

Energy efficient Axial Piston Pumps & Energy Recover Devices for Seawater RO Desalination System

VIJAY



The Danfoss Group - Facts

Net sales	5.1 bn EUR
EBIT	549 m EUR
Employees	23,400
Worldwide sales	more than 100 countries
Factories	61 in 20 countries
Top three markets	USA, Germany and China
Ownership	Privately held
Headquarters	Nordborg, Denmark

Danfoss High Pressure Pumps Focus Segments and Applications

Reverse Osmosis - RO



Applications

- Containerized
- Landbased
- Off-shore
- Marine

Ultra Pure Water



Applications

- Gas turbines
- Cleaning
- Humidification/
adiabatic cooling

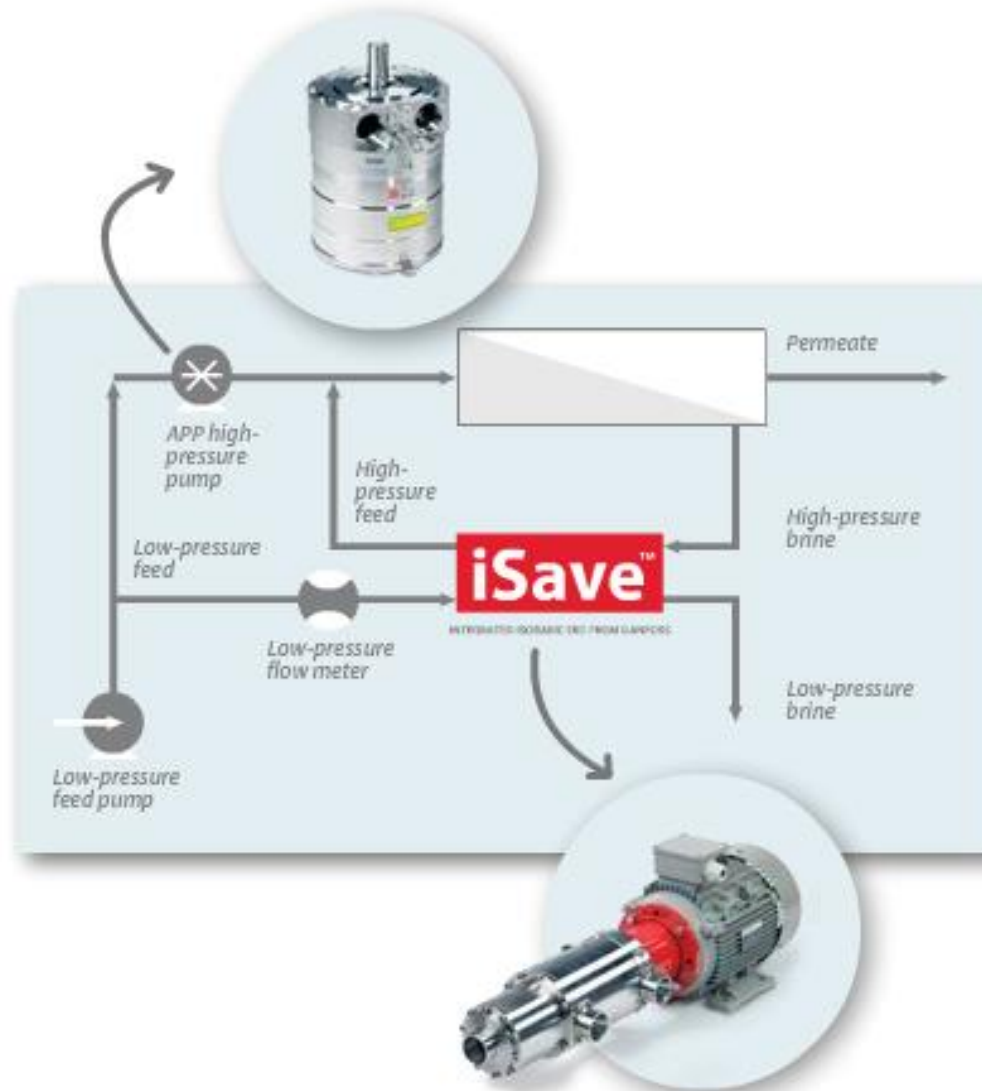
Oil and Gas



Applications

- Onshore
- Offshore
- Subsea

HPP and ERD for SWRO system



Danfoss High Pressure Pumps - RO product range



High-pressure pumps
APP



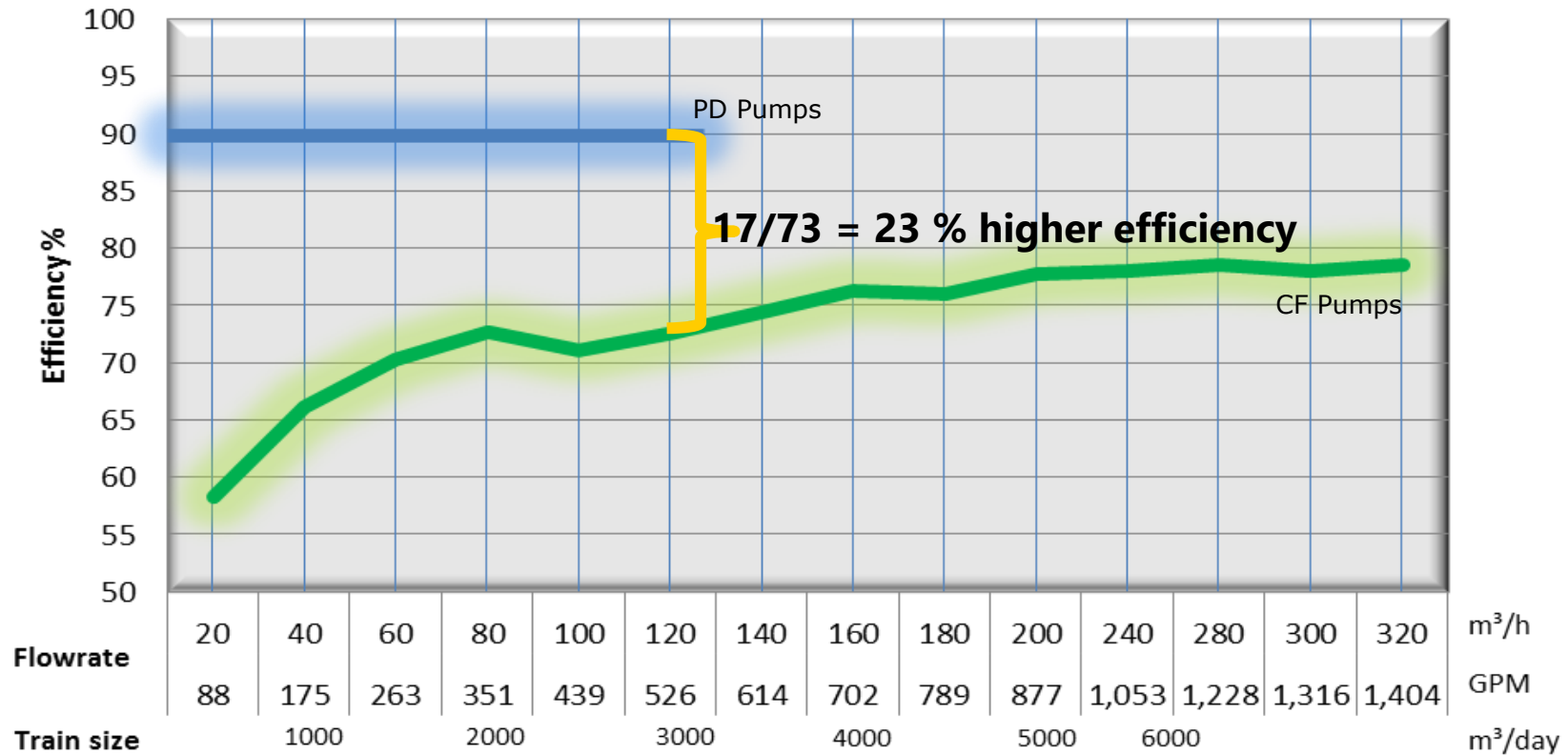
High-pressure pumps
APP S 674
(acc. to API and ATEX)



Energy Recovery Devices
iSave

The energy efficiency of High Pressure Pumps

- 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.

The Danfoss APP Pump Range

From 0.15 to 88 m³/h (0.7 to 387 gpm).



