Water Sustainability : Mixing of Brine and Impaired Freshwater

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KIM, Seung-Hyun

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Sustainability

"quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance"

dictionary.com

- Resource Management
- Environment Management

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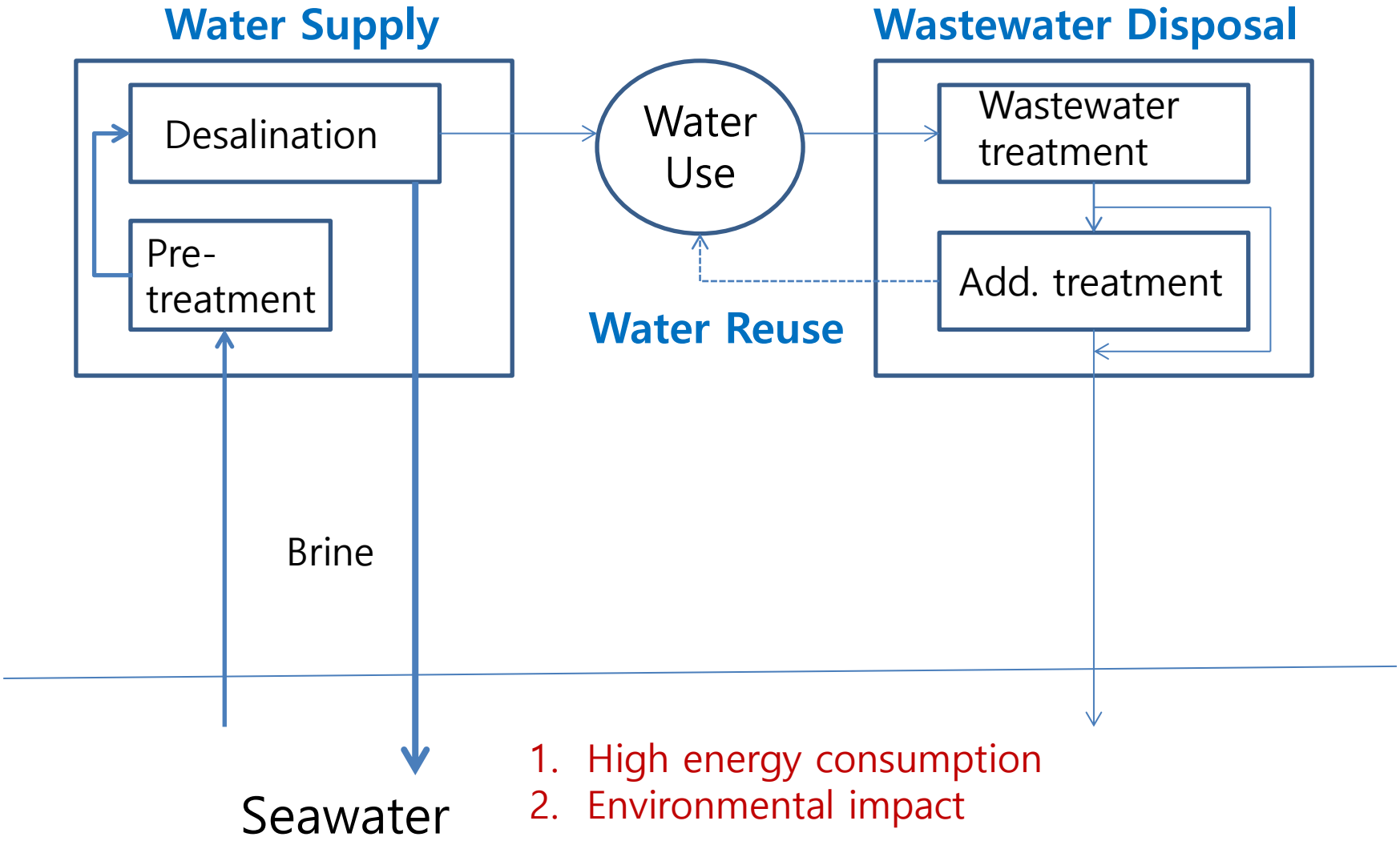
Contents

