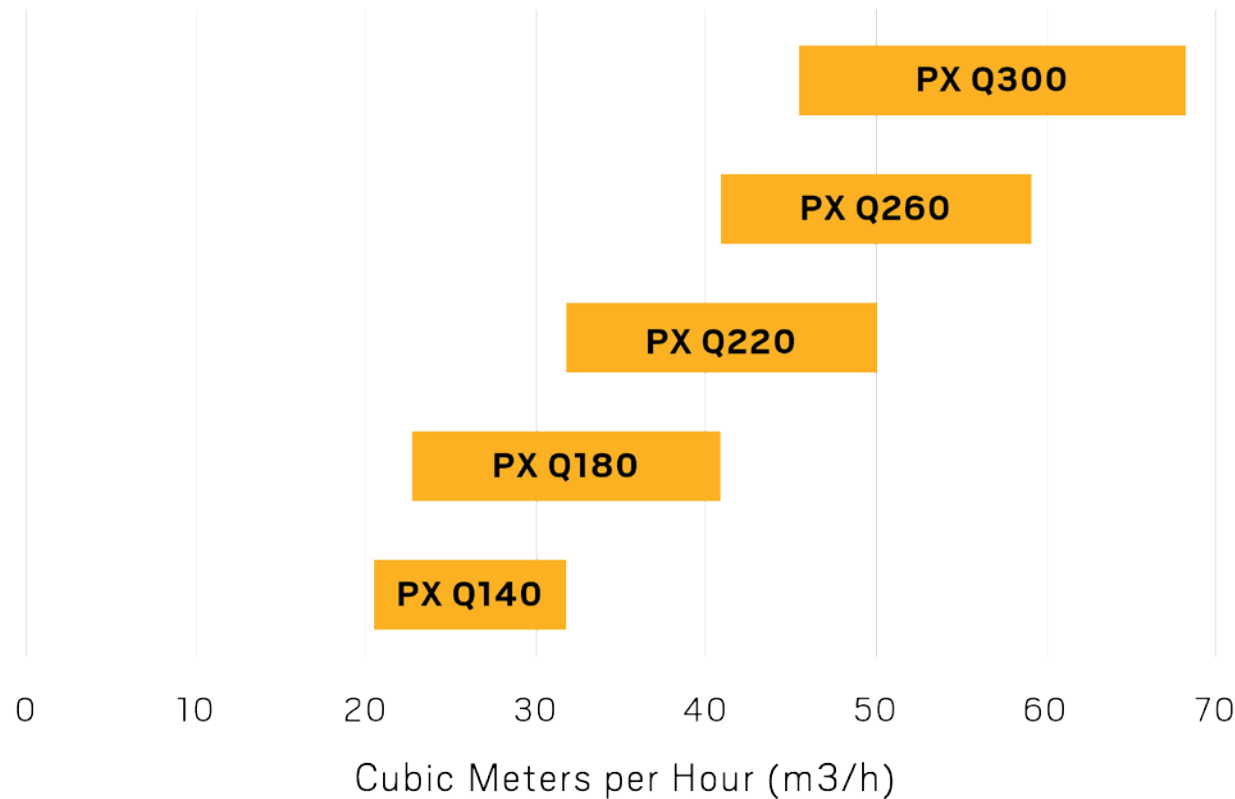
- Pressure up to 1,200 psi (82.8bar)
- Flow range 20 to 400 gpm (4.5-90.8 m³/h)
- Peak efficiency > 98%
- Quiet Series (< 79 dBA)

Low Pressure PX (LP PX 45/.../260)



- Pressure up to 400 psi (27.6 bar)
- Flow range 25 to 260 gpm (5.6-59 m³/h)
- Peak efficiency > 95%

PX Q Series



¹1000 PSI, 15 PSI BP, mid flow, ISO 3744; ²Compared to standard PX models

- **Audible Improvement**
Operational sound levels below 79 decibels¹ to enhance the working environment and safety of water treatment plants.
- **Reduced Mixing**
Further reduction in fluid mixing² from an already negligible level, resulting in lower membrane feed salinity and pressure and increasing desalination system performance.
- **Industry Leading Efficiency**
Unparalleled efficiency for energy recovery devices, up to 98%; a core benefit of all PX products

PX-Q400



		1717 Doolittle Dr. San Leandro, CA 94577, USA Phone: 1-510-483-7370 FAX: 1-510-483-7371		Energy Recovery, Inc. Specifications Sheet PX Q400		REV	BY	CKD	REVISION	DATE
DESCRIPTION: TECHNICAL DATA SHEET, POSITIVE DISPLACEMENT ENERGY RECOVERY DEVICE		Sheet Page 1 of 1 Document number: 8XXXX-01		0	SYB	DKH	Initial Release		10/4/2022	
1 Part number	TDD	2 Service	3 Reference							
4	Liquid	Seawater	46	Performance	Standard					
5	Operating Temperature	33°F-120°F (0.6-49°C)	47	Case Hydrotest	Standard					
6	Max. Temperature	120°F (49°C)	48	Rotation Speed Test	Standard					
7	Specific Gravity	1.03	49	Die Penetrant Test (ceramics)	Standard					
8	Viscosity	1.060 cP @ 70°F (21.1°C)	50	Cavitation Test	Standard					
9	Flow range	290 - 400 gpm (65.9 - 90.0 m ³ /h)	51	Witnessed Test	Optional					
10	Maximum High-Pressure Inlet Flow	400 gpm (90.9 m ³ /h)	52							
11	Maximum Low-Pressure Outlet Flow	400 gpm (90.9 m ³ /h)	53							
12	Maximum Inlet High-Pressure	1200 psi (82.7 bar)	54							
13	Maximum Inlet Low-Pressure	300 psi (20.7 bar)	55							
14	Minimum Discharge Pressure	12 psi (0.8 bar)	56							
15	Filtration Requirement (Nominal)	20 µm	57							
16			58	Outside Dr						
17			59	Internal Co						
18			60	Housing Di						
19			61	Ceramic Di						
20	Peak Efficiency	98%	62	Material Ce						
21	Maximum High-Pressure Differential	10 psi (0.7 bar) @ 400 gpm	63	Visual						
22	Maximum Low-Pressure Differential	10 psi (0.7 bar) @ 400 gpm	64	Packing ar						
23	Maximum Lubrication Flow	5.1 gpm (1.2 m ³ /h) @ 400 gpm	65							
24	Maximum Salinity Increase at Membrane	Please see ERI Projections	66							
25	Noise Per ISO 3744	Less Than 85 dBA	67							
26			68							
27			69							
28	Housing**	GFP	70	PX Q400 u	Dimensions					
29	Rotor, Sleeve, Endcover Assembly	Ceramic-alumina	71	PX Q400 u	Dimensions					
30	Low Pressure Inlet Port Fitting	CINMN	72	Drv PX Q40	Dimensions					
31	Low Pressure Outlet Port Fitting	CINMN	73	Cartridge S	Dimensions					
32	High Pressure Inlet Port Fitting	2507 Super Duplex	74	Shipping a	Temperature					
33	High Pressure Outlet Port Fitting	2507 Super Duplex	75							
34	Internal Low Pressure Interconnector	Titanium, AL6000, or 2507 Super Duplex	76							
35			77							
36	Fastener/Hardware (non-welded)	316SS	78							
37	Tension Rod Assembly**	AL-6000 / C-276	79							
38	O-rings	EPDM	80							
39	Low Pressure Inlet Port Fitting		81							
40	Low Pressure Outlet Port Fitting	4" (DN100) Grooved-end Flexible Pipe Coupling	82							
41	High Pressure Inlet Port Fitting		83							
42	High Pressure Outlet Port Fitting		84							
43										
44										
45										

PRICE: sales@energyrecovery.com

*AL-6000 is a registered trademark of Allegheny Ludlum
 **Housing designed in accordance with the engineering standards of the Boiler and Pressure Society of Mechanical Engineers.
 ***The standardized efficiency test is conducted under conditions of balanced flow, 1000psi f, PX model under test. For on-site performance warranty values, please refer to the ERI project ERI RESERVES THE RIGHT TO MAKE SPECIFICATION CHANGES AT ANY TIME WITHOUT

		1717 Doolittle Dr. San Leandro, CA 94577, USA Phone: +1(510)483-7370 Fax: +1(510)483-7371		ENERGY RECOVERY, INC. PX Q400		REV	BY	CKD	REVISION	DATE
PERFORMANCE CURVES, POSITIVE DISPLACEMENT ENERGY RECOVERY DEVICE		SHEET 1 of 1 DOCUMENT NUMBER XXXXX-XX Rev 0 MANUFACTURER ERI		0	SYB	DKH	Initial Release		10/4/22	

EFFICIENCY

DIFFERENTIAL PRESSURE

LUBRICATION FLOW AT 400 gpm / 90.9 m³/h

NOTE: See ERI document number XXXXX-XX for definitions and test conditions.

	Specifications
ERD Technology	PX
Flow Range	290 – 400 gpm (65.9 – 90.9 m ³ /h)
Max Inlet High Pressure	1200 psi (82.7 bar)
Min Discharge Pressure	12 psi (0.8 bar)
Filtration Requirement	20 µm
Peak Efficiency	98%
Max Hi Press. Diff.	10 psi (0.7 bar)
Max Lo Press. Diff.	10 psi (0.7 bar)
Max Lube Flow	5.1 gpm (1.2 m ³ /h)
All Ports	4" (DN100) Grooved-end Flexible Pipe Coupling
PV Size	9 inch ID

Ultra PX™ – Standard Features and Benefits

Ultra PX is the ERD for ZLD Applications using Energy Recovery's Award-winning PX Pressure Exchanger Technology



Features

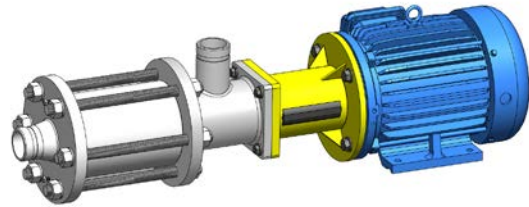
- Operates at pressures up to 120 bar (1740 psi)
- Unitary Flow range:
- UPX 4.55-56.8 m³/hr (20-250 gpm) capacity scalable connecting two or more units in parallel.
- One moving component, no control
- Corrosion resistant alumina core and Super Duplex ports/housing
- No scheduled maintenance

Benefits

- Designed to recover up to 60% of otherwise wasted energy
- Industry leading reliability
- Industry leading efficiency at all flow conditions (>93%)
- Low OPEX and lifecycle cost
- Compact, modular and scalable

UHP Pump – standard Features and benefits

Horizontal Multistage Circulation Pump Designed For Ultra High Pressure RO Applications



→ Features

- Designed to work with Ultra PX ERD
- Operates at pressures up to 120 bar (1740 psi)
- Flow capacity up to 13.6 m³/hr (60 gpm)
- Super duplex and Noryl wetted material