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	10 - 80	145 - 1160
APP 21 - 43	21.1 – 44.6	92.9 – 196.4	10 - 80	145 – 1160
APP 53 – 86	25 - 88	110 -387	30 – 80	435 - 1160

Advantages of axial piston pump technology

Few moving parts

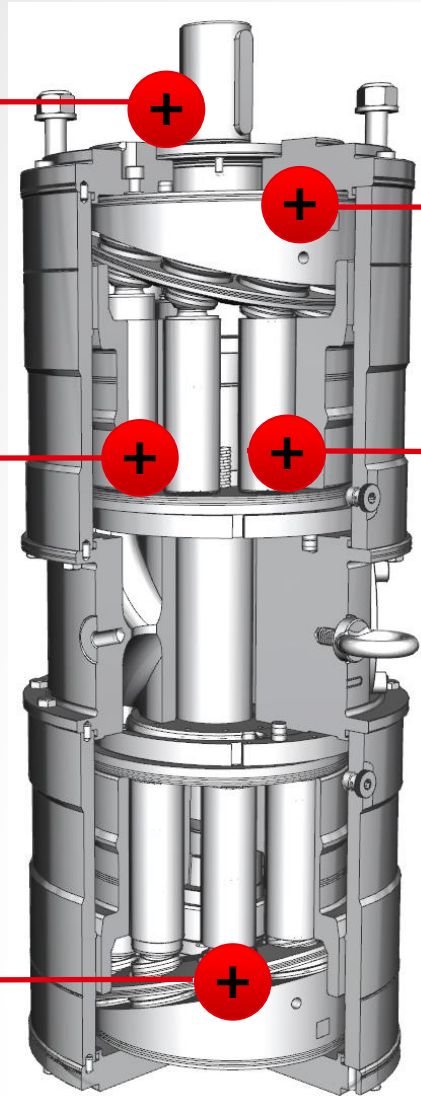
- Direct driven, no belts
- Long time between service
- Simple maintenance

Advanced design

- Unique efficiency
- Constantly high efficiency regardless of flow

Constant flow

- Constant flow regardless of pressure variations
- Wide flow ranges available with Danfoss VFDs



No oil lubrication

- Self-lubricating: pumped medium provides all necessary lubrication

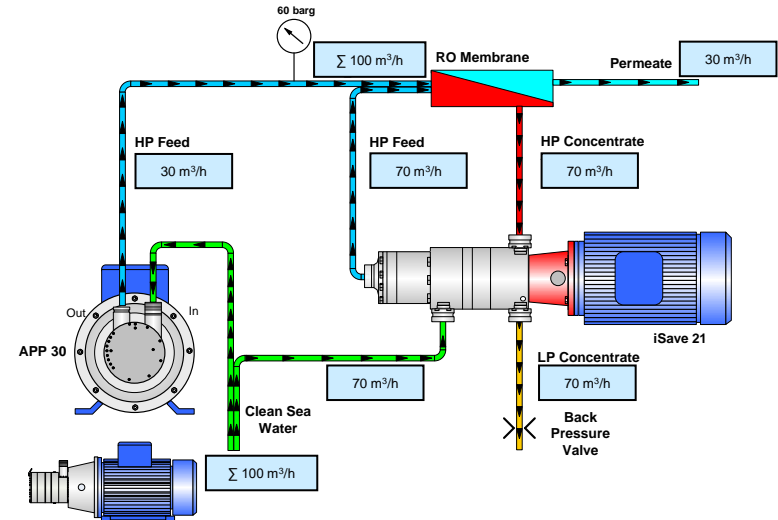
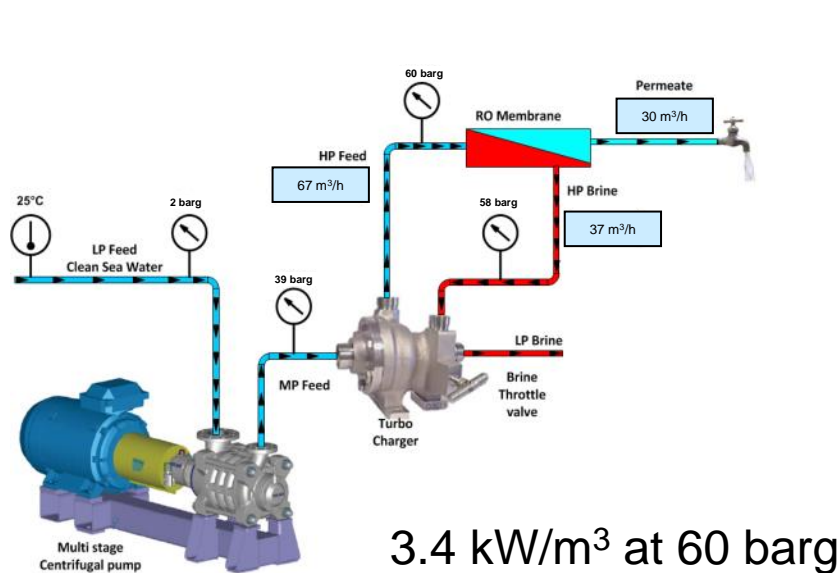
Low pulsation