Mixing of Brine & Impaired Freshwater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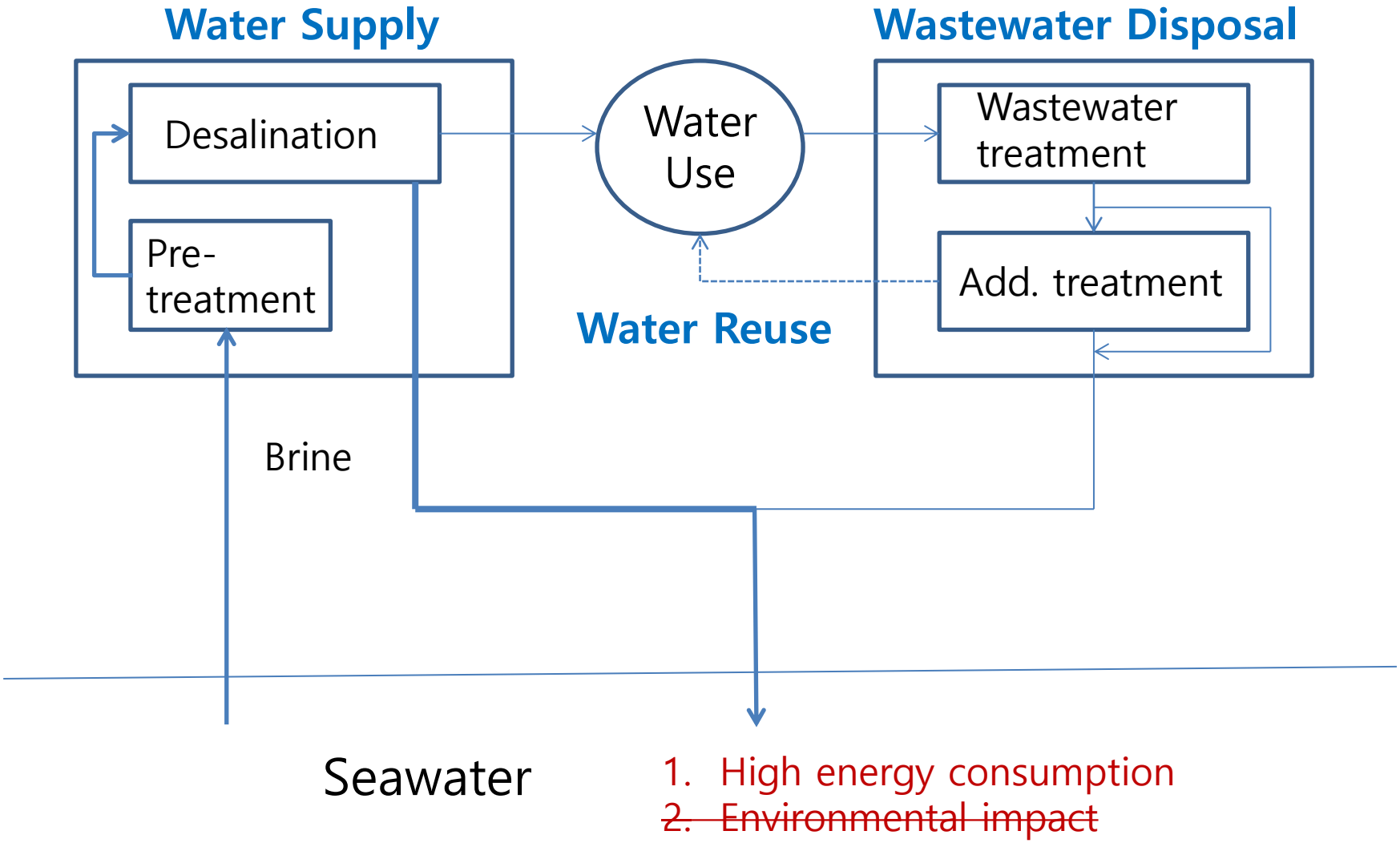
Add. treatment
Water Reuse
Brine
Seawater
1. High energy consumption
2. Environmental impact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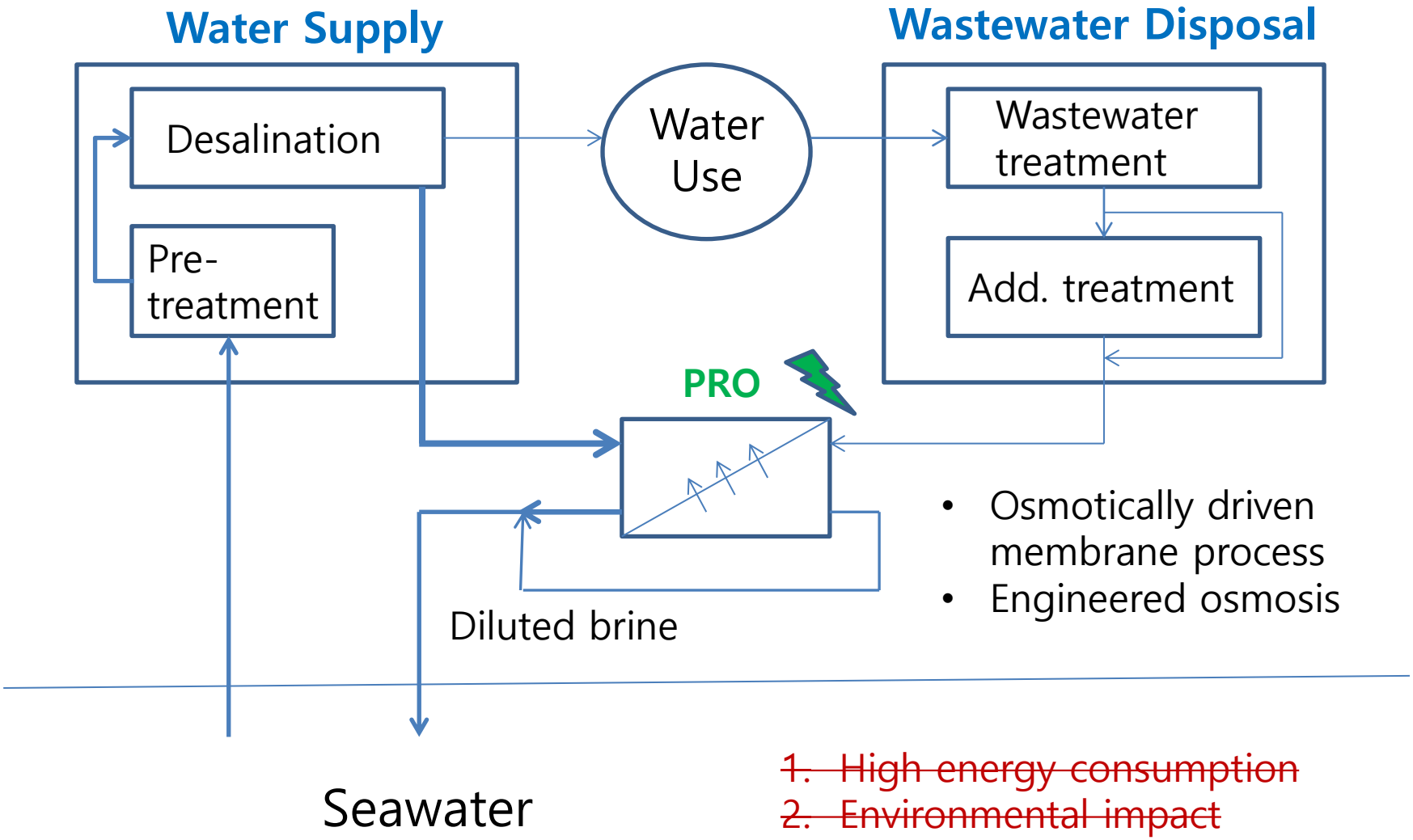
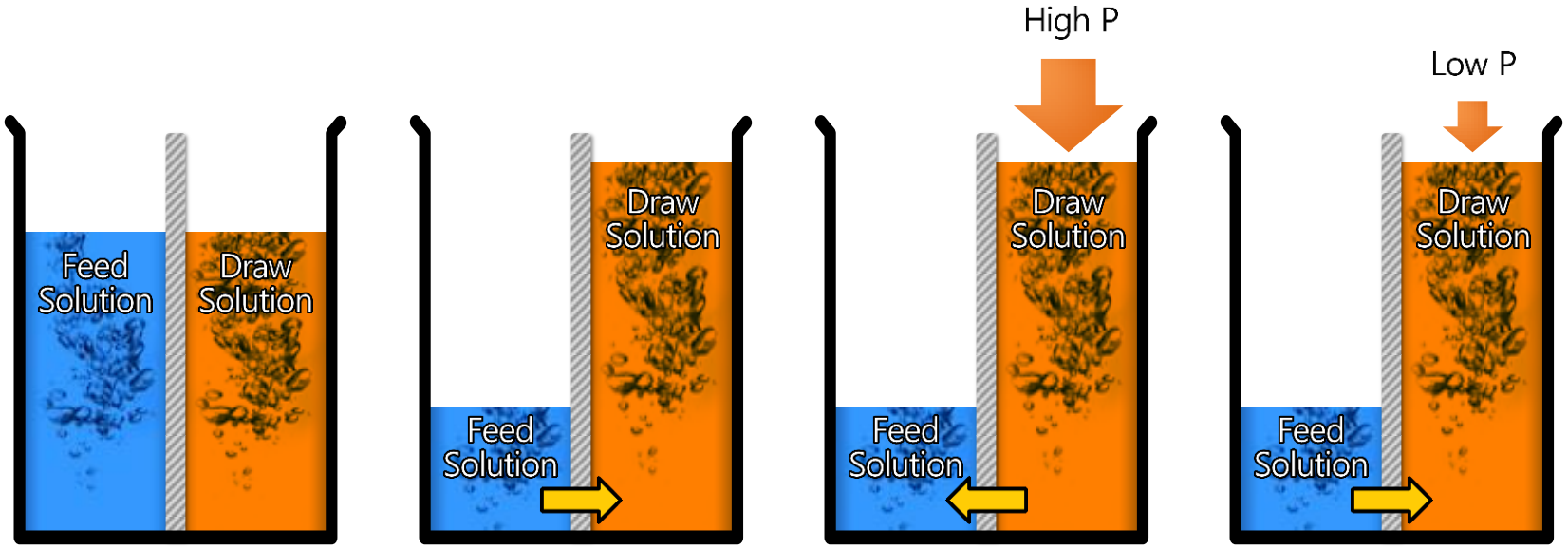