→ Benefits

- Enhanced corrosion resistance
- Longer bearing life and wear cycle
- No scheduled maintenance

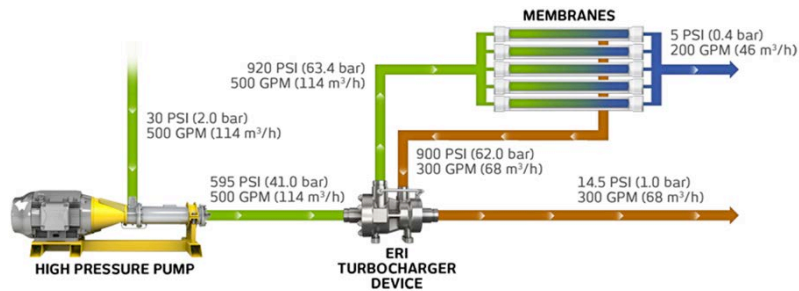
	Specifications
Pump Type	Multi-stage Centrifugal
Flow Range	20 – 60 gpm (4.5 – 14 m ³ /h)
MAWP	1740 psi (120 bar)
Min Discharge Pressure	29 psi (2 bar)
Filtration Requirement	20 μm
Peak Efficiency	65%
Maximum Head	150 ft (45 m)
Motor	5 hp (3.7 kW)
Process Connections	2" (DN50) Grooved-end Flexible Pipe Coupling
Certification	CE motor



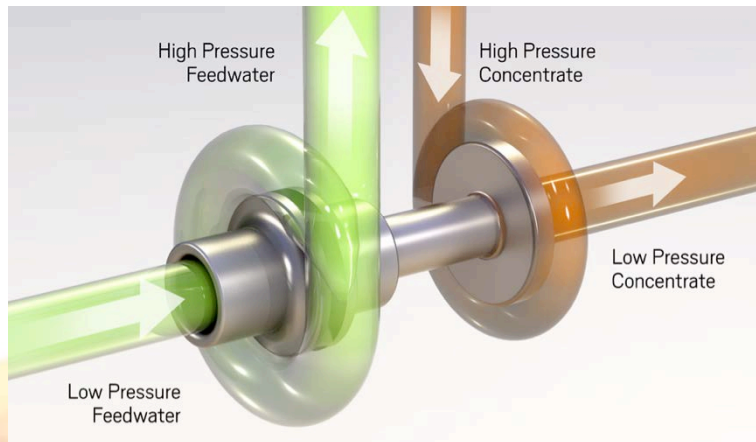
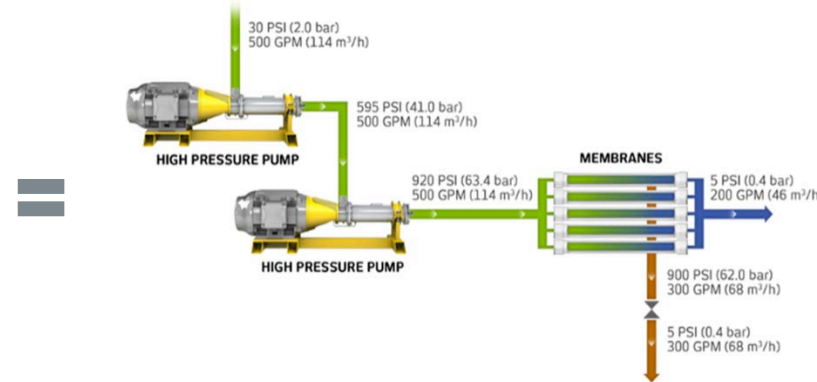
TurboCharger

Turbocharger: How does it work?

Turbocharger

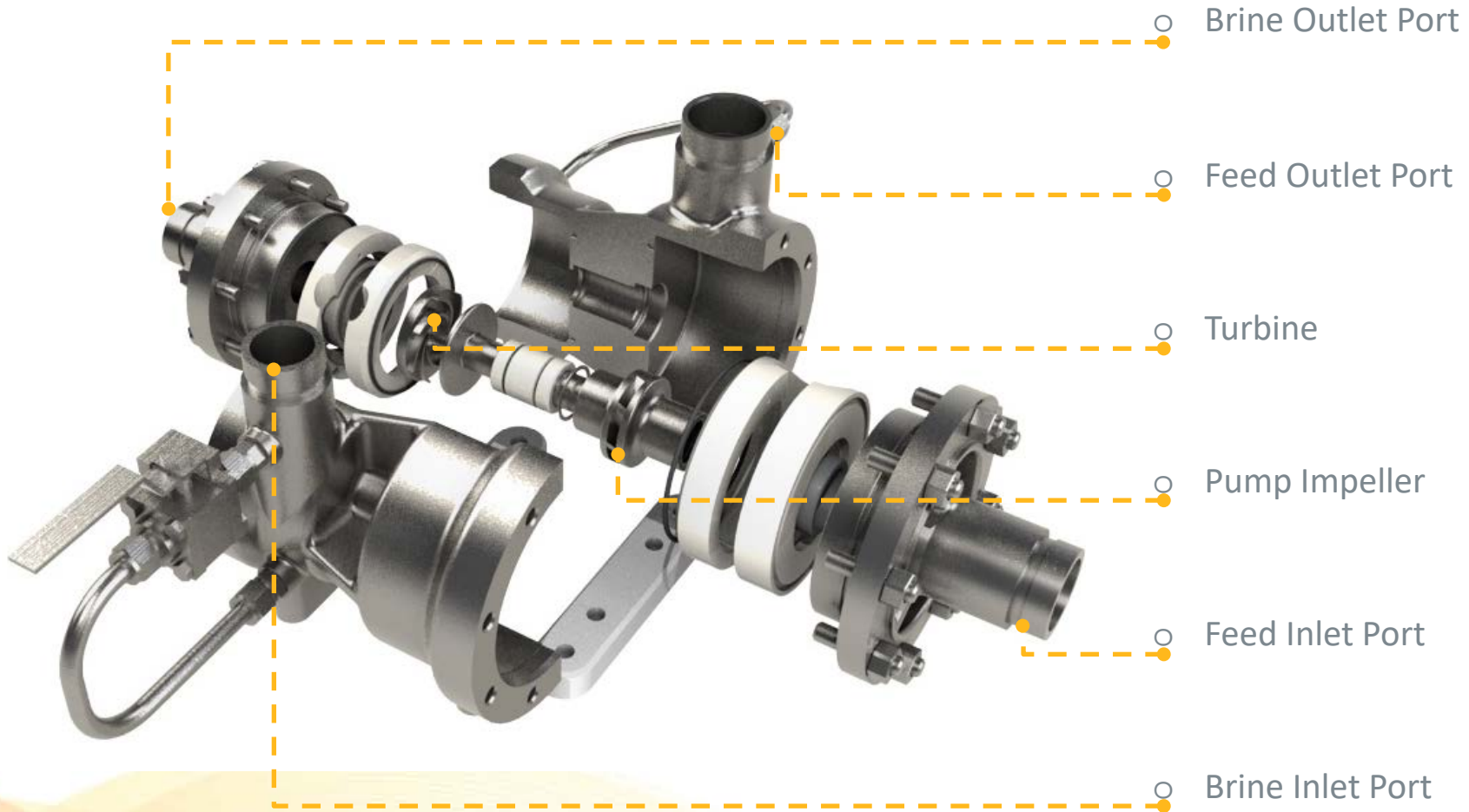


Pump in Series



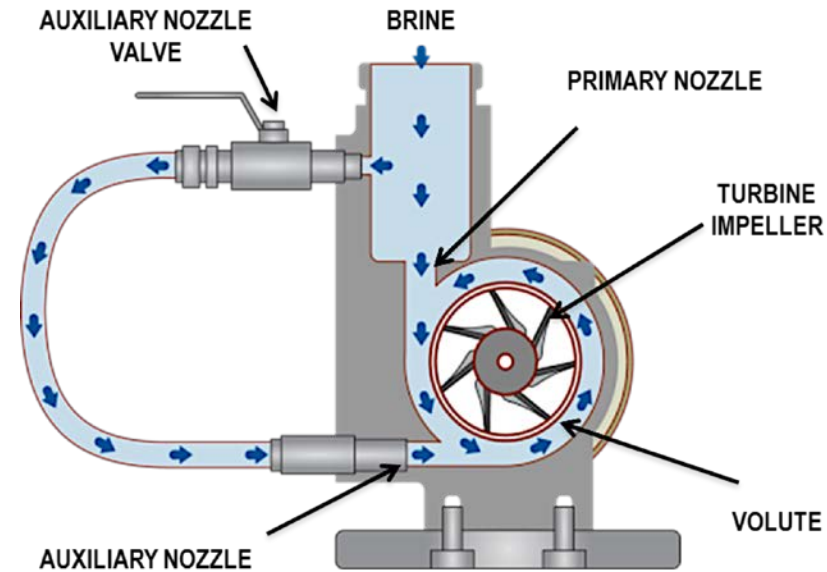
1. High pressure concentrate enters the turbine side of the turbocharger and transfers its energy into the rotating movement of the turbine.
2. The turbine drives the pump impeller.
3. The pump boosts the pressure of the low pressure feedwater.

Turbocharger: Key components



Turbocharger: Auxiliary Nozzle

The auxiliary nozzle valve on the turbocharger provides brine flow and pressure adjustment to accommodate typical variations in membrane requirements



- Opening the ANV will reduce system brine pressure and/or increase brine flow. This is typically done during those periods of plant operation that require less pressure than the maximum designed membrane pressure.
- Closing the ANV will increase system brine pressure and/or decrease brine flow.