- Traditional crankshaft replaced by unique swash plate
- Rotating pistons
- High number of pistons reduce flow pulsations

Illustration of cut APP 78

Energy Recovery Device

Turbocharged ERDs are 30% less efficient at low flow rates



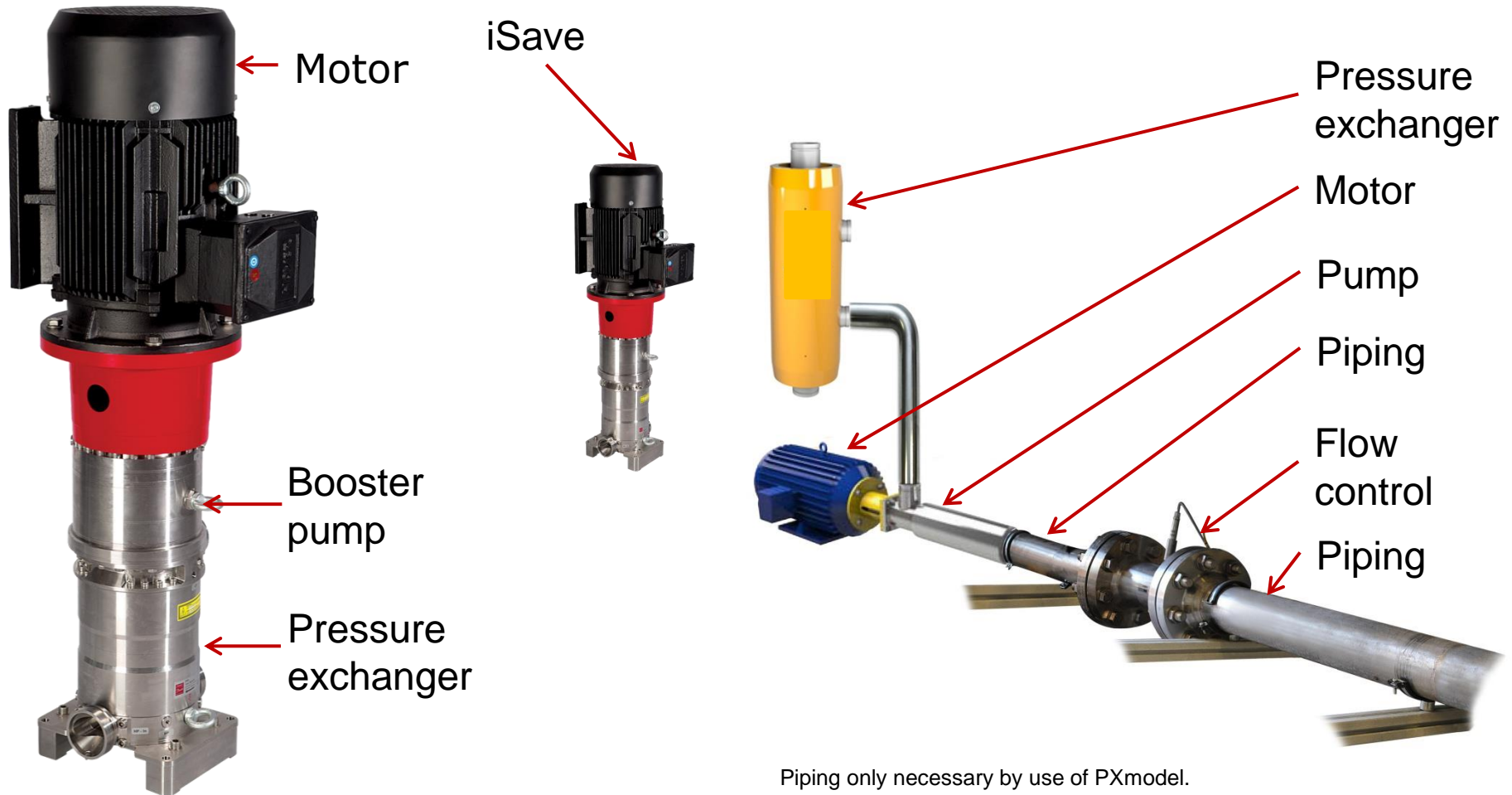
Typical energy saving per year using the iSave versus a turbocharger *