- Osmotically driven membrane process
- Engineered osmosis

~~1. High energy consumption~~
~~2. Environmental impact~~

PRO

FO, RO, PRO



Equilibrium | FO (ΔP=O) | RO (ΔP > Δπ) | **PRO (ΔP < Δπ)**

- At equilibrium, there is no flow
- At FO mode, water flows from feed side to draw side under osmosis
- At RO mode (ΔP > Δπ), flow direction is opposite to FO mode
- **At PRO mode (under ΔP < Δπ), water flows from feed side to draw side under osmosis**

"Depressurizing the permeate through hydro-turbine" → **ENERGY**

PRO development : Initial Stage

- 1954, concept of harvesting energy from mixing of freshwater and saltwater, Pattle

- 1974, diagram of osmotic salination energy converter, Norman
- 1975, term "**pressure retarded osmosis**", Loeb & Norman
- 1976~1979, experimental PRO results, Loeb
- 1975, closed-loop osmotic heat engine patented, Loeb
- 1981, PRO model developed, Lee et al.
  - $J_w = A(\Delta\pi - \Delta P)$; Flux
  - $W = J_w \Delta P = A(\Delta\pi - \Delta P)\Delta P$; Power density

- 2002, importance of pressure exchanger acknowledged, Loeb

Application Options

1. Seawater with river
   - Energy potential : 0.5~0.7 KWh/m^3

2. SWRO brine with treated wastewater
   - Energy potential : 1.4~2.0 KWh/m^3

3. Dead sea or salt lake with river
   - Energy potential : 10~14 KWh/m^3

   Source : Yip & Elimelech, ES&T, 2012

- …

Scaling-Up

Scaling-Up

- 2009~2013 Statkraft (Option 1)
  - Goal : "Power generation"
  - Timetable : 10 KW prototype -> 2 MW pilot -> 25 MW demo
  - Feed/Draw : Seawater/River