Turbocharger: Efficiency

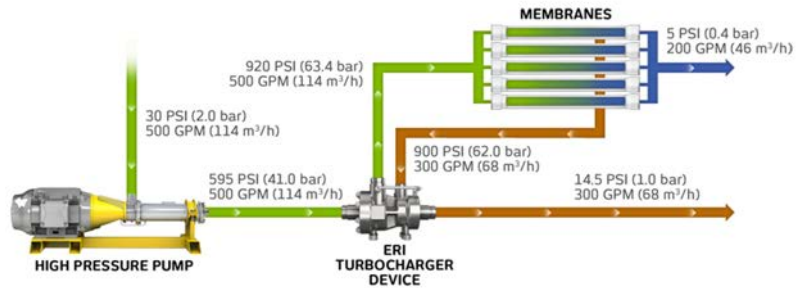
$$\eta_{te} = \frac{\Delta P}{R_r \cdot (P_c - P_e)}$$

Where:

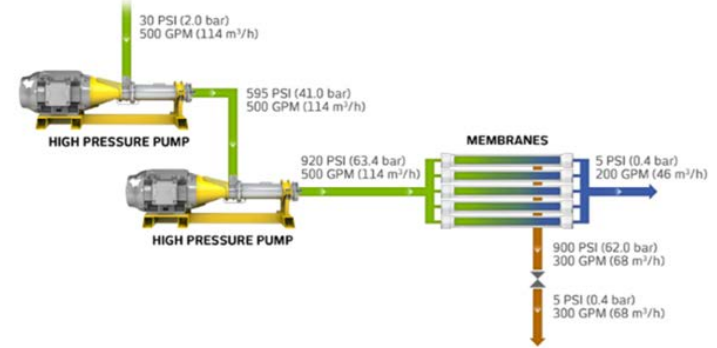
- η_{te} = hydraulic energy transfer efficiency
- ΔP = Boosting pressure
- R_r = Brine flow to feed flow ratio
- P_c = Concentrate pressure at turbine inlet
- P_e = Turbine exhaust pressure

Energy recovery Devices: Pump analogy

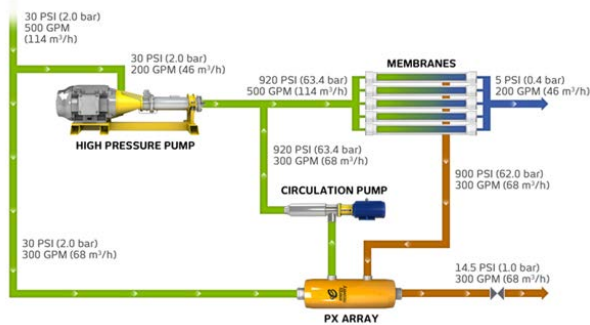
TURBOCHARGER



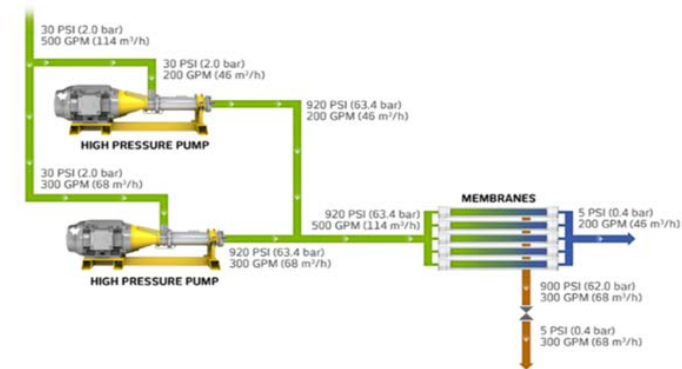
Pump in series



PX



Pump in parallel



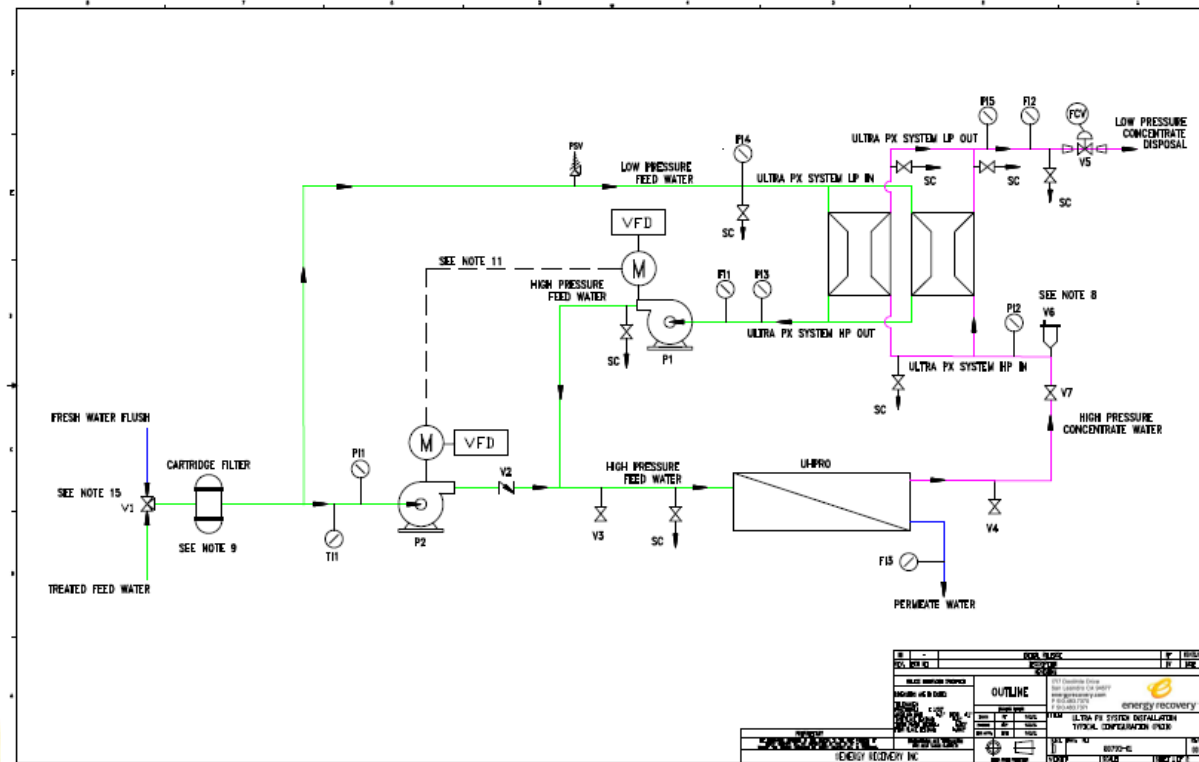
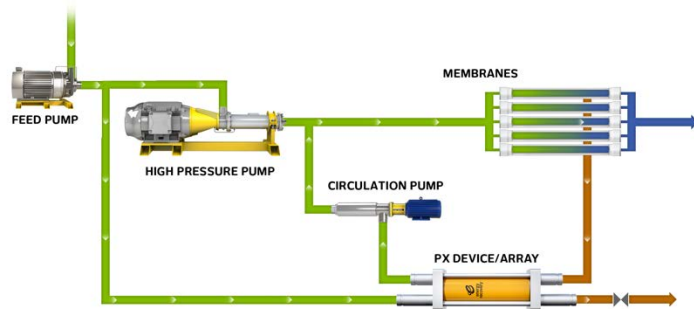
ERD Solution



PX: Reference Design

Design #1: Single Stage with PX

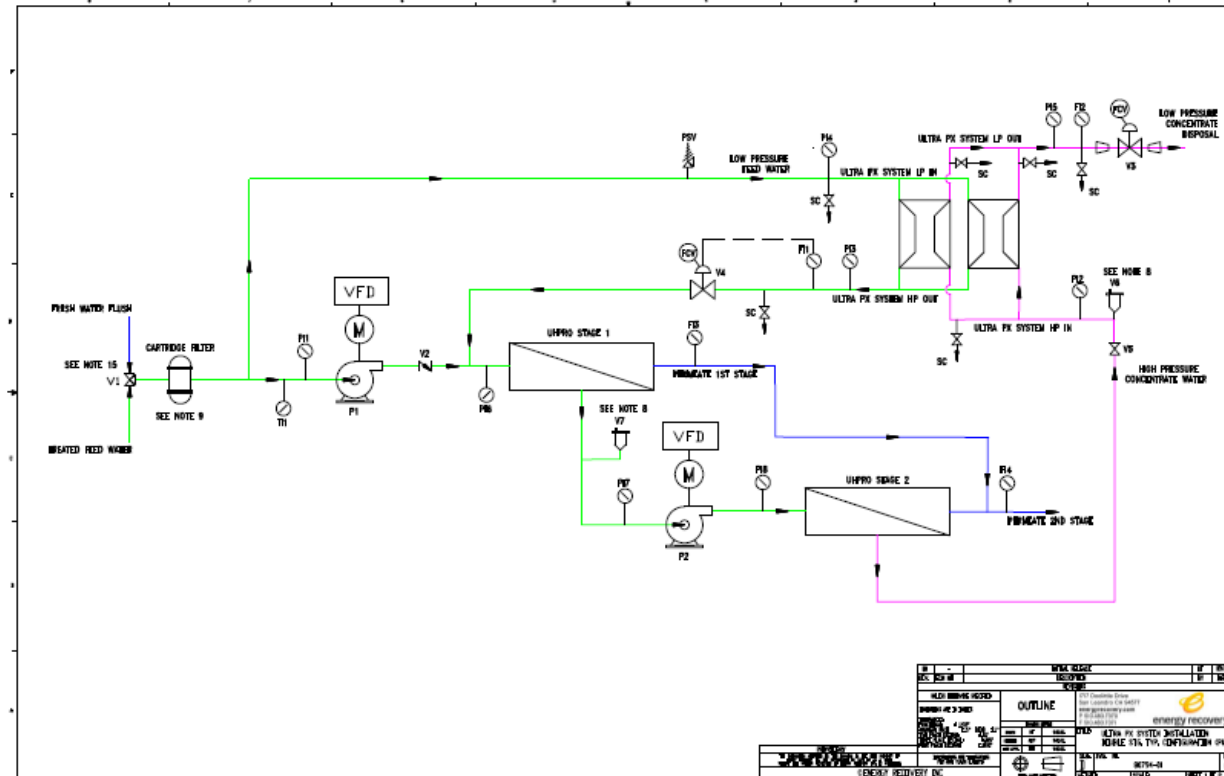
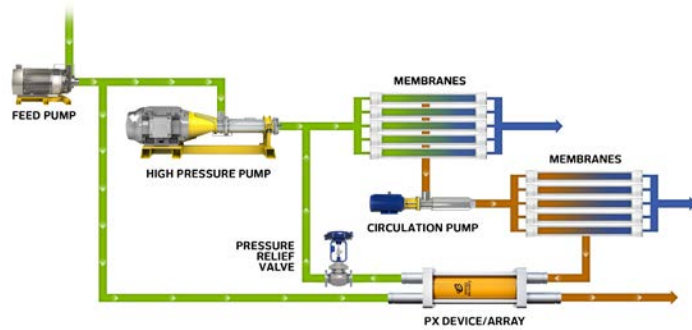
- Most typical design
- Circulation pump handles the PX flow only
- Higher operational flexibility, recovery rate and flux are independent
- Easy to control



