

Energy Efficiency in Reverse Osmosis Systems

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CREST

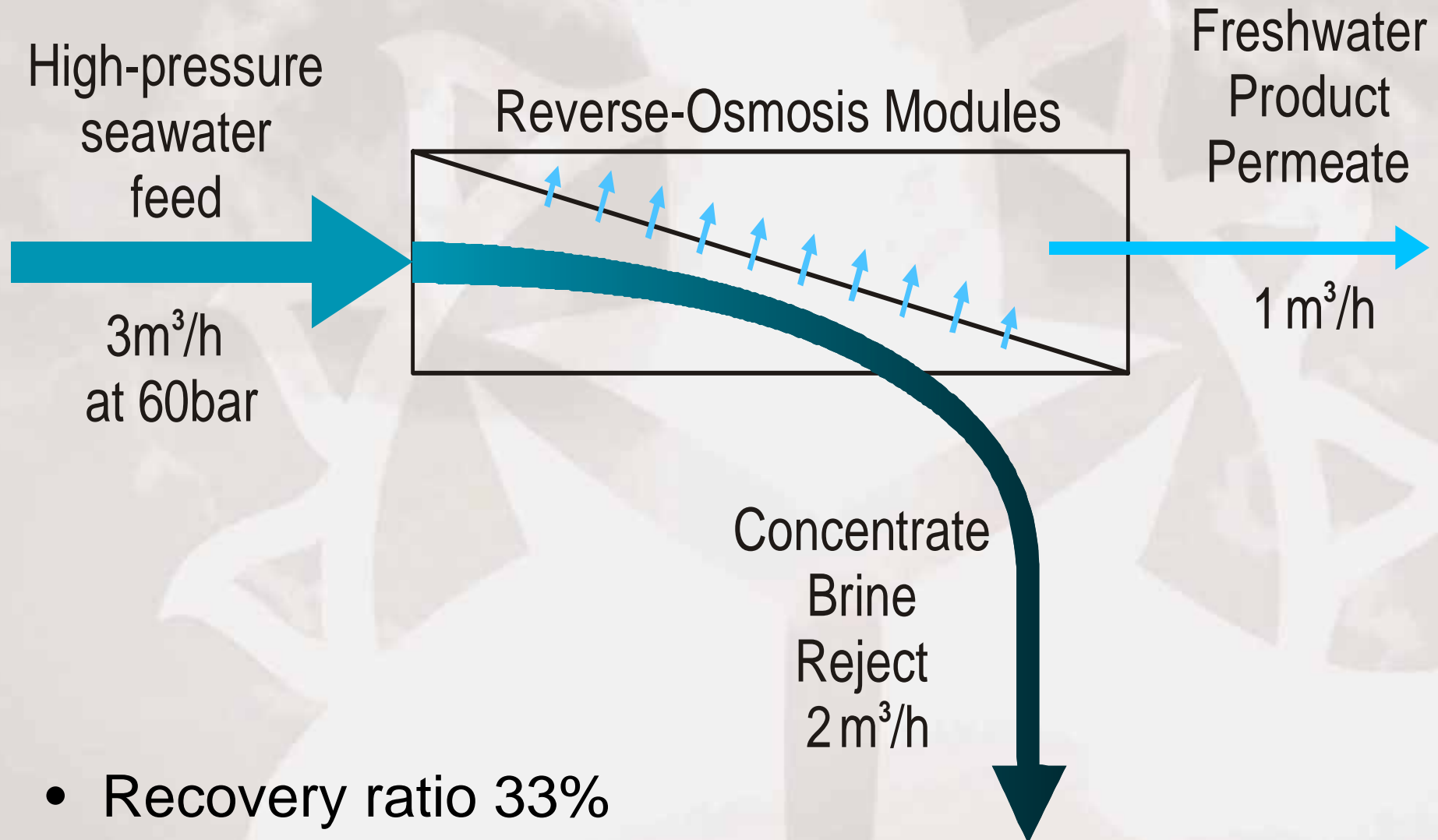
**Centre for Renewable Energy Systems Technology
Loughborough University, UK**

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Energy required to desalinate seawater