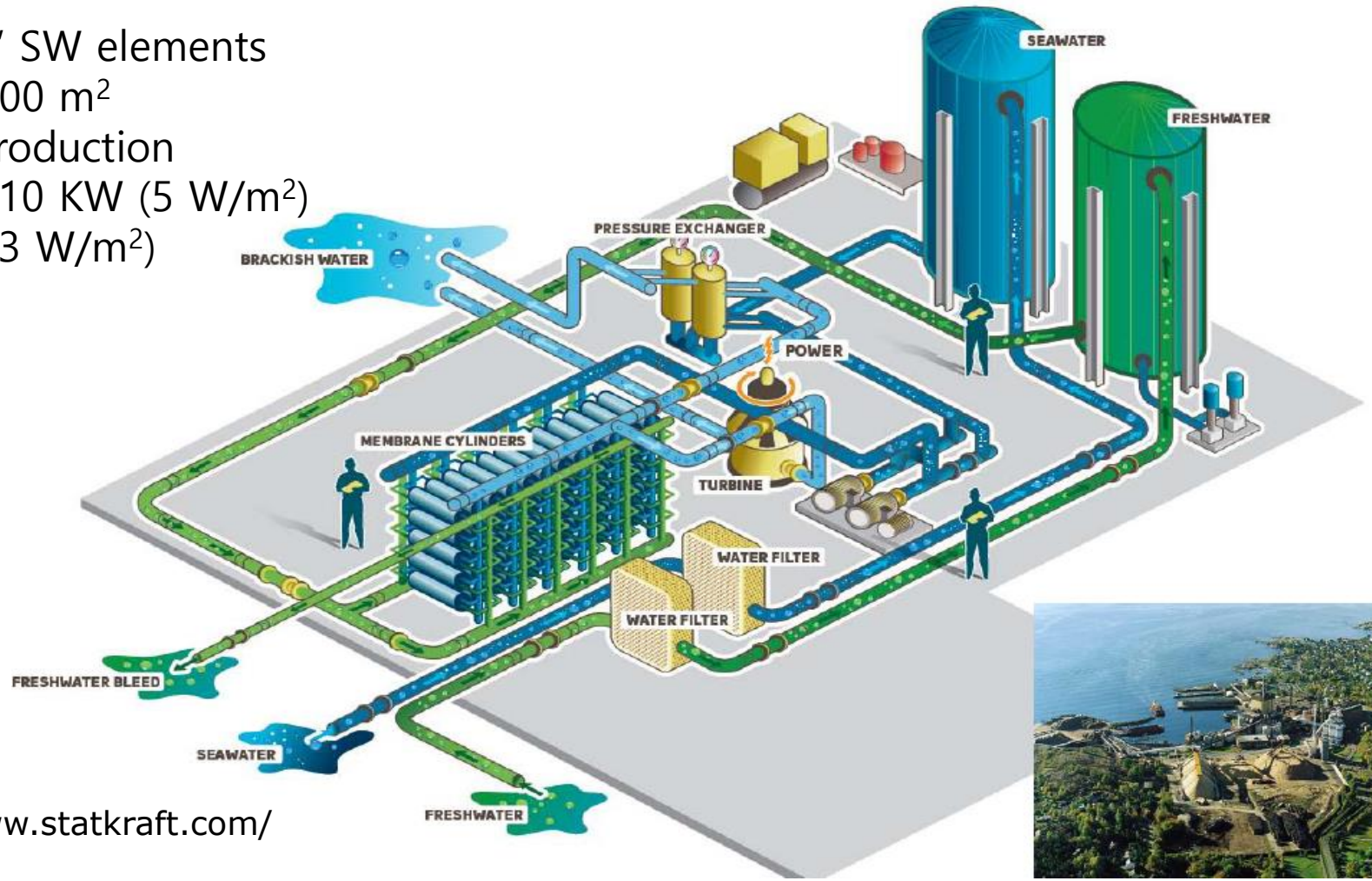
- 2010~2014 Mega-Ton (Option 2)
  - Goal : "Environmental impact reduction"
  - Feed/Draw : SWRO brine/Treated Wastewater Effluent

- 2013~2018 **GMVP** (Option 2)
  - Goal : "Reduction of SWRO energy consumption/environ. impact"
  - Timetable : 20 m^3/d pilot -> 240 m^3/d demo
  - Feed/Draw : SWRO brine/Treated Wastewater Effluent

Statkraft

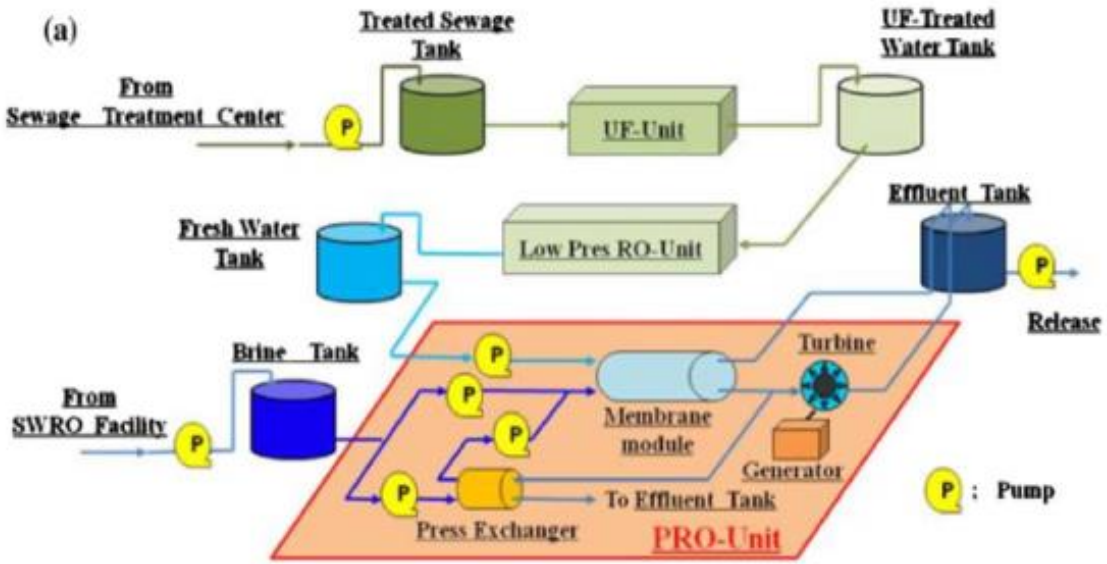
First prototype PRO installation
in Tofte, Norway at 2009

66 PV/8" SW elements
MA : 2,000 m^2
Power production
Target 10 KW (5 W/m^2)
6 KW (3 W/m^2)



http://www.statkraft.com/

Mega-Ton



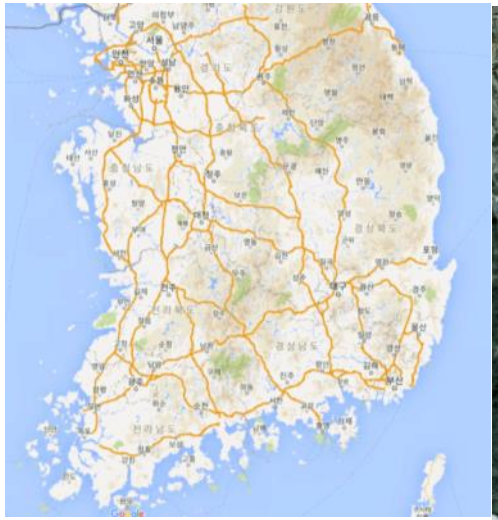
Draw : 460 m^3/d
SWRO brine
Feed : 420 m^3/d
treated sewage

