Membrane Technology: Past, Present and Future Trends

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Overview

- Current international status of membranes
- Historical developments in South Africa
- Current status in SA
- Possible bottlenecks and lessons learned
- Future trends





International perspective

- Membranes are fast becoming the standard accepted technology for potable water, municipal wastewater and industrial wastewater treatment in N America, Europe, Middle East, South East Asia
  - Industrial applications: internal recycle, reuse, effluent reclamation (UF, RO, NF)
  - Potable water production: MF and UF (non-saline waters), RO (desalination)
  - Municipal wastewater: immersed membrane bioreactors (IMBRs)
  - Reclamation of tertiary effluent: UF, RO

- Drivers: water quality, economics
  - Membranes deliver a consistent high quality, irrespective of skills level of operator
  - Cost of membranes have decreased very significantly
  - RO membranes now a “commodity”

International perspective

- Scale of operations:
  - Potable water production (non-saline): Minneapolis – raw water from Mississippi River – UF and disinfection – 180 ML/day
  - Treatment of municipal wastewater: Shendinge (China) – IMBR – 120 ML/day
  - Reclamation of tertiary effluent: Surabaya – tertiary effluent from municipal wastewater treatment works – UF-RO – used for irrigation, Class A, etc except potable – 375 ML/day
- Some important lessons:
  - Membranes are not a "silver bullet" – throw anything at it and it will do the job
  - Industrial applications: Membranes are part of a broader waste minimisation / cleaner production strategy
  - Membranes are just one unit process in a broader treatment train – requires good pretreatment and possibly posttreatment





SA: Historical Perspective

- Membrane development
  - 1959 – ED plant for desalination of minewater – largest in world (7 ML/day) – locally produced ED membranes
  - Early 80s
    - CA & thin film composite tubular RO membranes developed at Institute Polymer Science, Univ. Stellenbosch
    - Inexpensive tubular RO support system developed by Membratek
    - TRO commercialised





SA: Historical Perspective

- Late 80s
  - tubular UF membranes developed at Univ. Stellenbosch.
  - Woven fabric MF membranes developed at Univ. Natal
  - Dynamic UF membranes developed at Univ. Natal
  - TUF commercialised by local company
  - WFMF commercialised by overseas company
- Early 90s
  - Capillary UF developed at Univ. Stellenbosch
  - Recently commercialised





SA: Historical Perspective

- Membrane Process Development
  - ADUF – anaerobic digestion combined with tubular ultrafiltration
  - SPARROW – “seeded slurry” to reduce crystalisation onto membranes





SA: Historical Perspective

- Early applications
  - Treatment of wool scour effluent – dynamic UF
  - Paint recovery in automotive industry - UF
  - Size recovery in textile industry – UF
  - Pre-treatment for RO – UF
  - Lignosulphonate recovery – UF
  - Colour removal from textile dyehouse effluent – RO
  - Treatment of minewater – SPARROW
  - Treatment of cooling water blow-down - RO





SA: Historical Perspective

- Applications 90's and early 2000's
  - Fairly successful
    - Treatment of cooling water blowdown – RO
    - Desalination of minewater – RO
    - Desalination of seawater – RO
  - Limited success
    - Treatment of combined industrial effluent - biological + UF/MF
    - Dewatering of sludges - MF





SA: Historical Perspective – WRC Role

- WRC the major funder of membrane research in SA
- Special theme on “Membranes”
- Funded over 66 membrane projects
- Projects included both membrane development and applications development
- Majority of people who are currently vending membrane systems were involved in a WRC project





SA: Current status

- Potable water production from raw waters
  - Saline water
    - Various small plants for seawater desalination and brackish water desalination
    - Major driver – water scarcity
  - Non-saline raw waters
    - No major plants at present
    - Various small plants: Swellendam, Spanjaardskloof (UF + flocculation)





SA: Current status

- Municipal wastewater treatment and reclamation
  - Move towards IMBRs in Western Cape (Zandvliet, Bellville, Malmesbury) ~ 50 ML/day
    (drivers – water quality, preparation for reuse)
  - Beaufort West – upgrade tertiary effluent for direct reuse – RO
    (driver – water scarcity)
  - Pilot investigation on IMBRs at Umgeni water
    - treat raw sewage using IMBR
    - upgrade tertiary effluent to potable using:
      0_3 /GAC – UF ? – NF/RO - AOT