Train/plant size m ³ /d	500	1,000	1,500	2,000	3,000
Train/plant size [MGD]	[3.2]	[6.3]	[9.5]	[12.6]	[18.9]
Saving kW/h	68,000	105,000	204,000	197,000	287,000
Saving EUR [0.10 EUR/kW/h]	6,800	10,500	20,400	19,700	28,700
Saving USD [0.10 USD/kW/h]	6,800	10,500	20,400	19,700	28,700

* including the Danfoss high-pressure APP pump and a high-pressure centrifugal pump used for the turbocharger

**Isobaric ERD is the
right choice
for medium-sized plants**

Integrated Energy Recovery Device, iSave



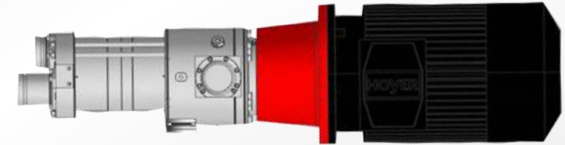
The Danfoss iSave ERD Range



NEW:

iSave 50

iSave 70



		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

Danfoss iSave™ energy recovery device

- **Simple to install**

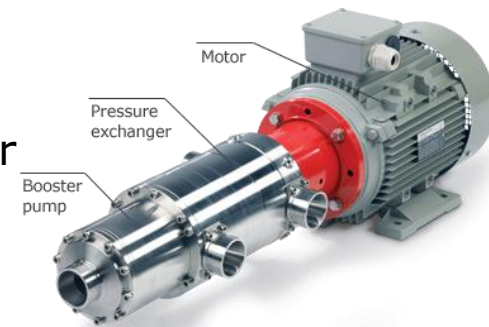
- The smallest footprint available in isobaric ERD
- Compact solution gives greater design flexibility and easier installation
- 1 unit instead of 3 as in other isobaric ERD systems

- **Simple to use**

- No risk of overflow/overspin at start-up or during operation
- Motor-controlled rotor spin: flow controlled by electric motor
- Fail-safe operation – ideal for staff of varying skill levels

- **Simply reliable**

- Rotor and other key components in corrosion resistant Super-Duplex
- Low-pressure shaft seal with long lifetime
- Provides constant flow despite changes in feed water salinity or temperature



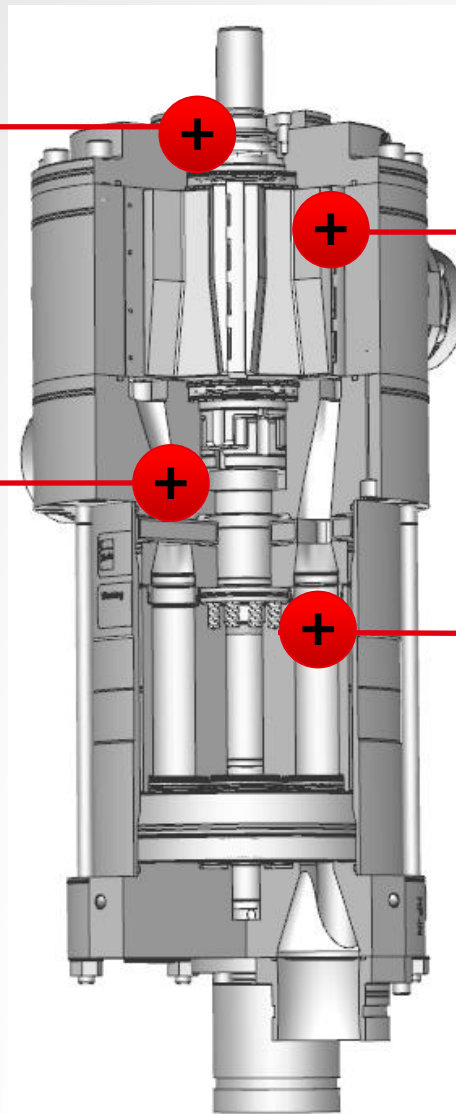
Advantages of the iSave ERD

Few moving parts

- Direct driven
- Long time between service
- Simple maintenance

Combined pressure exchanger and pump in one

- Easier monitoring and failure detection
- Fewer components
- Easy to service



Integrated vane pump

- Constant flow regardless of pressure variations
- Maintains high efficiency at different flows