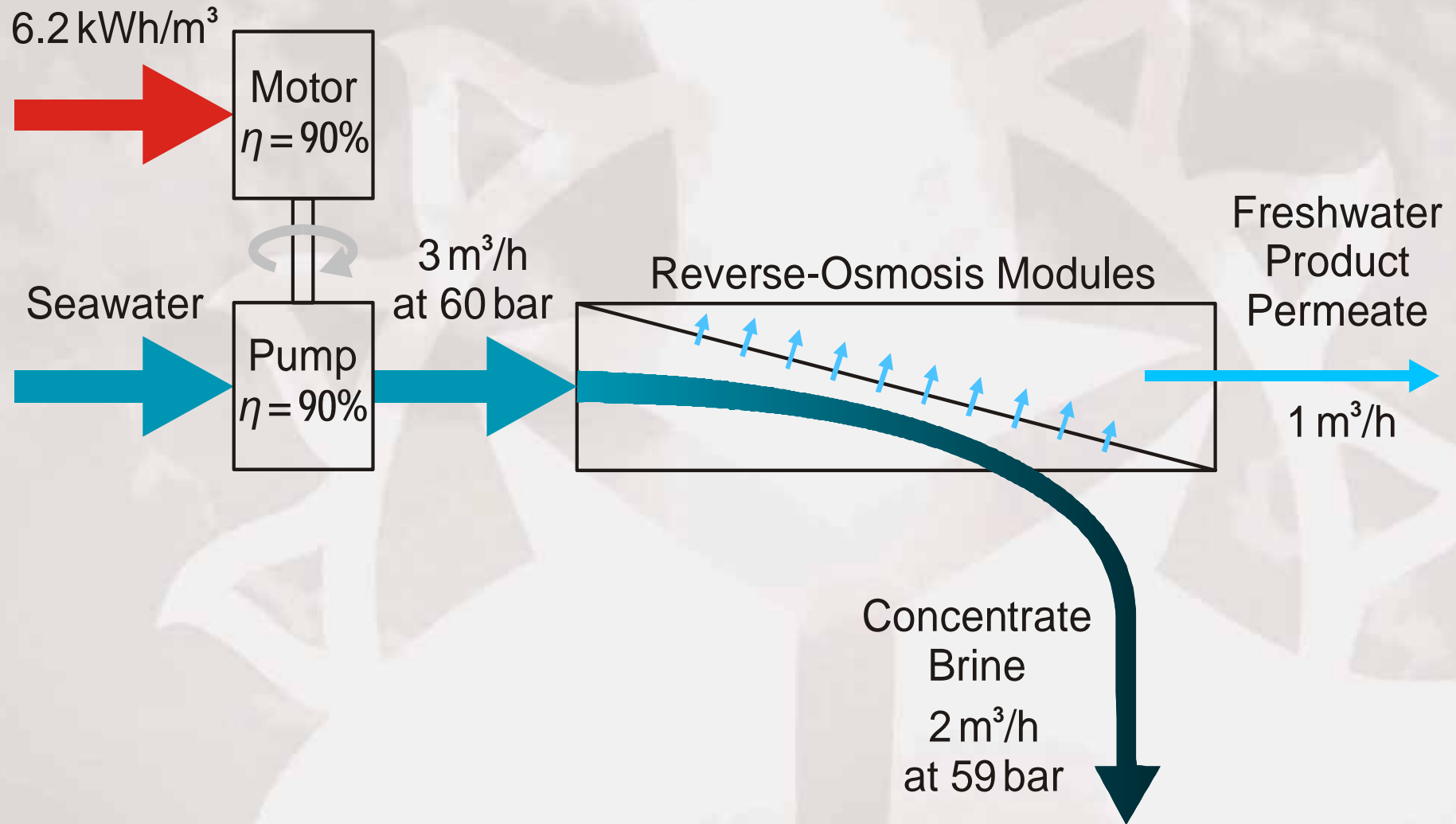
- Theoretical minimum: $\sim 1 \text{ kWh/m}^3$
- Simple distillation (theoretical): $\sim 627 \text{ kWh/m}^3$
- Thermal desalination
(Large MED, MSF & VC): $6 - 16 \text{ kWh/m}^3$
- Typical RO: $3 - 8 \text{ kWh/m}^3$
- Best practice RO: 2 kWh/m^3