10" HF module, 8 elements

10% reduction
in energy consumption of
SWRO system :
3->2.7 KWh/m^3@65% R

Source : Kurihara presentation (ISIDT, 2014)

PRO demo pilot (240 m^3/d)



GMVP

GMVP, Global MVP

- Funding : MoLIT/KAIA
- Period : 2013. 6.20 ~ 2018. 6.19
- Budget : ~32 mil. USD (~22 mil. USD)

- Principal institution & Research themes
  - Principal institution : Kyungnam Univ.
  - Research Theme 1 (MD) : KICT
    Theme 2 (PRO) : GS E&C
    Theme 3 (VRR) : Seoul National Univ.

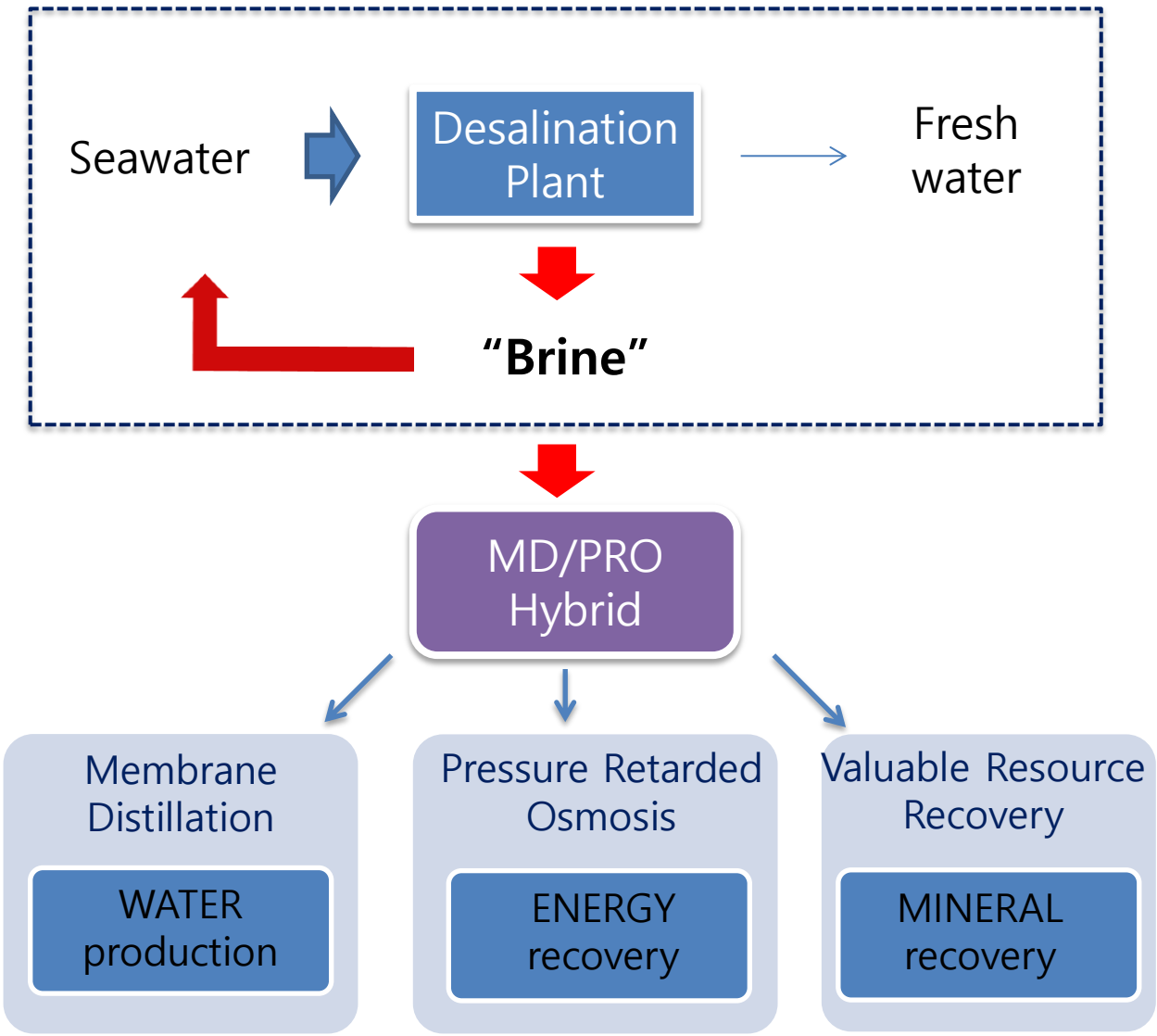
- Members
  - Industry : GS E&C, Econity, TCK, …
  - Research Institutes : KICT, KIST, KIER, RIST
  - Academia : KNU, SNU, KMU, HYU, KU, PKNU, GIST, UTS

Mission

- Title — Technology development of MD/PRO demo pilot plant of hybrid desalination

- Mission — **Develop** future desalination technologies
  &
  Demonstrate at pilot-scale