PX: Reference Design

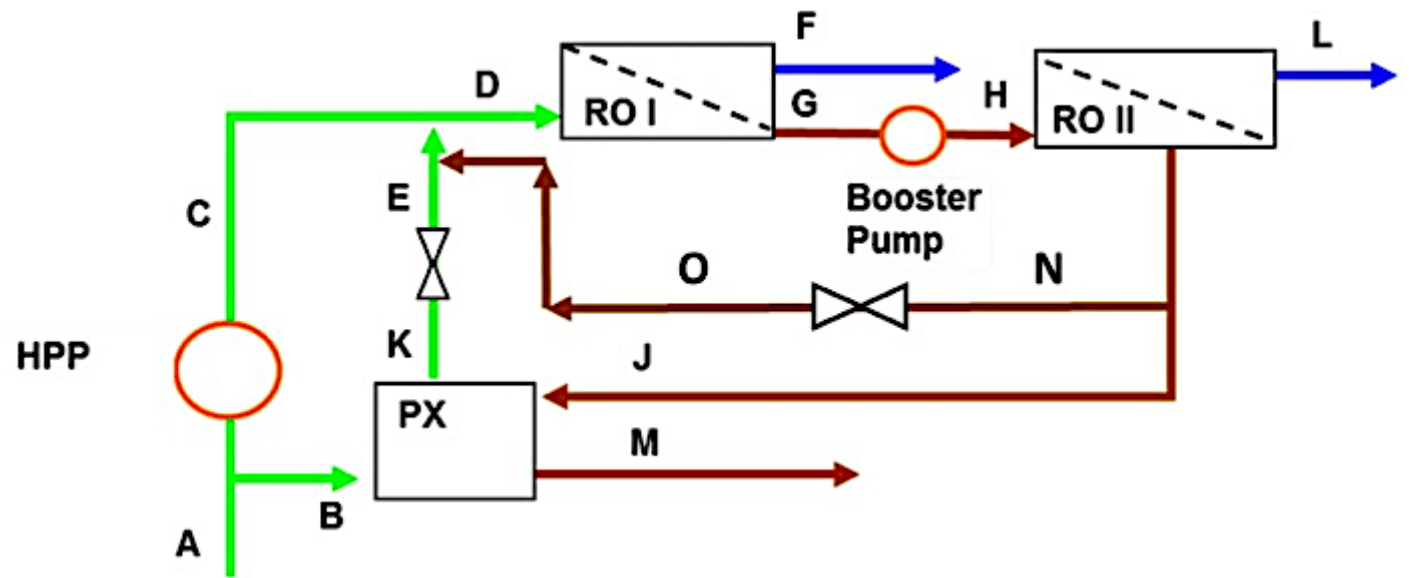
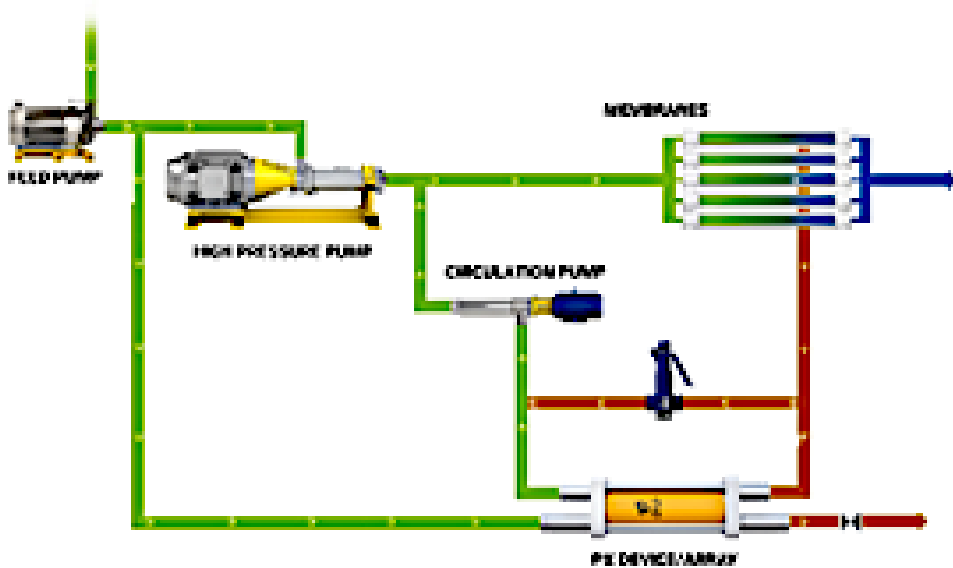
Design #2: Double Stage with Inter-stage Booster Pump

- The inter-stage booster pump is the UPX circulation pump
- Requires a Flow control valve at the PX HP outlet
- Allows flux balance between 1st and 2nd stage and higher recovery rates



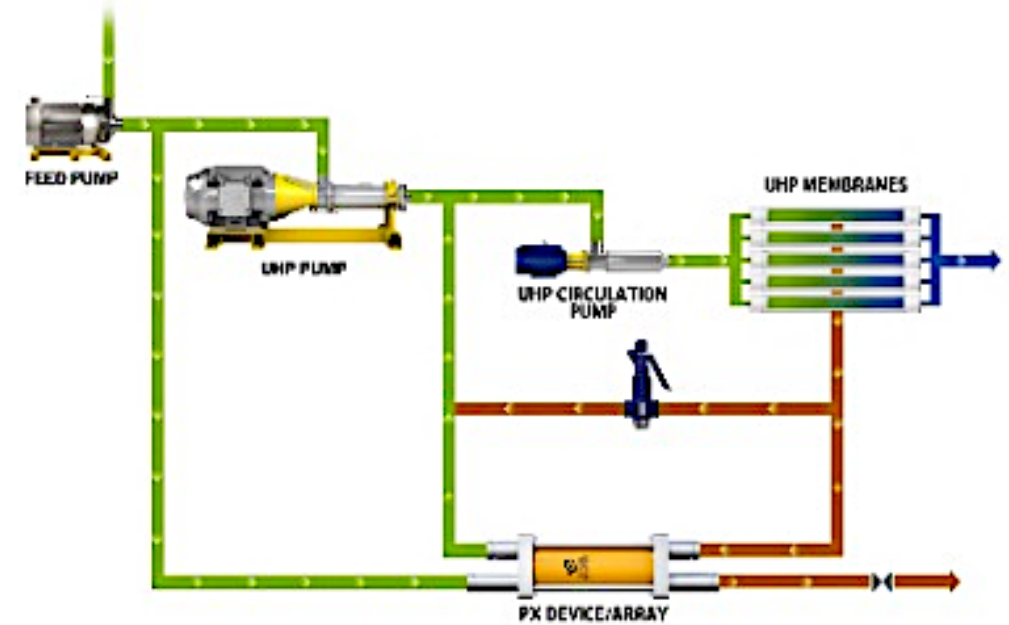
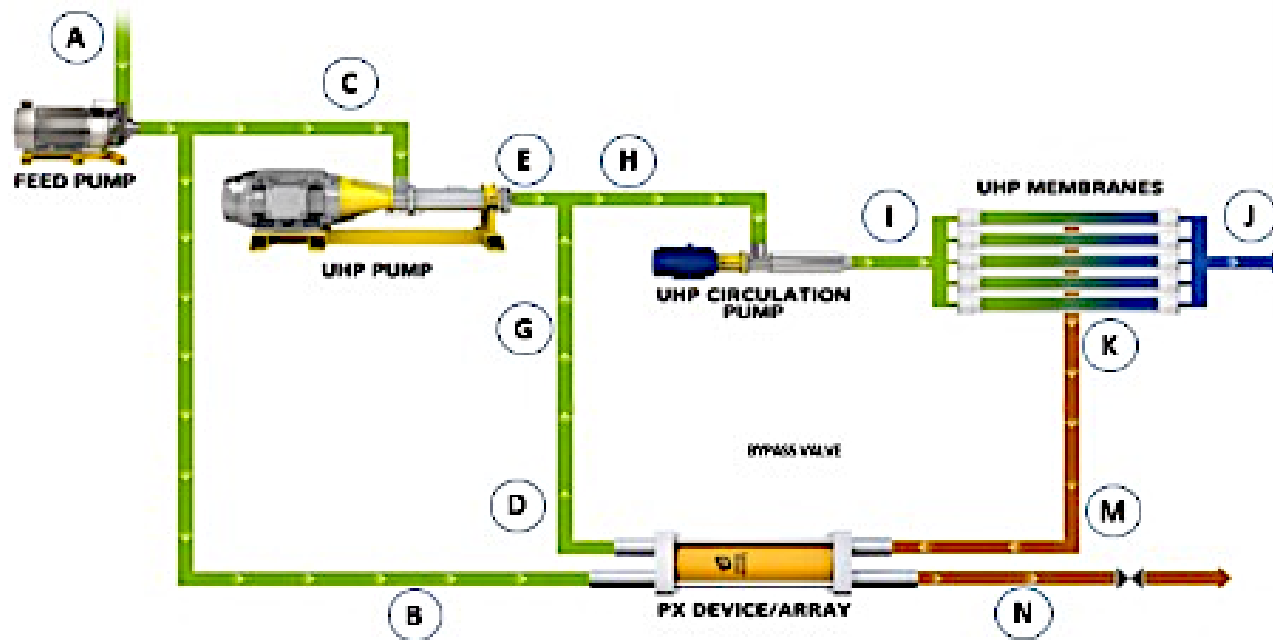
PX: Reference Design