Seawater RO – Example

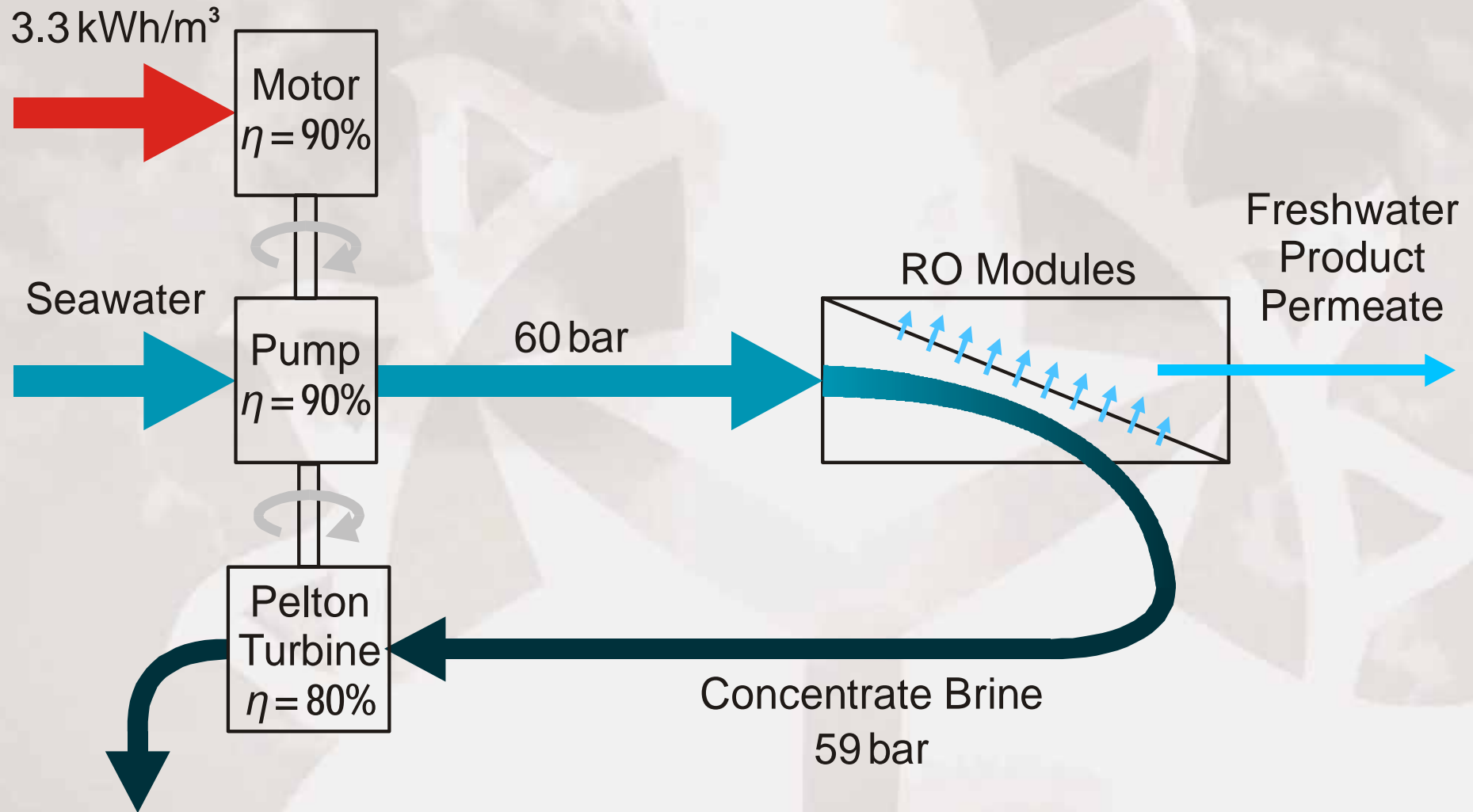


- Recovery ratio 33%

Pumping requirements



Pelton turbine energy recovery