Future Desalination Technologies



Demonstration

Design, build, and operate pilot
<-> System engineering technology

Start small and

gradually increase the capacity

Scale-up:
Prototype → Pilot → Demo Pilot

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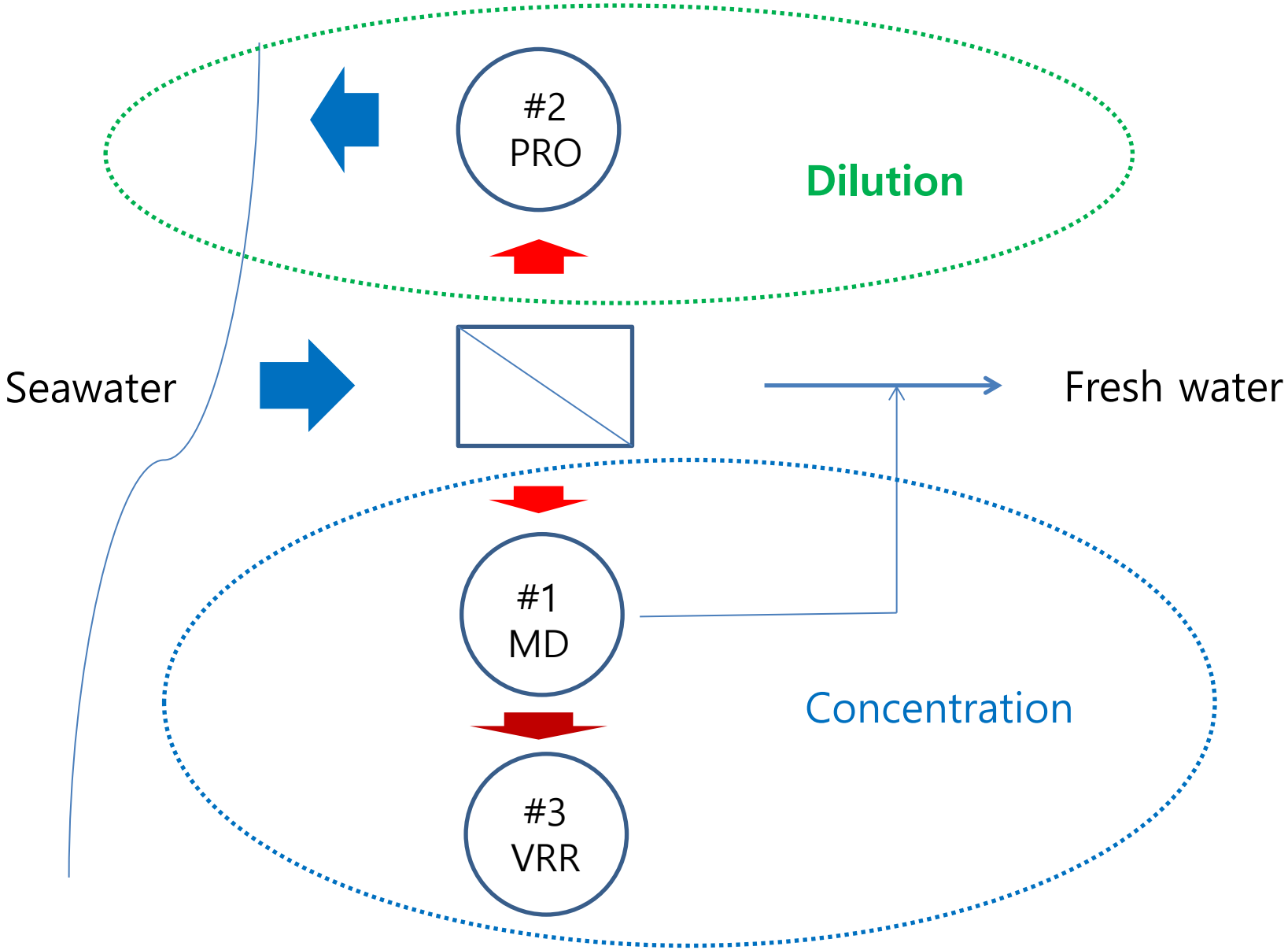
Brine Solution Strategies