- Low Capex and OPEX to do recirculation
- Easy to control recirculation flow

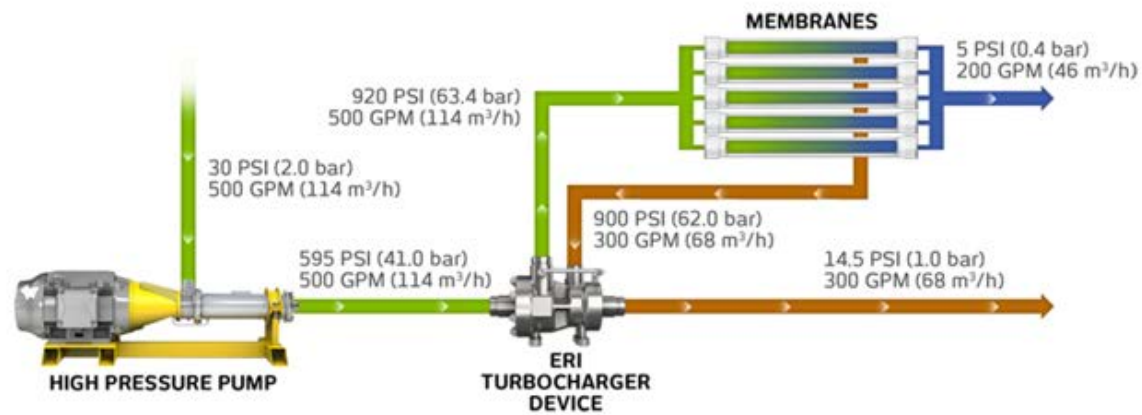


PX: Reference Design

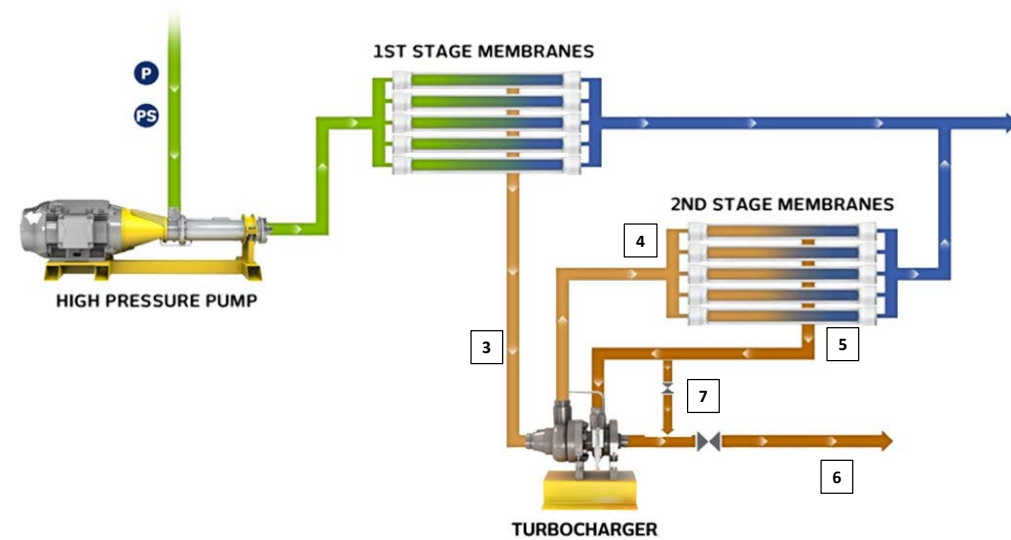
- Circulation Pump at membrane inlet
- Common design for DTRO and STRO systems



Turbocharger: Reference Design



1 Stage RO with TurboCharger



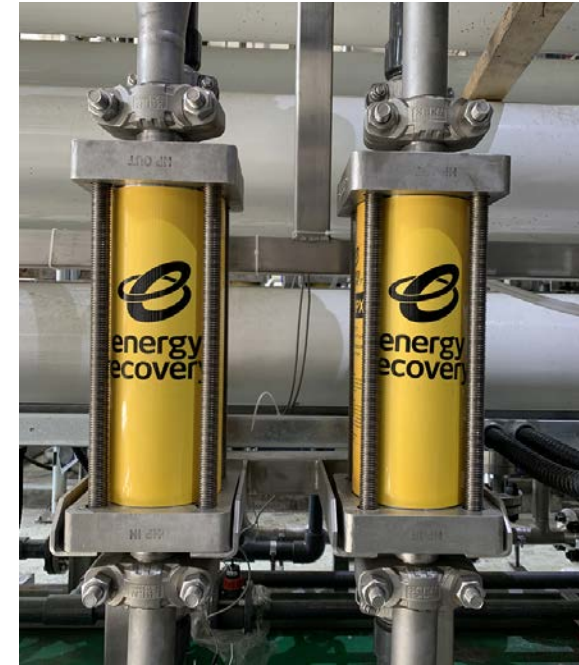
RO Interstage Boost

Case Studies:



Lithium Battery Material 1

Client	WanRun
Start up date	2022
Total Plant Capacity	NA
Number of Trains	4
Estimated energy savings	65%
ERI Product Model	PX U40
Application	50K ton/year LFP
Total Number of Modules	8



Lithium Battery Material 2

Client	Wanrun
Start up date	2023
Total Plant Capacity	NA
Number of Trains	8
Estimated energy savings	65%
ERI Product Model	PX U250
Application	240K tons/year LFP
Total Number of Modules	8



Salt Lake Direct Lithium Extraction

Client	SanDa Membrane
Start up date	2022
Total Plant Capacity	NA
Number of Trains	1
Estimated energy savings	50%
ERI Product Model	PX U40
Application	6K tons/year Li_2CO_3
Total Number of Modules	2



CETP (for Chemicals)

Client	BGT
Start up date	2021
Total Plant Capacity	30K tons/day effluent
Number of Trains	3
Estimated energy savings	50%
ERI Product Model	PX Q300
Application	Common Effluent Treatment Plant for chemical plants
Total Number of Modules	3



CTX(Coal to Chemicals)

Client	BOTIAN
Start up date	2016
Total Plant Capa	5K tons/day brine water
Number of Trains	3
Estimated energy savings	35%
ERI Product Model	PX 180
Application	Coal to diesel, liquids
Total Number of Modules	3



Coal Mining

Client	Beijing BGT
Start up date	2021
Total Plant Capacity 规模	NA
Number of Trains 装置套数	2
Estimated energy savings 节能比	45%
ERI Product Model 产品型号	PX 70S
Application 应用	Buertai Coal Plant
Total Number of Modules 总数量	2



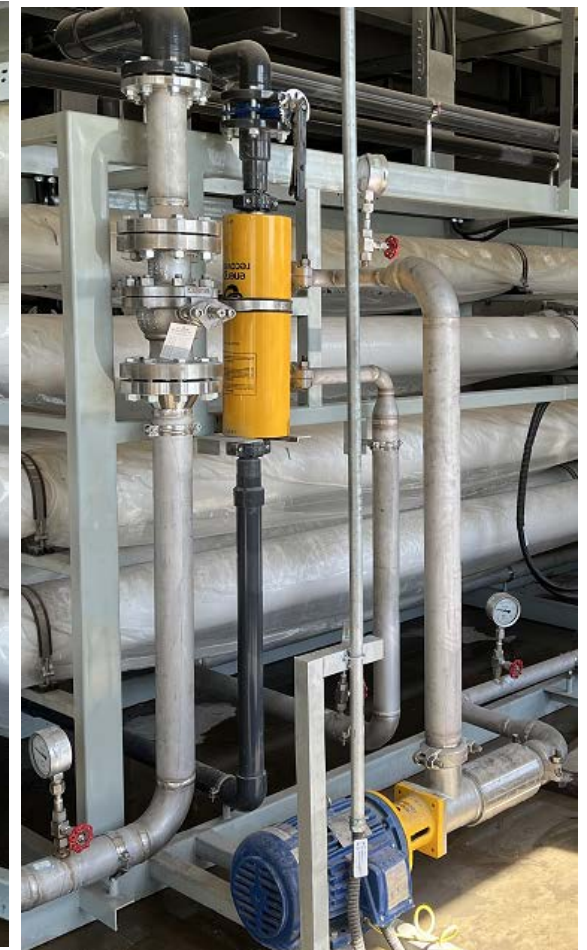
STEEL

Client	BAOWU STEEL
Start up date	2023
Total Plant Capacity	NA
Number of Trains	3
Estimated energy savings	40%
ERI Product Model	PX 140
Application	Wastewater from steel plant
Total Number of Modules	3



COKING

Client	XUYANG COKING
Start up date	2022
Total Plant Capacity	NA
Number of Trains	4
Estimated energy savings	45% & 40%
ERI Product Model	PX 140 & PX 70
Application	Coking wastewater
Total Number of Modules	4



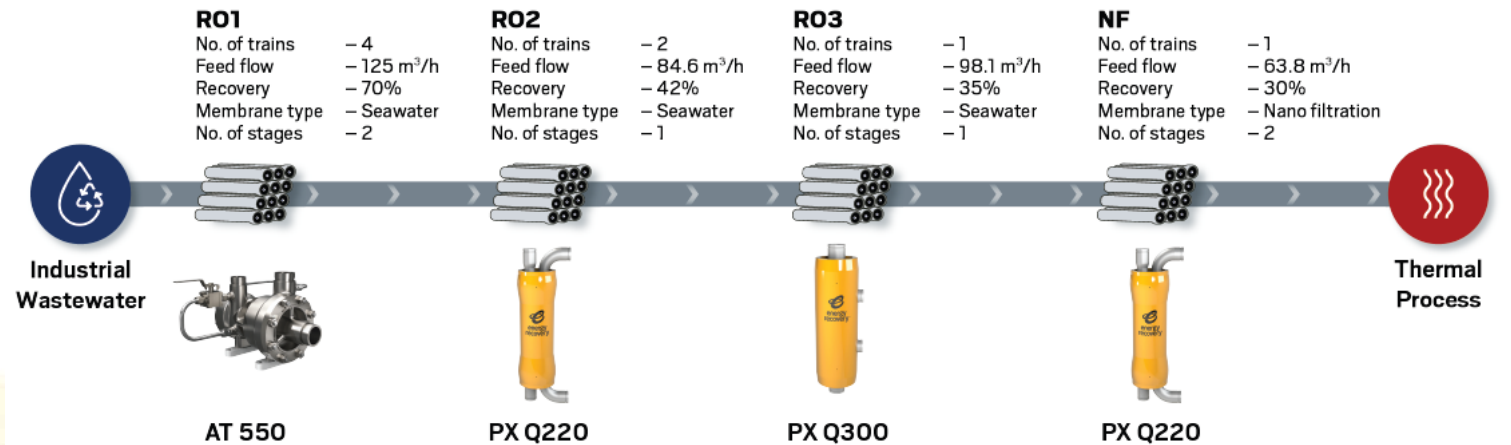
MUNICIPAL w/LPPX

Client	Key Largo	Kona Village
Start Date	2016	2015
Train Capacity	Increase from 1,750 CMD to 2,400 CMD per train	4,000 CMD
Number of Trains	60% recovery	7 x 570 CMD trains; 55% recovery
ERII Product Model	2 PX 180B per train	2 PX 90B per train
Application	brackish wells.	Drinking and Irrigation Water for Tourism
Total Number of Modules	2	14



TEXTILE

Client	Pali India
Start up date	2022
Total Plant Capacity	NA
Number of Trains	8
Estimated energy savings	20%~65%
ERI Product Model	PX Q220,Q300,AT 550
Application	Textile CETP
Total Number of Modules	7



DTRO W/PX

Client	TianDiRen
Start up date	2015
Total Plant Capacity	NA
Number of Trains	3
Estimated energy savings	NA
ERI Product Model	PX 140S
Application	Coal mining in Inner Mongolia
Total Number of Modules	3