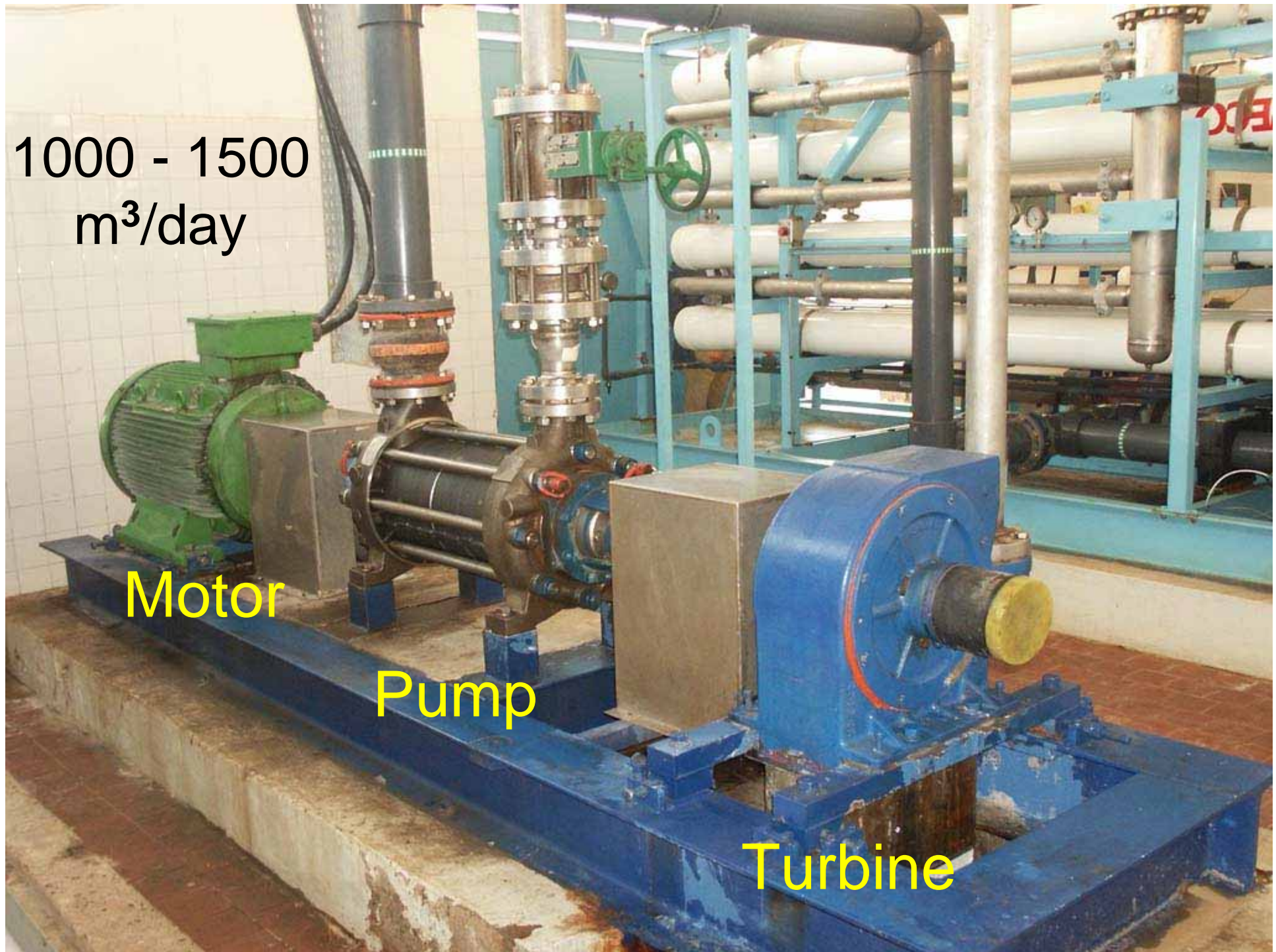
- Only for medium and large scale

1000 - 1500
m³/day