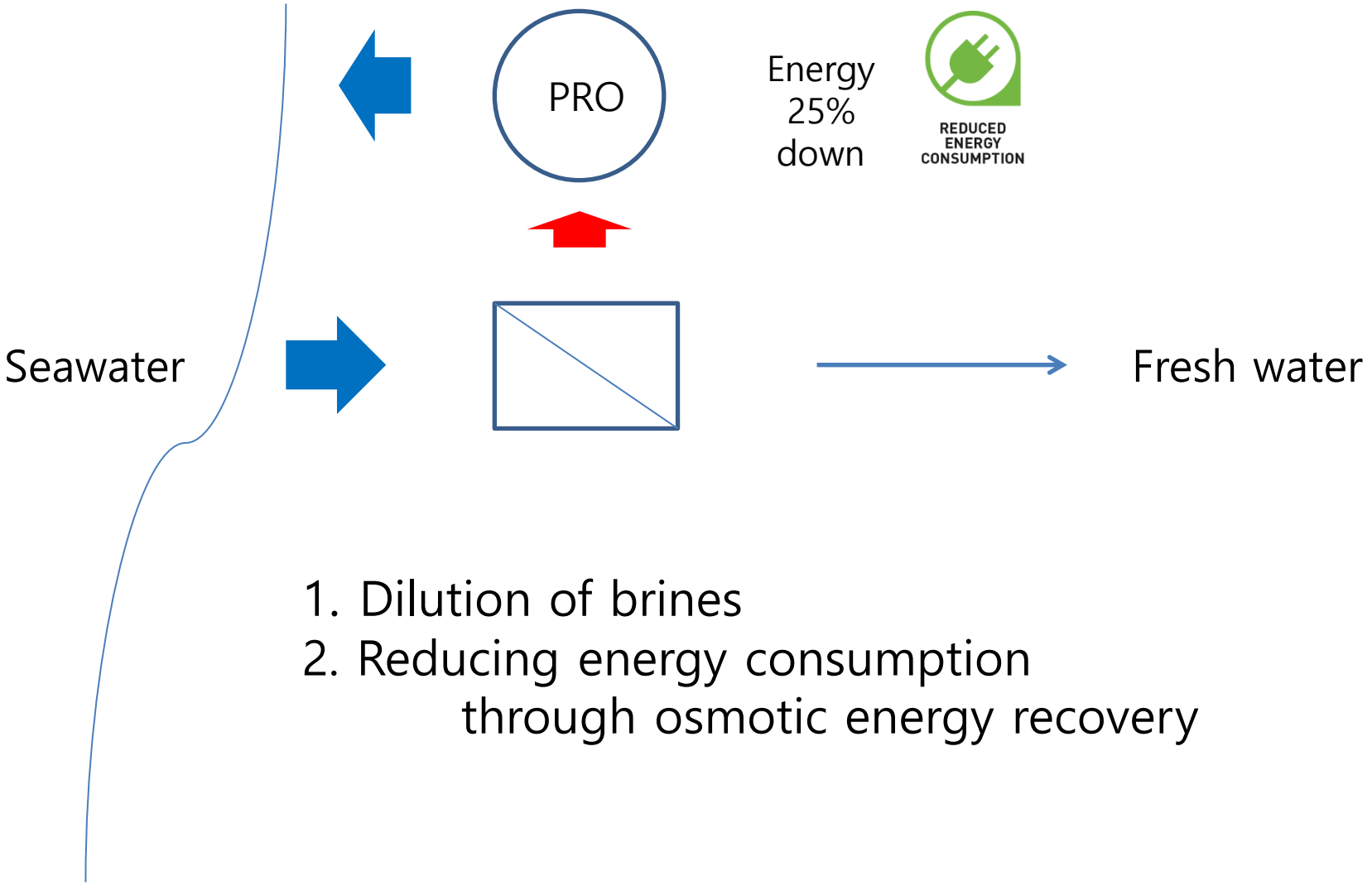
1. **Dilution**

2. Concentration

Proposed Brine Management



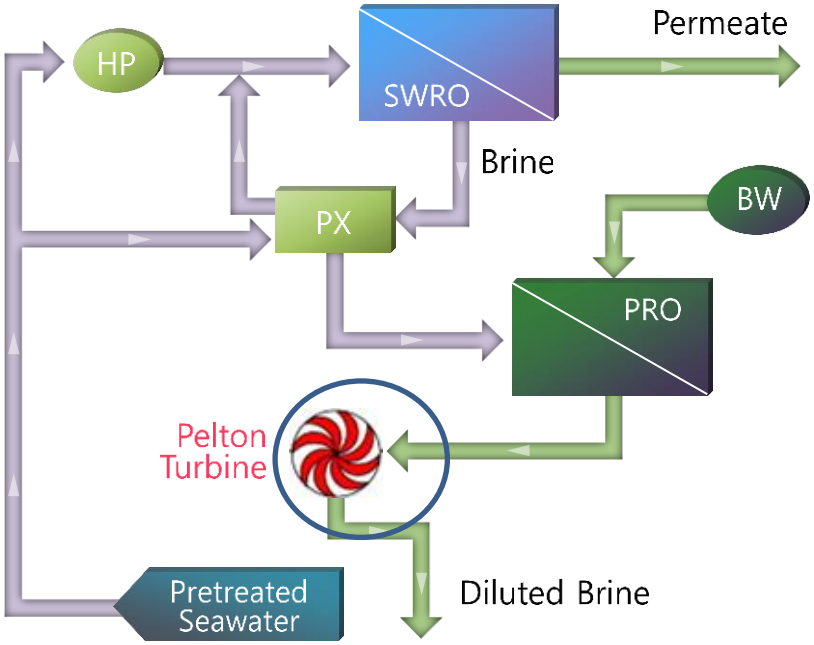
Strategy 1. **Dilution**



1. Dilution of brines
2. Reducing energy consumption
   through osmotic energy recovery

GMVP-PRO Process

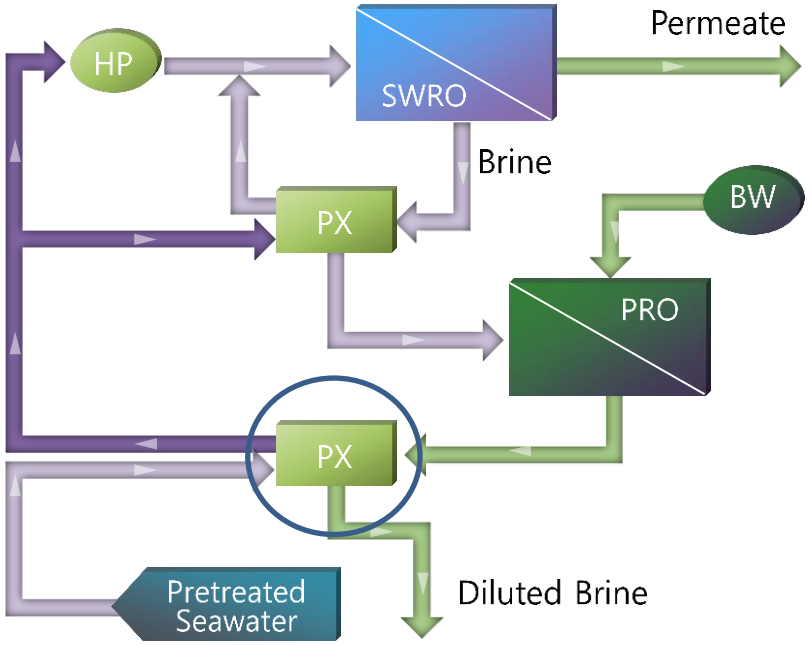
Pelton Turbine



Characteristics

- LOWER energy recovery efficiency
- NO mixing of WTP effluent with seawater

Pressure Exchanger



Characteristics

- HIGHER energy recovery efficiency
- Mixing of WTP effluent w/seawater

PRO pilot build-up plan

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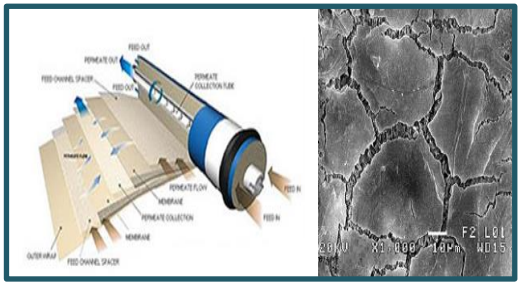
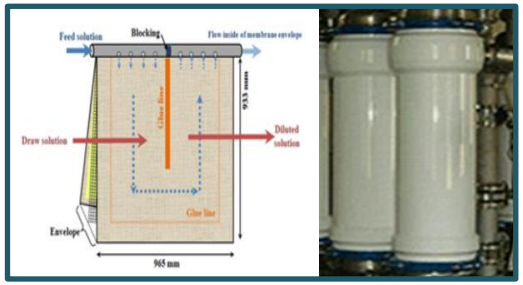
Pilot Stage 1 (2013~2014)	**Demo Pilot** Stage 2 (2014~2016)	Optimization Stage 3 (2016~2018)
		