Thank You

energyrecovery.com

IWW Overview






工业废水水处理简述



Industrial Wastewater (IWW) Overview 工业废水处理总览

Industrial wastewater is diverse and utilizes numerous treatment options

工业废水的多样化和处理方法多样性

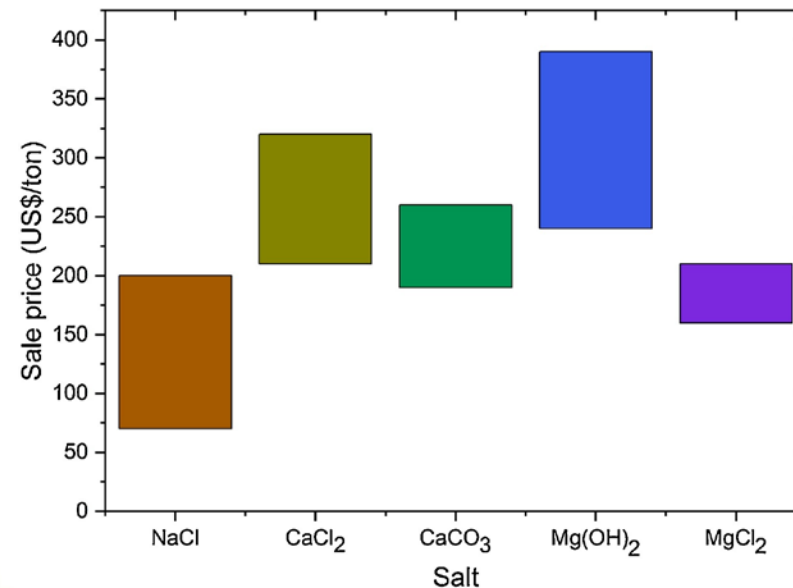
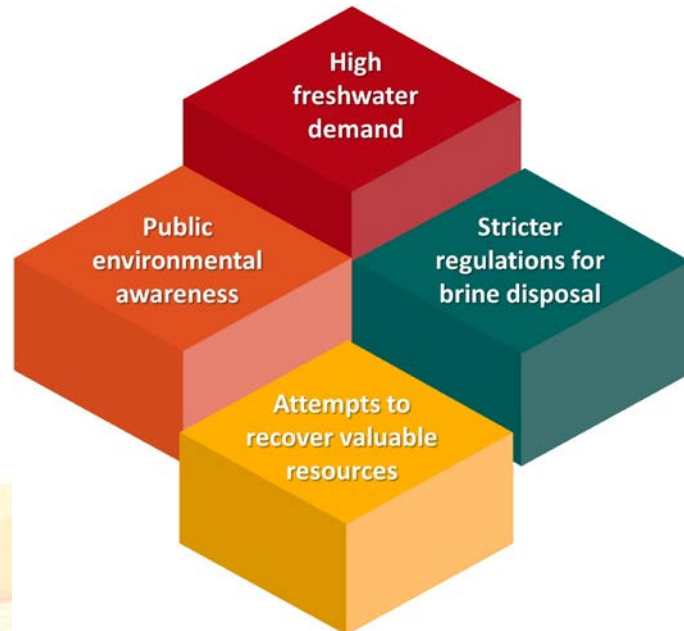
		10K	20K	30K	40K	50K	60K	Salinity (ppm)
	Power Plants	Cooling Tower: SO ₄ , Cl, Ca, Na	FGD WW: Cl, Ca, SO ₄ , Na, Mg					
	Mining	SO ₄ , Mg, Metals						
	Landfill Leachate	Cl, Na, Ca, K, SO ₄ , Organics						
	Textiles	Cl, SO ₄ , TSS, dyes						
	Produced Water				Zn, Pb, Mn, Fe, Ba, oils			

IWW Treatment Drivers 工业废水处理的驱动力

Minimum Liquid Discharge (MLD)/Zero Liquid Discharge (ZLD) addresses each of these drivers

近零排放 (MLD) 和零排放 (ZLD) 的驱动力

- Increasingly stringent IWW regulations aimed at reducing pollution along with surface and ground water consumption
越来越严格的工业废水排放法规旨在减少污染以及地表水和地下水的消耗
- Water scarcity in many regions will limit industrial output without extensive treatment and reuse of wastewater
如果工业废水不进行处理和再利用，许多地区的水资源短缺将限制工业产量
- Economics of brine mining (i.e., recovery of valuable materials in the waste streams)
卤水开采的经济效益（即回收废物流中的有价值物料）
- Reduction of off-site transportation and disposal costs
减少非现场运输和处理成本



Source: <https://doi.org/10.1016/j.jece.2020.104418>

Industrial wastewater Management 工业废水管理

o Disposal 处置方法

■ Municipal Wastewater Treatment Plants (sewer) 市政污水处理 (污水管网)

- ✓ Mix with other WW for dilution 和其他污水混合稀释
- ✓ Regulations / Fees limit applicability 法规/费用限制

b. Evaporation ponds 蒸发塘

- ✓ Requires real estate and long term up-keep 需要土地和长期维护
- ✓ Environmental liability – leaching, rupture, overflow 环境责任 – 渗滤, 破裂, 溢出
- ✓ Capacity constraints 容量限制

c. Injection wells 注水井

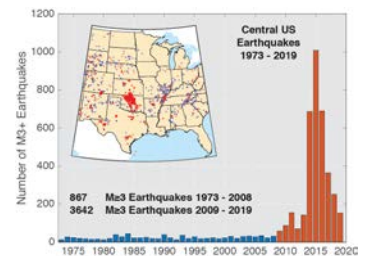
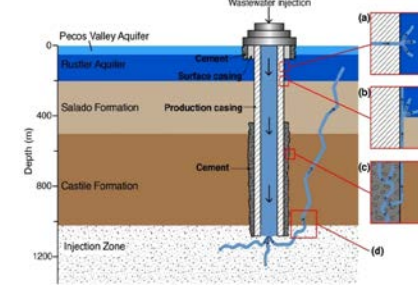
- ✓ Proximity to suitable formation 注入至适合的地层
- ✓ Energy for transport and injection 运输和回注需要耗能
- ✓ Environmental liability for potable aquifer damage, earthquakes 饮用水危害, 地震责任

d. Trucking, inland brine disposal pipelines 卡车运输, 内陆浓水排放管道

- ✓ Costly, only offsets disposal location or dilutes contaminants, capacity limitations 高成本, 只改变处理位置或者稀释污染物, 容量有限

e. Illegal/Unregulated disposal 非法/不受监管的处置

- ✓ Creates financial and public relations liability 产生财务和公共关系责任
- ✓ Business continuity risk 业务可持续性风险



River in Hawaii that smells like beer discovered to be alcoholic

Brewery the centre of investigations into 'reeking' stream off H2 highway on Oahu

Gina Specchia • Wednesday 17 November 2021 17:18 • Comments



Spain
ILLEGAL BWR0 BRINE CONTAMINATES LAGOON
Last week, a Spanish magistrate accused farmers and government officials of environmental crimes for catastrophic damage to water and wildlife in Mar Menor, a 170km² (65 m²) coastal saltwater lagoon in Murcia, on Spain's southeastern coast, near Cartagena.

Industrial wastewater Management 工业废水管理

2. Recovered water 水回收

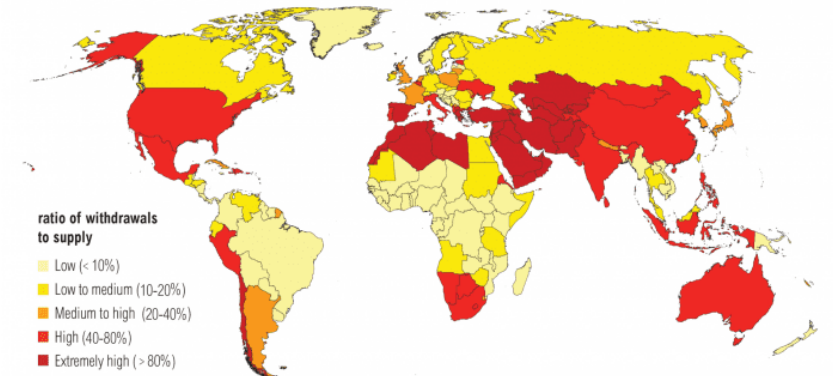
- Water is a key input to industrial and agricultural productivity
水是工业和农业生产力的关键投入
- Regional industrial development relies on the availability of suitable water 区域工业发展依赖合适的水资源
 - ✓ Treated industrial effluent can be cleaner than local surface waters 经过处理的工业废水可以达到比地表水更洁净
- Economic development of nations relies on the circular water economy 各国的经济发展依赖水的循环利用



Water Utility Pathways
in a Circular Economy



Water Stress by Country: 2040



NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

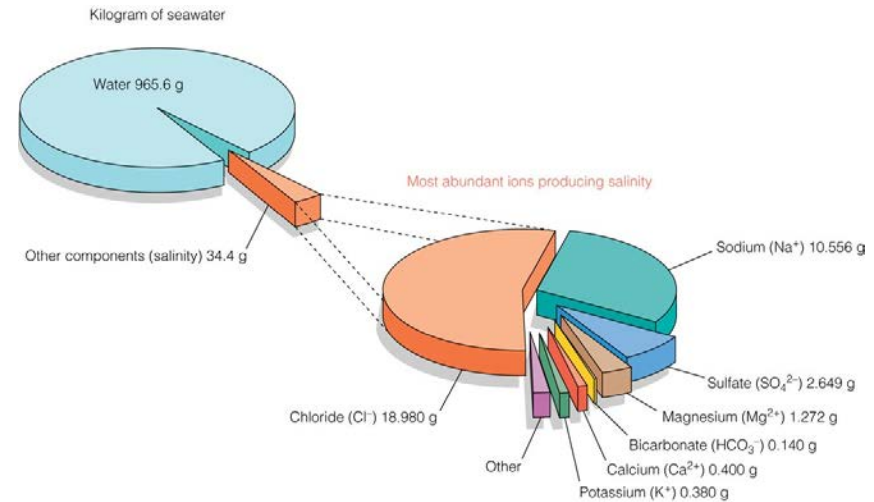
For more: ow.ly/RiWop

 WORLD RESOURCES INSTITUTE

Industrial wastewater Management 工业废水管理

3. Recovered Salts 盐回收

- Dissolved salts can be sold or reused as feedstock if economically concentrated and purified 通过经济合理的浓缩和提纯，溶解性的盐可以销售或者作为原料使用
- Examples:
 - ✓ Caustic soda from textile dyeing 从纺织染色中回收烧碱
 - II. LiFeP from battery manufacture 从电池中回收磷酸铁锂
 - III. Sodium Sulfate from coking process 从焦化废水中回收硫酸钠
- Brine mining from Oceans, Continental, and Geothermal Brines: 从海洋，大陆和地热卤水中开采卤水
 - ✓ Desal permeate: 0.50 USD per ton
 - ✓ NaCl ~50 USD per ton
 - ✓ Potassium Chloride ~250 USD per ton
 - ✓ Mg ~3,000 USD per ton
 - ✓ Bromine ~3,500 USD per ton
 - ✓ Lithium Carbonate (battery grade) ~25,000 USD per ton