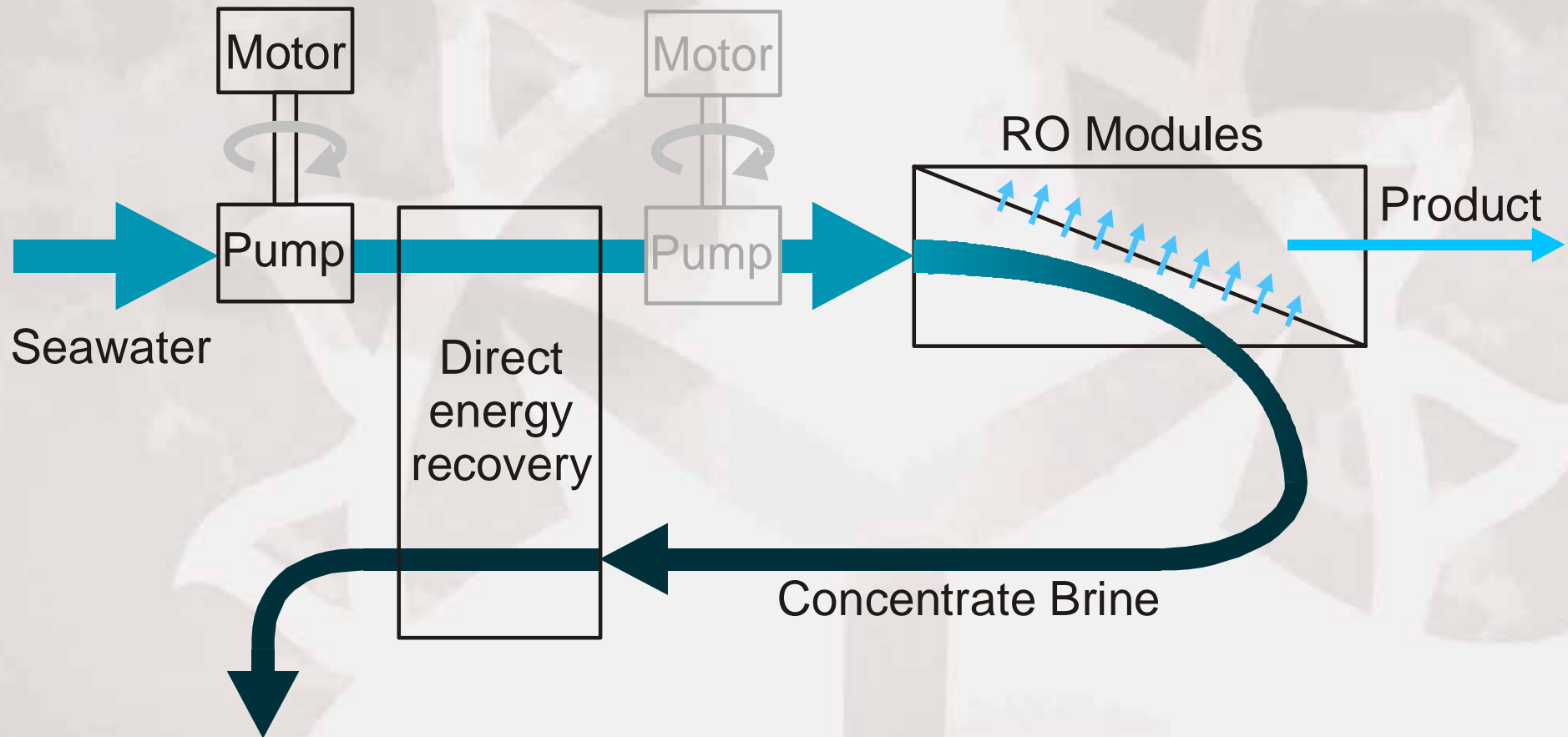
Motor

Pump

Turbine

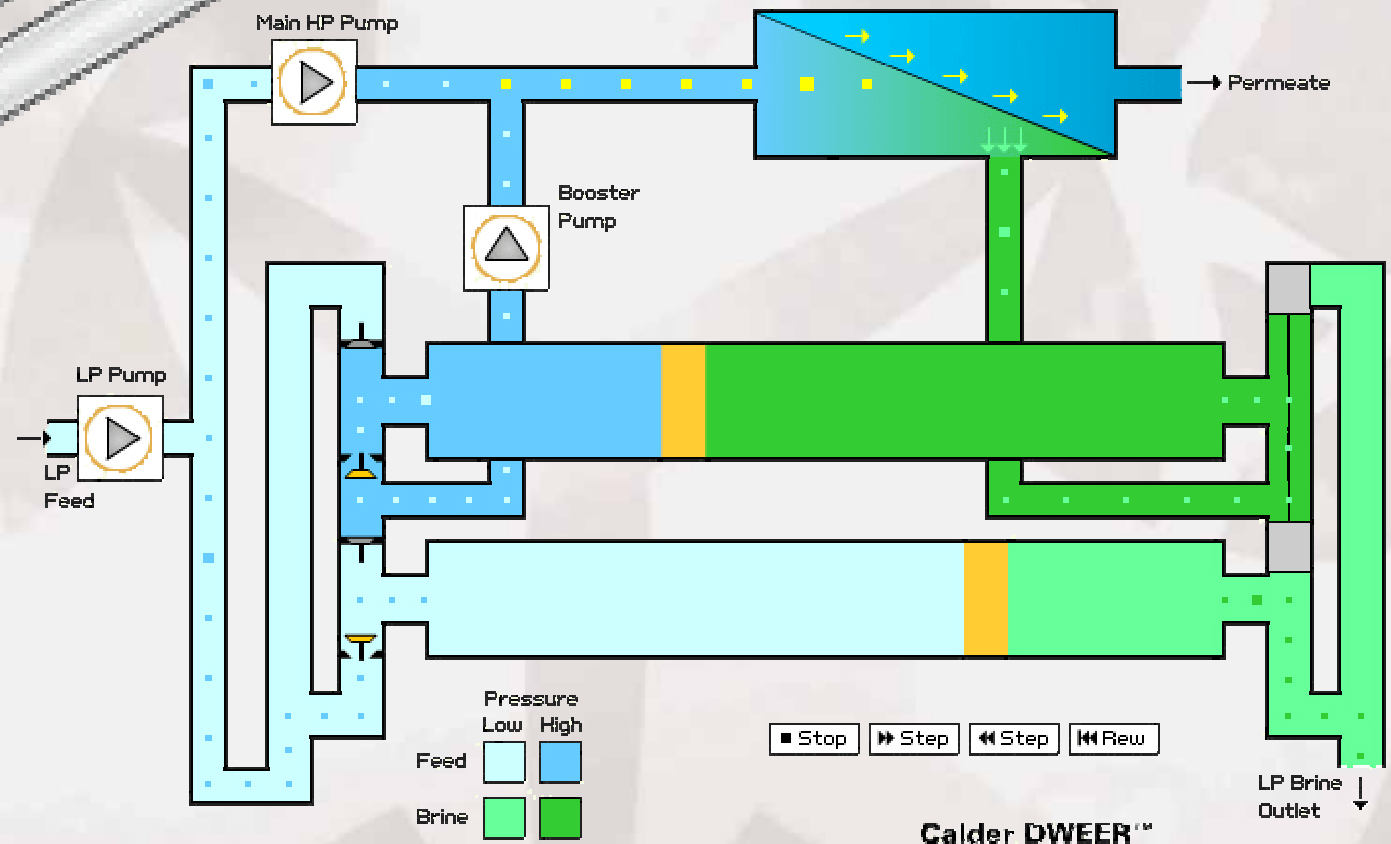
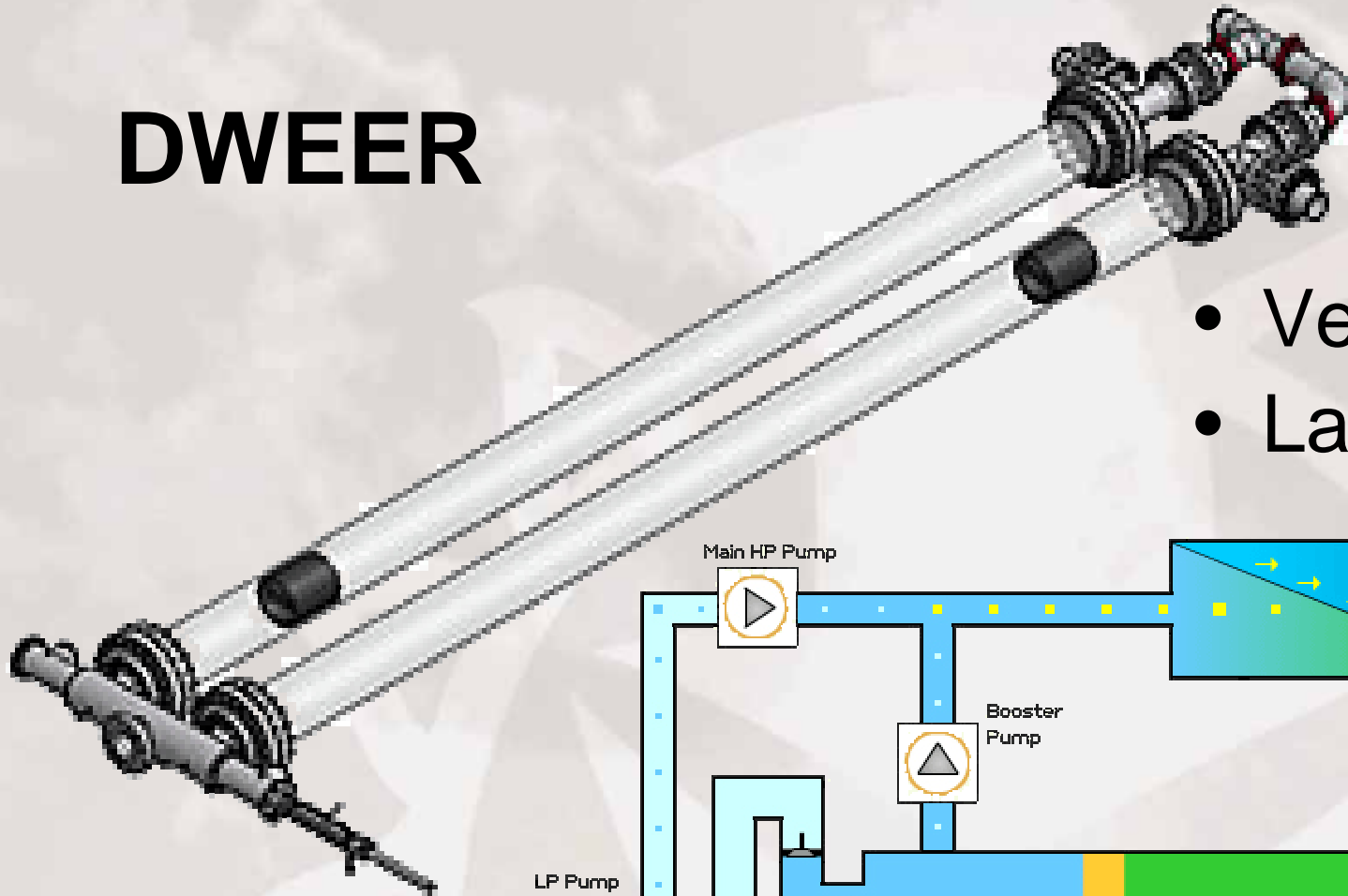