Proven corrosion-resistant design of pressure exchanger

- Well tested recovery principle that runs in hundreds of water makers
- High grade duplex and super duplex stainless steel

Illustration of cut iSave 50

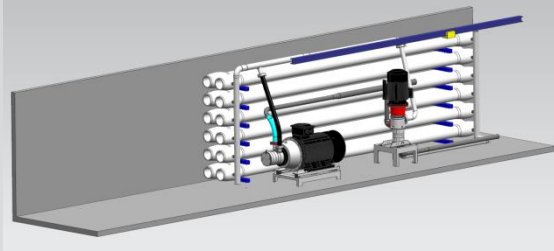
iSave matched with APP

Wide choice and modularity make a great match with typical train sizes

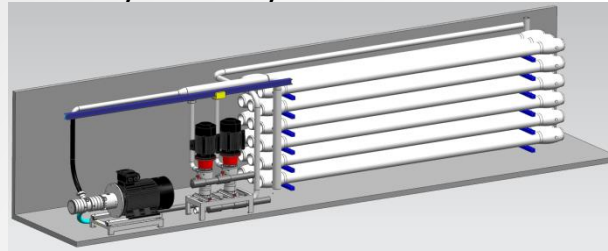
Pump	ERD	Train size			
		No. of pumps	No. of ERDs	CMD	GPM
APP 38	iSave 50	1-2	1-2	750-1700	150-300
APP 43	iSave 50	1-2	1-2	950-2000	175-350
APP 53 NEW	iSave 70	1	1	1050-1200	195-220
APP 65 NEW	iSave 70	1	1	1250-1350	230-250
APP 65 NEW	iSave 50	1	2	1400-1500	255-275
APP 78 NEW	iSave 50	1	2	1600-1800	295-330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

Mix and match configurations (examples)

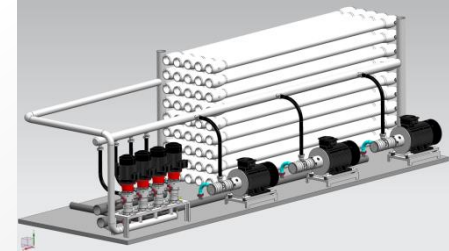
1,000 CMD



1,800-2,000 CMD



5,000 CMD



CMD	Recovery rates	Configuration
1,000	38-44%	1 x iSave 70 1 x APP 43
1,800	42-45%	2 x iSave 50 1 x APP 78
2,000	38-45%	2 x iSave 70 1 x APP 86
5,000	43-45%	4 x iSave 70 3 x APP 78

Selection Tool(examples)

Version 4.20

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
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Node 1: Pressure 2.0 bar, Flow 312.5 m³/h, Salinity 38,000 ppm

Node 2: Pressure 1.6 bar, Flow 184.2 m³/h, Salinity 38,000 ppm

Node 3: Pressure 1.0 bar, Flow 187.5 m³/h, Salinity 63,182 ppm

Node 4: Pressure 60.0 bar, Flow 128.3 m³/h, Salinity 38,000 ppm

Node 5: Pressure 60.0 bar, Flow 184.2 m³/h, Salinity 39,492 ppm

Node 6: Pressure 60.0 bar, Flow 312.5 m³/h, Salinity 38,869 ppm

Node 7: Pressure 58.0 bar, Flow 187.5 m³/h, Salinity 64,648 ppm

Node 8: Pressure 1.0 bar, Flow 125.0 m³/h, Salinity 200 ppm

Select units

Flow:

Pressure:

Power:

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.

Legend:
 Required input to calculation
 Can be changed. Standard values

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	<input type="radio"/> Yes <input checked="" type="radio"/> No
Suggest Danfoss APP pump	<input checked="" type="radio"/> Yes <input type="radio"/> 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/m ³
Specific cost	0.43 USD/m ³
Annual power cost	472,164 USD/year
Annual power cost saving*	611,244 USD/year
Energy Price	0.20 USD/kWh

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.

Conclusions

Positive displacement pumps, APP and isobaric ERDs, iSave offer:

- ✓ The lowest possible energy consumption in a SWRO plant
- ✓ Multiple pumps and ERDs installed in parallel secure system uptime.
- ✓ The most compact system.
- ✓ Simple to design and assembly.
- ✓ Simple for maintenance and service.
- ✓ Simple to control
- ✓ With mass produced standardized items, quick delivery and competitive price

=>The solution for small and medium sized SWRO system
up to 30,000 CMD of capacity!