Photography Credit: Brave Blue World

© 2005 Brooks/Cole - Thomson

Recovered RM	Major use	Price ⁶⁹	Targeted amount ⁴¹
Mg(OH) ₂	Precursor of magnesium oxide (MgO) - application in steel and refractory industry	225€/tn (Purity >95%)	Up to 2.5 kg/m ³
Sc ₂ O ₃	Alloying additive	4,140€/kg (Purity 99.0%)	0.92 mg/m ³
LiCO ₃	Batteries, Ceramics, Lubricants, Pharmaceuticals.	12 €/kg (Purity >95%)	1.45 g/m ³
RbCl	Fibre optics, lamps, night vision devices, laser technology	1,900-4,900 €/kg (Purity >99.5%)	120 mg/m ³
H ₃ BO ₃	Tiles, Ceramic, and Fiberglass Manufacturers, Flame Retardants, Agriculture, Wood Preservation, Pharmaceuticals, Cosmetics	640€/ton (99%)	4.5g/m ³
V ₂ O ₅	Catalysis, metal alloys (bond Ti to Steel), aniline black	6.95€/kg (Purity 98%)	3.35 mg/m ³
InCl ₃	Semiconductors, electrical motors, dental prothesis, alloys, nuclear medicine.	300 €/kg (purity 99.9%)	42 mg/m ³
MoO ₃	Metal products, Base metal and alloys, Automotive industry, High strength parts.	16 €/kg	10 mg/m ³
GaCl ₃	Integrated circuits, LED lighting, CIGS solar cells.	110 €/kg (purity 99.99%)	3 x 10 ⁻² mg/m ³

Brine concentration technologies summary 浓水浓缩技术汇总

Process	Total Cost (\$/m ³)*	Energy (\$/m ³)	Benefits	Cons
Evaporation ponds 蒸发塘	Varies	n/a	Simplicity, insensitive to feed water type 简单, 对给水无限制	Footprint, rain, slow process, smell, risk of environmental discharge 占地大, 雨水影响, 过程缓慢, 环境排放风险
MSF/MED* 多级闪蒸/低温多效*	\$2.50	\$0.75	Very low TDS permeate; performance independent of feed 产水TDS低; 产水水质和进水TDS无关	Does not scale well to small systems, requires steam and electricity. Sensitive to scale. More labor than RO 小规模系统不适用, 需要蒸汽和电力。比反渗透需要更多的劳动力
MVC / "Brine Concentrator" 机械蒸汽压缩蒸发/"卤水浓缩"	\$5.76	\$1.19	Very low TDS permeate; performance independent of feed TDS; suitable for small scale 产水TDS低; 产水水质和进水TDS无关; 小规模适用	Sensitive to scale, startup time, time to stabilize for flow changes, cannot easily separate out salts 结垢, 启动时间长, 流量变化后需要较长时间稳定, 盐分不容易被分离
UHPRO & UHPNF** 超高压反渗透 &超高压纳滤	\$1.40	\$0.45	Scalable, Small footprint, some ability to separate salts 可扩展, 占地面积小, 具有一定的盐分分离能力	Limited output TDS, may still require MVC. Sensitive to scale, foul, TSS 产水TDS限值。仍需要MVC, 对结垢, 污堵, 总悬浮物敏感
UHPRO & UHPNF with PX 超高压反渗透&超高压纳滤+PX	\$1.18	\$0.23	Lowest OPEX, Process flexibility 运营成本最低, 工艺灵活	Limited output TDS, may still require MVC. Sensitive to scale, foul, TSS 产水TDS限值。仍需要MVC, 对结垢, 污堵, 总悬浮物敏感

*3785 CMD plant size, 20 year life, Electricity: 0.06 \$/kWh, Steam 3.12 \$/1000 lb 工厂规模: 3785CMD, 使用寿命20年

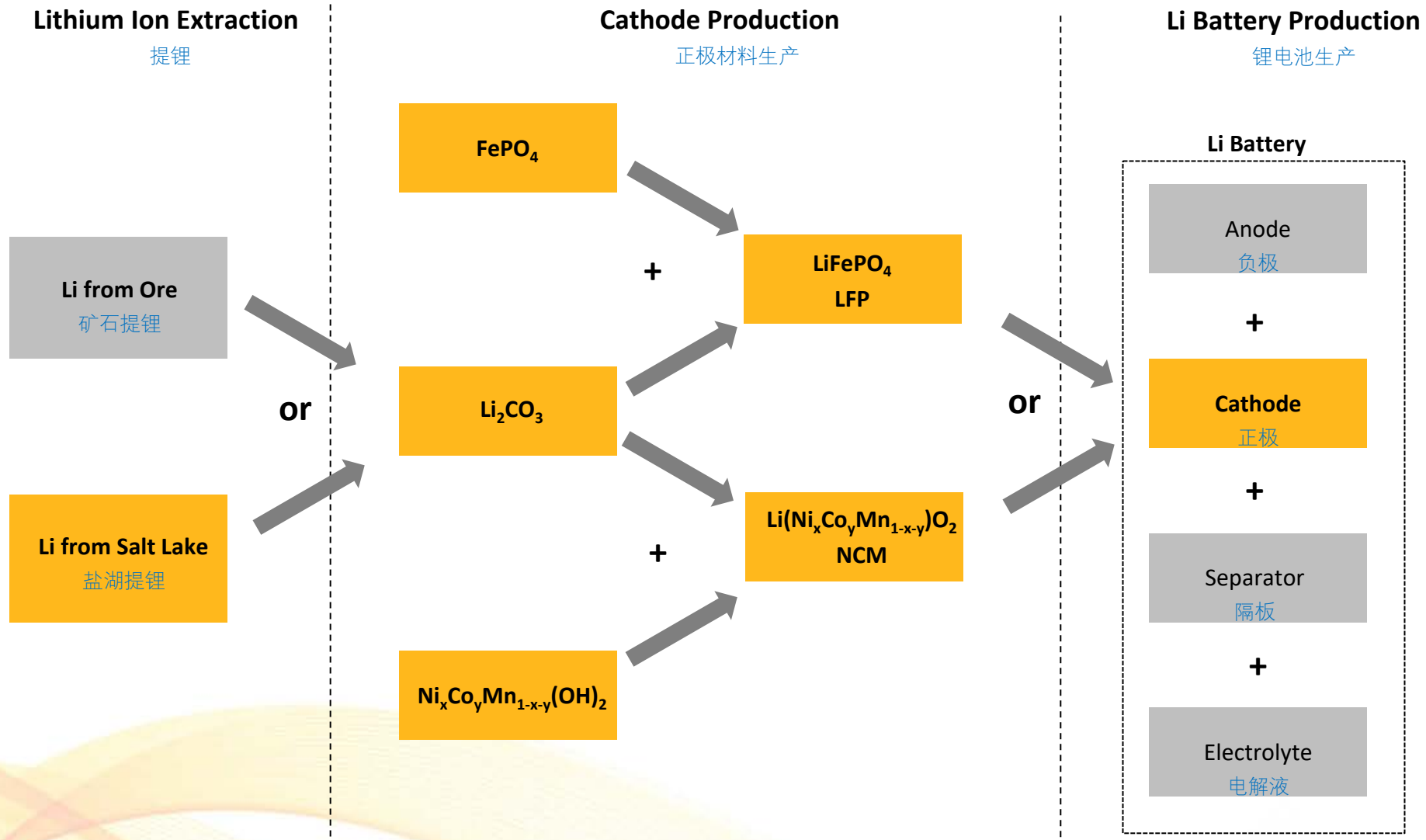
** Total cost includes capex, energy, labor, R&M, Chemicals, and indirect costs. 总成本包括运行费用, 能耗, 人工, 维护&保养, 化学品和间接成本

References:

- Technology review and data analysis for cost assessment of water treatment systems; <https://doi.org/10.1016/j.scitotenv.2018.09.363>
- Minimal Liquid Discharge (MLD) and Zero Liquid Discharge (ZLD) strategies for wastewater management and resource recovery – Analysis, challenges and prospects; <https://doi.org/10.1016/j.jece.2020.104418>
- Inland Desalination & Concentrate Management; AWWA Manual M69, First Edition Draft

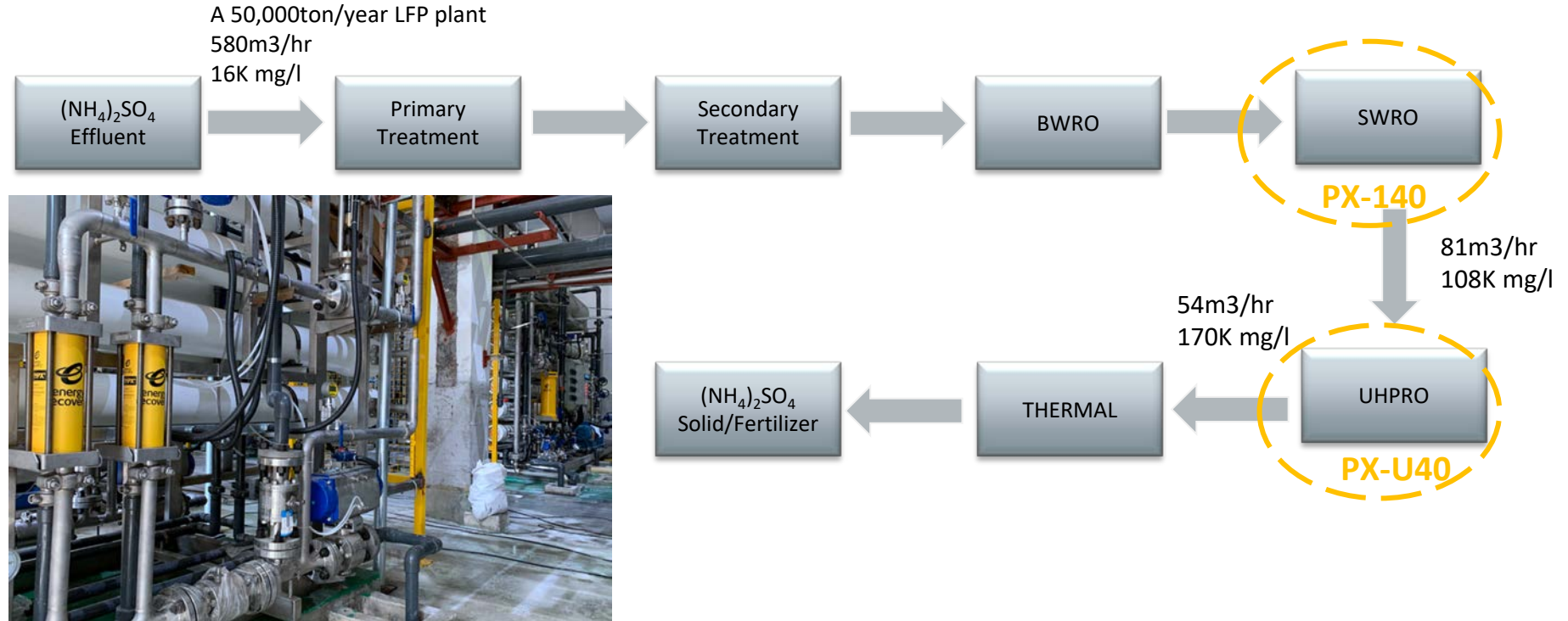
CASE STUDY: LITHIUM ION BATTERY PRODUCTION OVERVIEW