Direct energy recovery

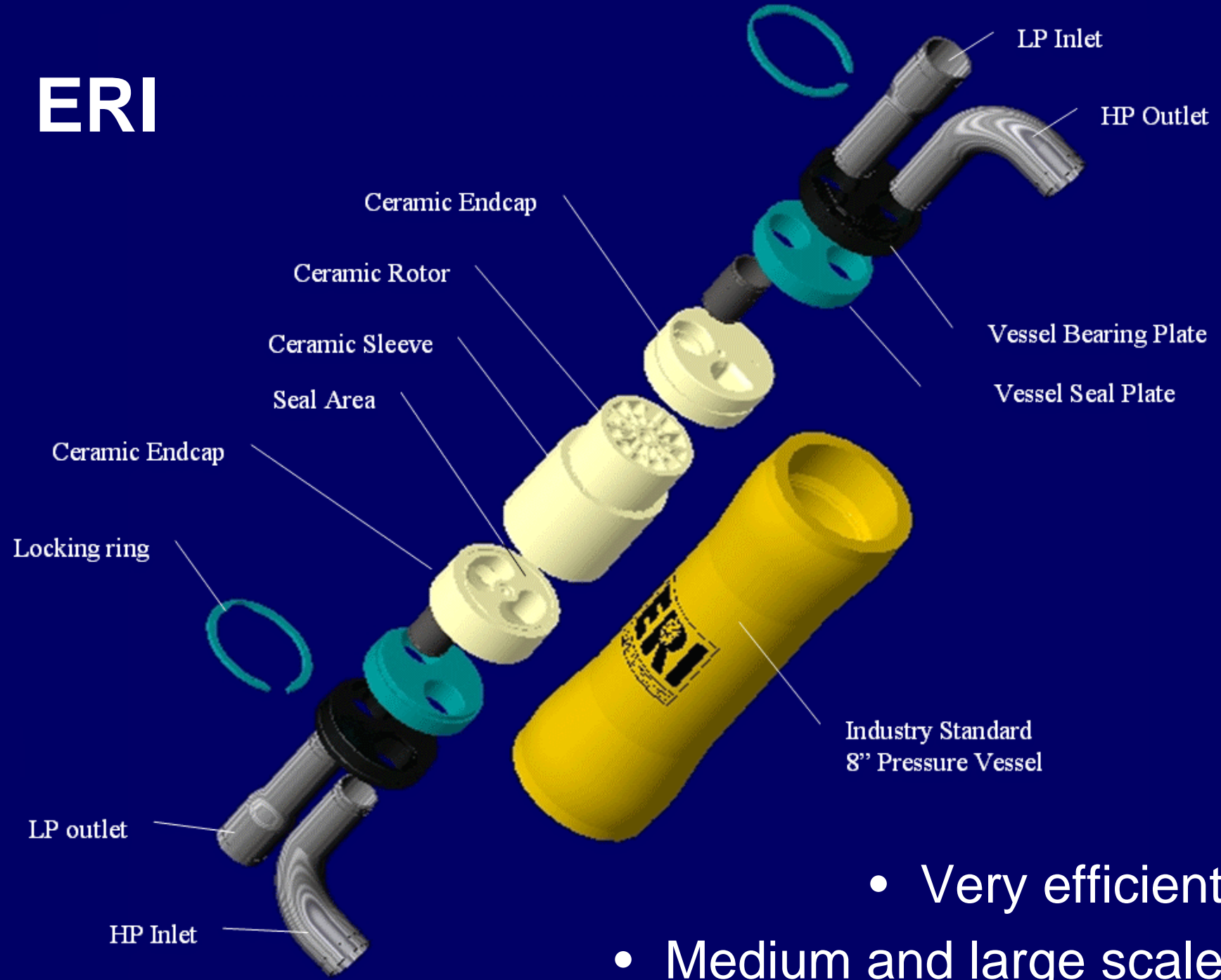


DWEER

- Very efficient
- Large scale



ERI

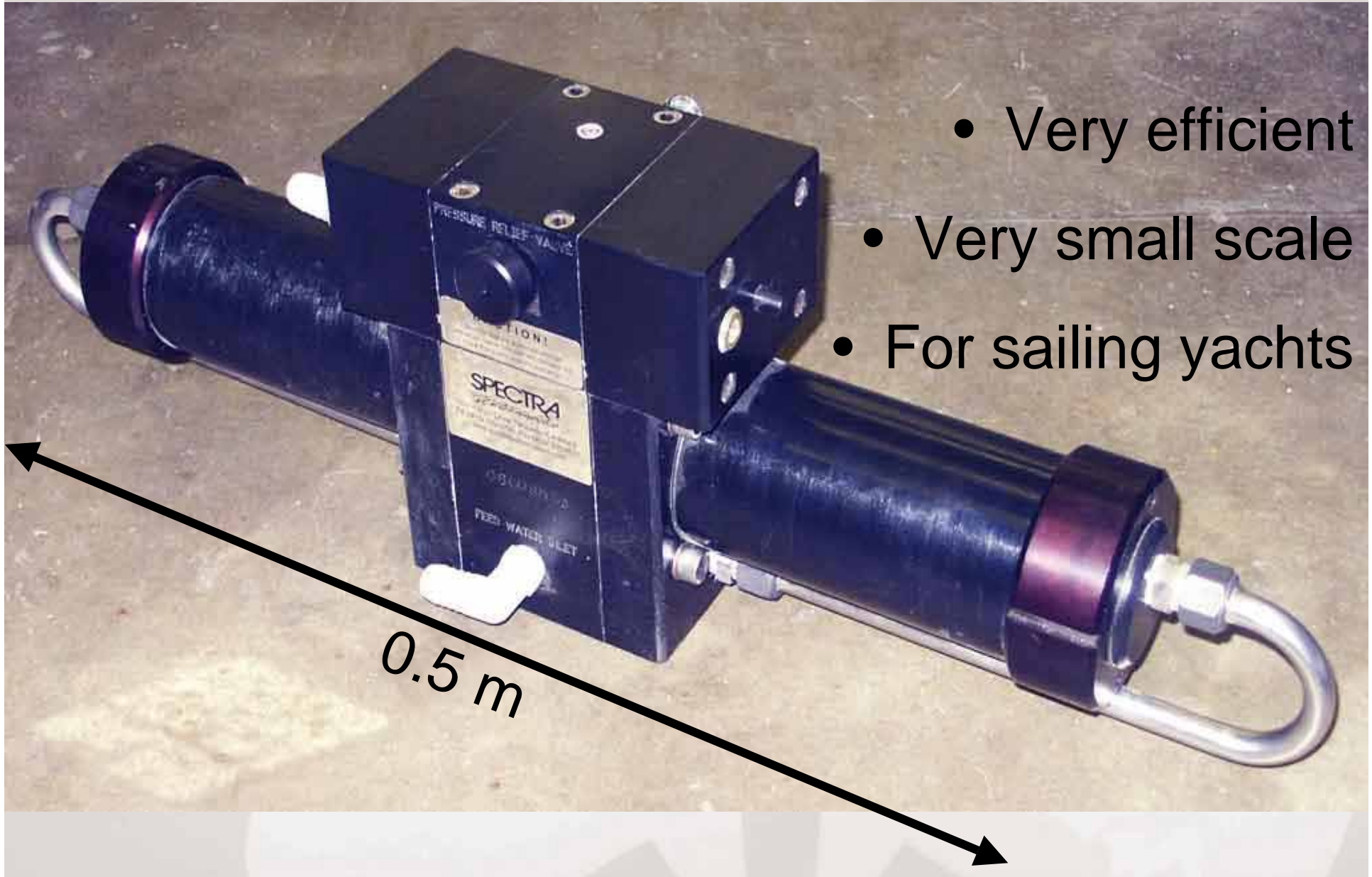


- Very efficient
- Medium and large scale

- The Pelton turbine, DWEER and the ERI devices, and their similar competitors, help to achieve very low energy consumptions:
 - sometimes approaching 2 kWh/m^3
 - **in medium and large-scale systems.**
- We now turn our attention to small-scale systems.