▶ PRO membrane development	▶ PRO module development	▶ system optimization
		
▶ design, build, operate pilot	▶ design, build, operate demo pilot	▶ Design of large scale SWRO-PRO ▶ Economic evaluation ▶ Business model

PRO pilot (20 m^3/d)

PRO demo pilot (240 m^3/d)

Shop work and Plant installation




Civil work (2015.07)


Shop work (2015.07)

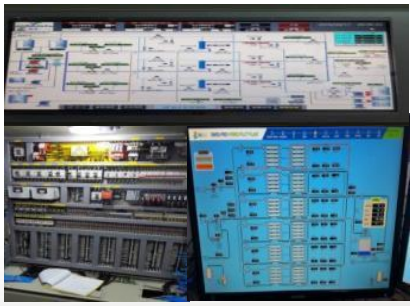
Moving (2015.08)

Container installation (2015.08)

Steel frame installation (2015.08)

Pipe/electric work (2015.09)

Connection (2015.09)

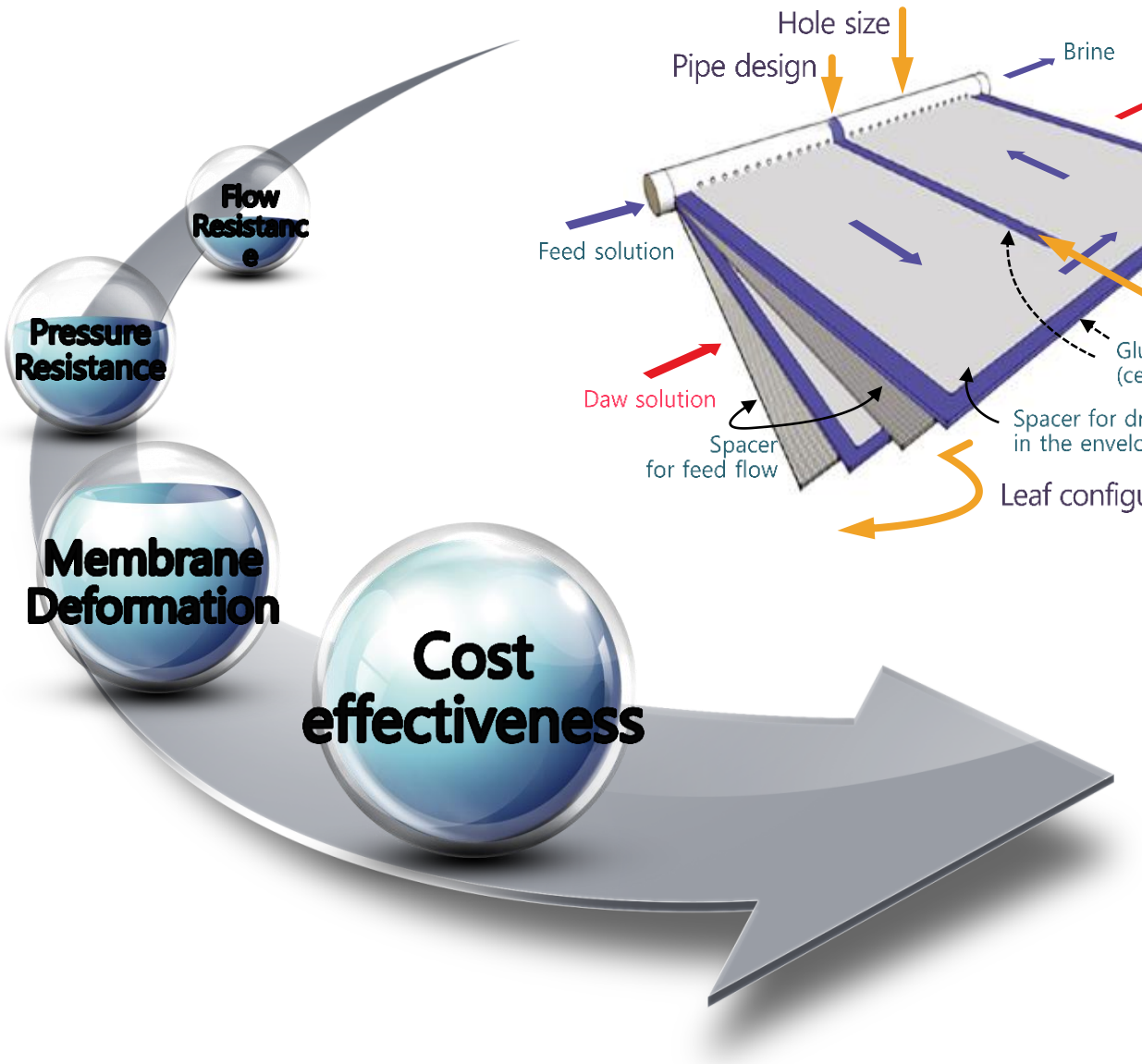


HMI (2015.09)

PRO demo pilot (240 m^3/d)

8″ spiral wound module
2PX, Pelton turbine

PRO membrane/module



Conclusion

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Conclusion

- Water sustainability comes from effective management of resource and environment.
- Sustainability of water system can be improved with proper technology and water-energy nexus consideration.

shkim@kyungnam.ac.kr

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