案例分析：锂电池生产概况



CASE STUDY: WASTEWATER TREATMENT AT LFP PLANT

案例分析：磷酸铁废水处理

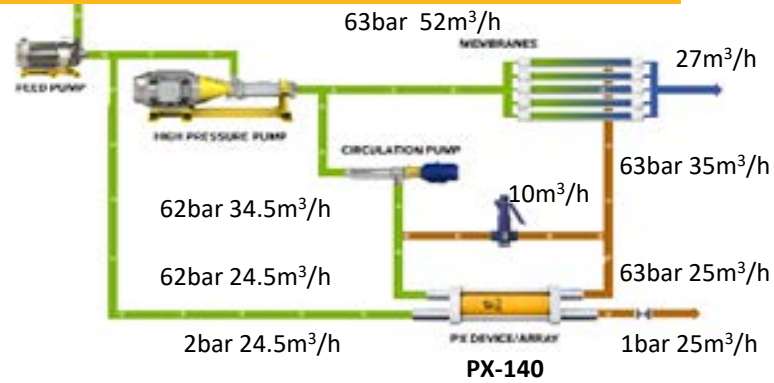


UHPRO-UPX section key facts: 关键信息

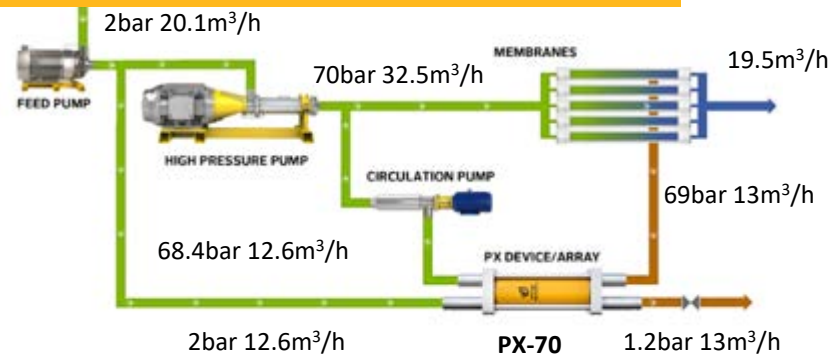
- 50,000 tons LFP per year production plant generates enough wastewater to require (6) Ultra PX for the UHPRO stage recovering 54m³/hr of UHP brine.
5万吨/年磷酸铁锂产能的工厂产生的废水在UHPRO段需要6台UPX来回收高压浓盐水的能量 54m³/h
 - Each UHPRO train: Feed=27m³/hr @ TDS 108K mg/L, Brine= 18m³/hr @170K mg/L, recovery 33%, and (2) PX-U40
每套UHPRO系统：进水=27m³/h @ TDS 108K mg/L, Brine= 18m³/hr @170K mg/L, recovery 33%, and (2) UPX-40
 - Plant has (3) UHPRO trains for a total of (6) UPX that save **150K USD per year** (0.1USD/kWh) in energy
3套UHPRO共需要使用6台UPX，每年节省15万美元的电费 (0.1USD/kWh)
- => payback less than 1 year 投资回收期小于1年

Case Study: XY CTX ZLD Plant – Coking 案例：河北某焦化厂

浓缩工艺参数



HPRO Stage Design Parameters 超高压浓缩工艺参数

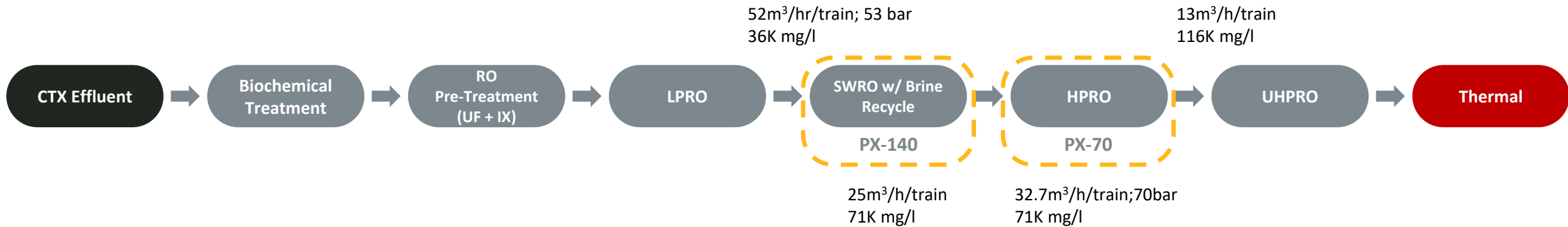


Commissioned Sept. 2022 2022年9月调试完成



Value:

- Achieves regulations & ZLD using ~38% & ~48% less energy 节能~38%&~48%同时满足零排放要求
- PX performed at 22 bar SWRO and 21 bar HPRO pressure during commissioning 调试期间在22bar高压反渗透和21bar超高压反渗透工况下PX和系统也能正常运转
- Reliable operation after initial commissioning 初始调试后系统稳定可靠运行



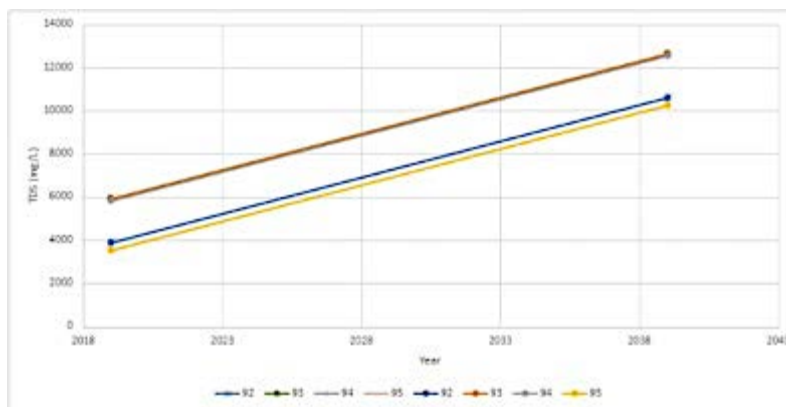
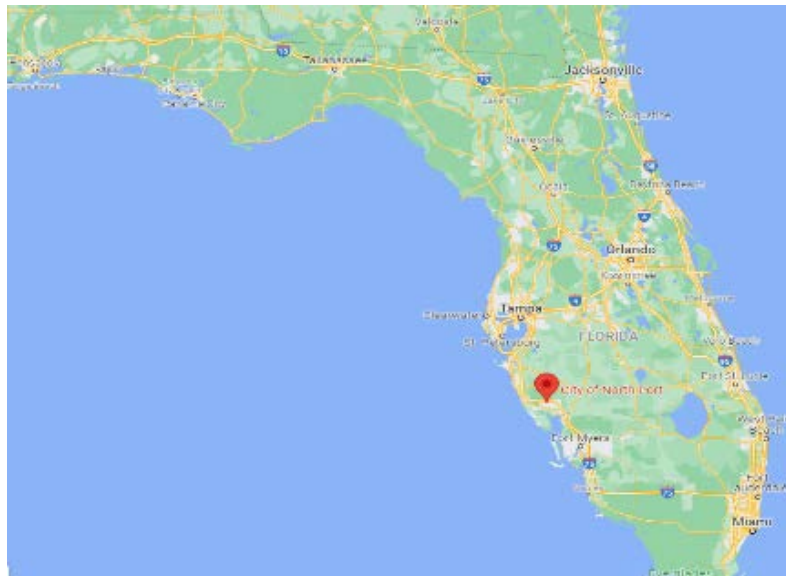
Case Study: Florida Southwest Water Treatment Plant-LPRO

案例:佛罗里达州北角市西南水处理厂-低压反渗透

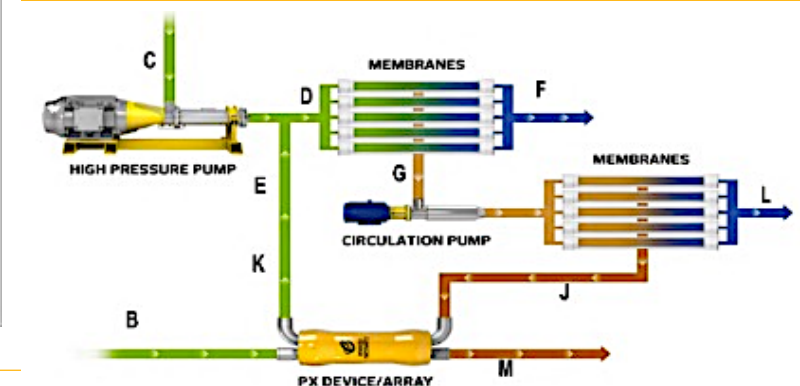
City of North Port, Florida Southwest Water Treatment Plant

佛罗里达州北角市西南水处理厂

- 2.0 MGD RO Greenfield Design
- 2 BWRO Skids
- 80% Recovery ,31.5m³/h brine
- Design raw water TDS of 3,500 mg/L
- 2.0MGD新建项目/2套BWRO系统/回收率80%，浓水量31.5m³/h，原水TDS设计值 3,500mg/L
- Water quality degradation
- Skids expandable: 1.0 to 2.5 MGD
- Design TDS from: 3,500 to 13,600 mg/L
- Seawater membranes
- Increased energy demand
- 水质恶化/反渗透系统需要扩容：从1.0到2.5MGD/原水TDS设计值从3,500mg/L上升至13,600mg/L使用了海淡膜/能耗增加



PX Process Schematic



Energy Recovery Device Selection for WTP

污水处理厂能量回收装置的选择

- **20% reduction in feed pump flow** 高压泵流量减少20%
 - Reduced horsepower 降低功率
 - Minimum 33 HP 最低33HP
- **Reduced energy requirements** 降低能耗
 - Operational expense savings
 - \$12,000 to \$106,000
 - 运营成本节省 \$12,000 至\$106,000
- **Reduced capital expense** 降低投资成本
 - Pump motor, conduit, switch gear, additional components
 - 水泵电机, 管道, 开关柜, 附加部件
 - Estimated \$95,000
 - 估算 \$95,000



Kimley»»Horn

Capital and Operational Costs 投资和运营成本

Cases	TDS (mg/L) 含盐量	Feed Pump HP Reduction 功率节省	Savings Per Day 每天节约电费	Savings Per Year 每年节约电费
1	3,500	33	\$32	\$11,680
2	13,000	108	\$140	\$52,195
3	6,250	110	\$36	\$13,140
4	13,000	270	\$290	\$105,850



Assumptions: 预设值

- \$0.12 KWh 0.12美元KWh
- Plant Operations: 24 hours 工厂按24小时运转