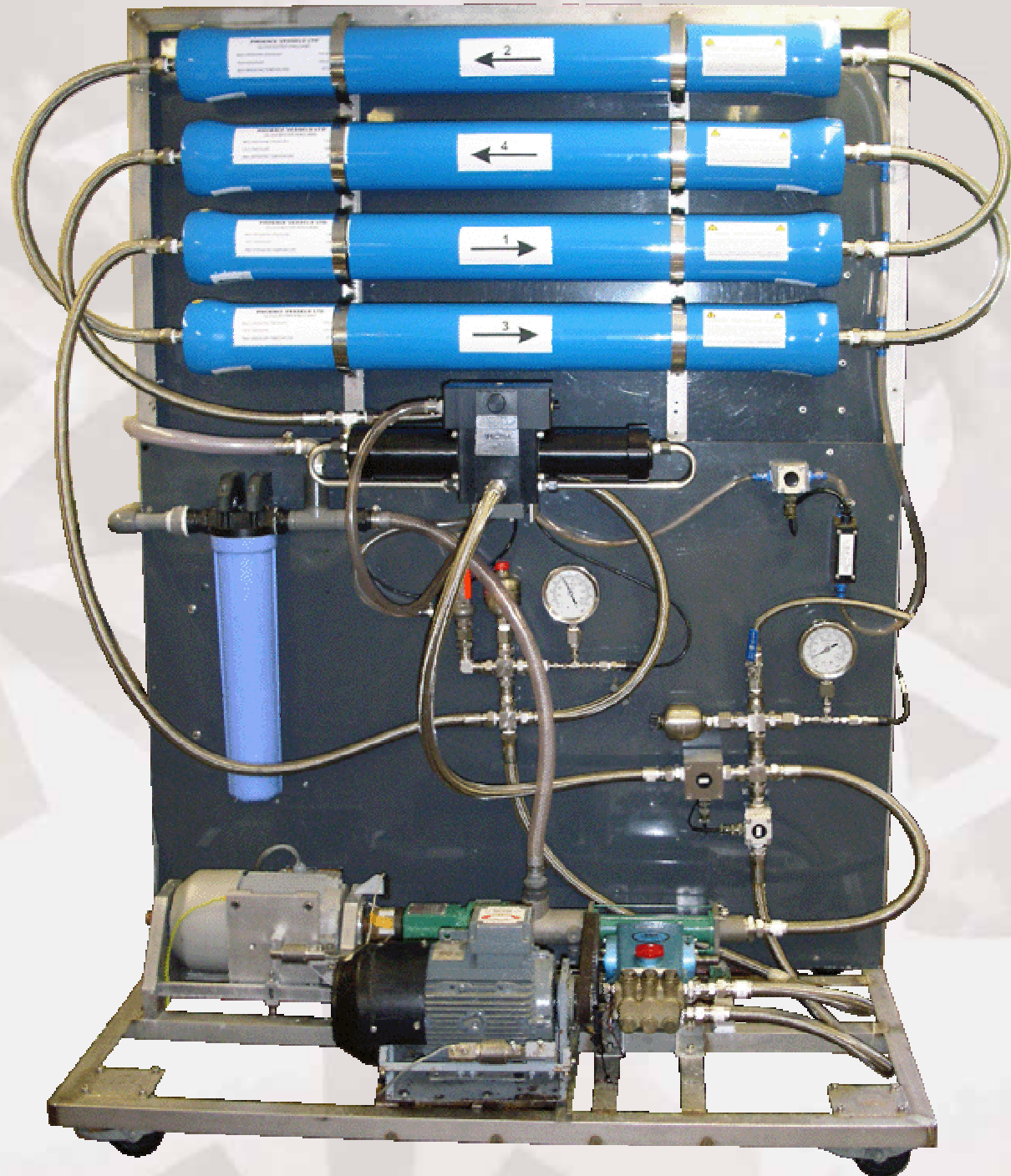
Clark Pump - Pressure Intensifier

- Very efficient
- Very small scale
- For sailing yachts

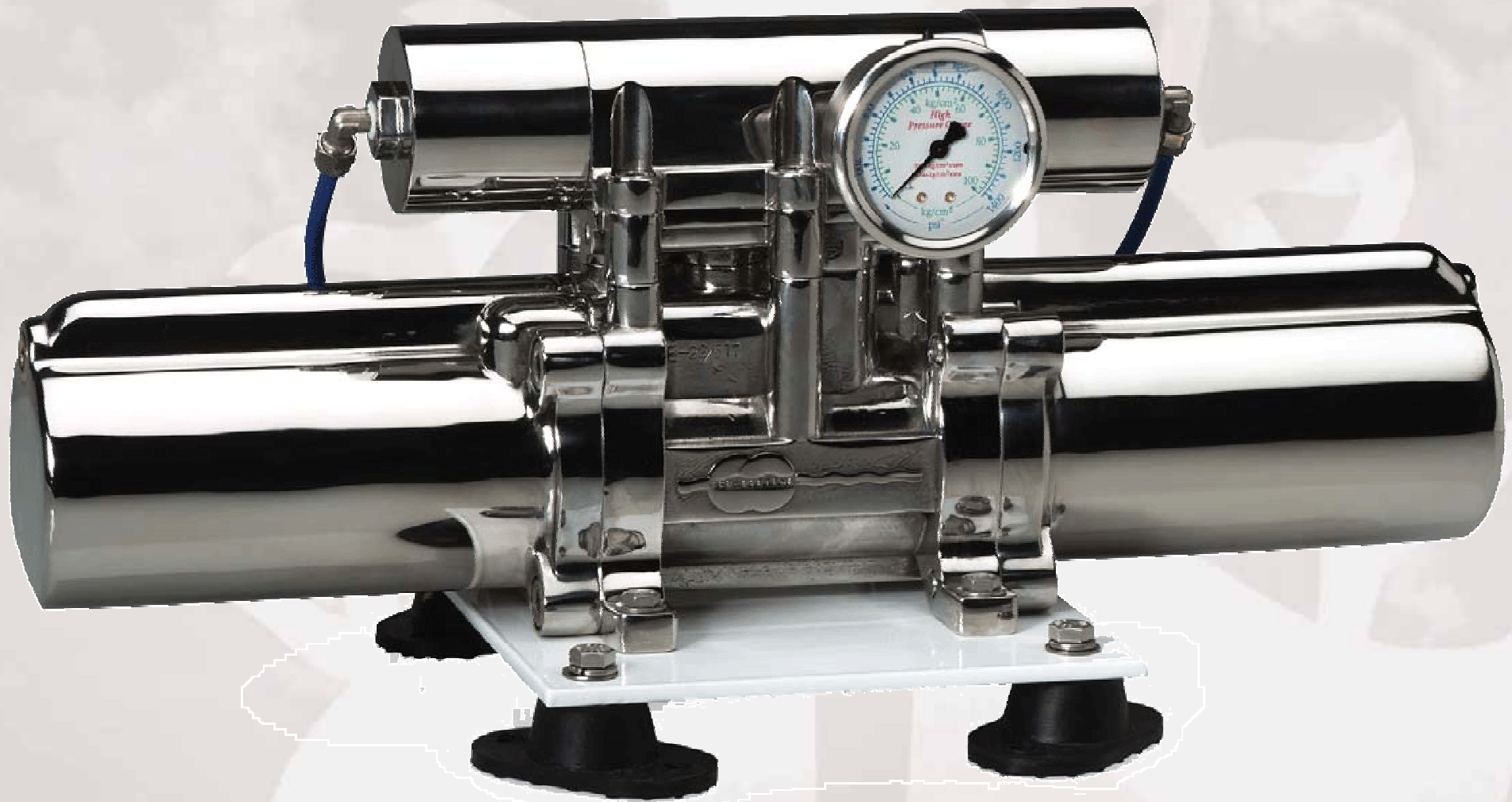


CREST RO Test Rig

- PV or wind powered
- “Seawater”
- Energy recovery
 - Clark pump
- No batteries
- Variable flow



Sea Recovery - Ultra Whisper



Hydraulic Motor

eg: Danfoss Nessie

- Provides shaft power

- Swash plate

- Axial-pistons



Renewable energy powered RO

- Various researchers and companies worldwide have built demonstration systems employing these energy recovery devices in renewable energy powered RO systems, with varying success.
- Many small systems are still built without any energy recovery.

Enercon

- Sorry no picture!
- Energy recovery for seawater RO
- Three pistons
- Oil coupled
- Pressure intensifier

Brackish water

- Typically uses higher recovery ratio
- Smaller proportion of energy in brine
- Energy recovery less critical
- Notable exception: SOLCO:
 - 16% recovery ratio
 - Energy recovery integrated in pump

Conclusions

- Energy recovery
 - critical for efficient seawater RO
 - but does make designs more complex
- Proven devices available at large-scale
- Less so at small scale

Thank you