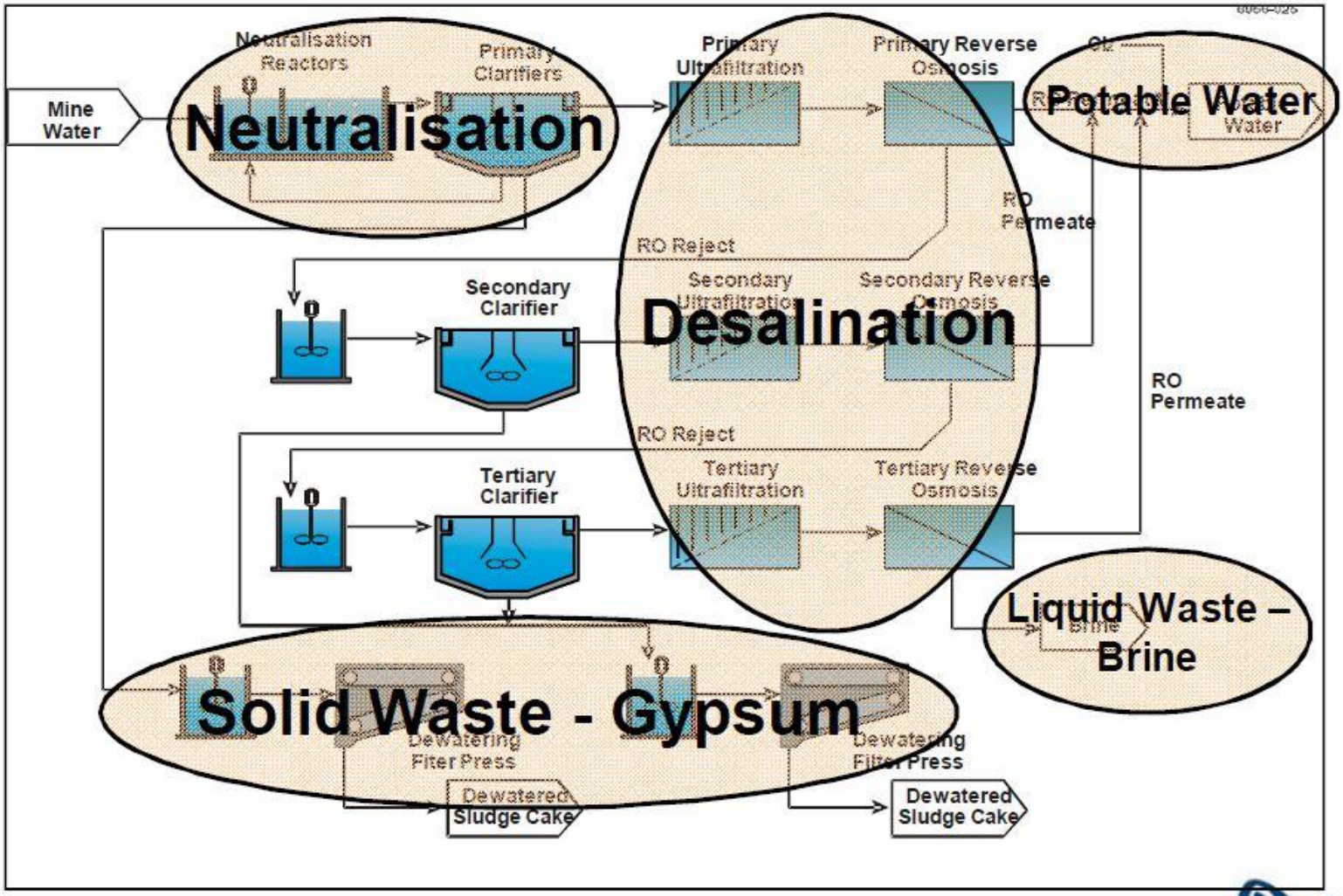
SA: Current status

- Industrial effluent treatment and reclamation
  - Fairly successful penetration into larger industries - mining and power
  - *Very limited penetration into petrochemical, smaller industries, chemical, textiles etc*
  - Applications - cooling water blowdown, desalination of minewater, treatment of acid mine water, upgrading municipal water for process water, water reclamation to potable standards
  - Most impressive application – eMalaheni Water Reclamation Plant
    - Joint initiative between Anglo Coal and BHP Billiton on Olifant;s river catchment
    - 26 ML/day (to be upgraded)
    - 99.7 % water recovery !!!





SA: Current status



Source: KeyPlan (Pty) Ltd

SA: Current status - Summary

- Potable water production
  - Slow penetration into desalination market (water scarcity)
  - Negligible penetration for treatment of non-saline waters
- Municipal wastewater treatment
  - Some move towards IMBRs in water stressed regions (water quality, preparation for reuse)
  - Umgeni Water, eThekwini, others contemplating IMBRs, leading to reuse





SA: Current status - Summary

- Industrial effluents
  - Good penetration into larger water stressed industries (mining and power)
  - Very poor penetration into broad industrial base





SA: Current status - Research

- Functionalised membranes
- Incorporating nanotechnology into membranes
- Immersed woven fabric membranes
- Combined FMS-UF
- *Generally membrane R&D has decreased significantly over the past 5 years (good or bad ?)*





SA: Potential …

- Are membranes applicable for potable water production in developing countries ?
  - Product dependant on membrane only, and not on skills of operator
  - If operated poorly, membrane will stop producing. However, water quality will never be compromised.
- Are IMBRs relevant for sanitation in developing countries ?
  - Increasing capacity of larger works
  - Pretreatment for reuse
  - Package plants for decentralised sanitation





SA: Barriers to membrane technology

- National will ?
  - Example of Singapore
- Gap between research and commercialisation
  - Commercialisation drives further development
  - Major gap in SA





SA: Barriers to membrane technology

- Lack of awareness/knowledge of membranes
  - More membrane education at tertiary level
  - Membrane database
  - Publicise success stories (WISA-MTD ?)
- Suspicion/distrust of membranes and membrane vendors
  - Membrane test/demonstration facility ?
  - Demonstration plants (especially to municipalities)





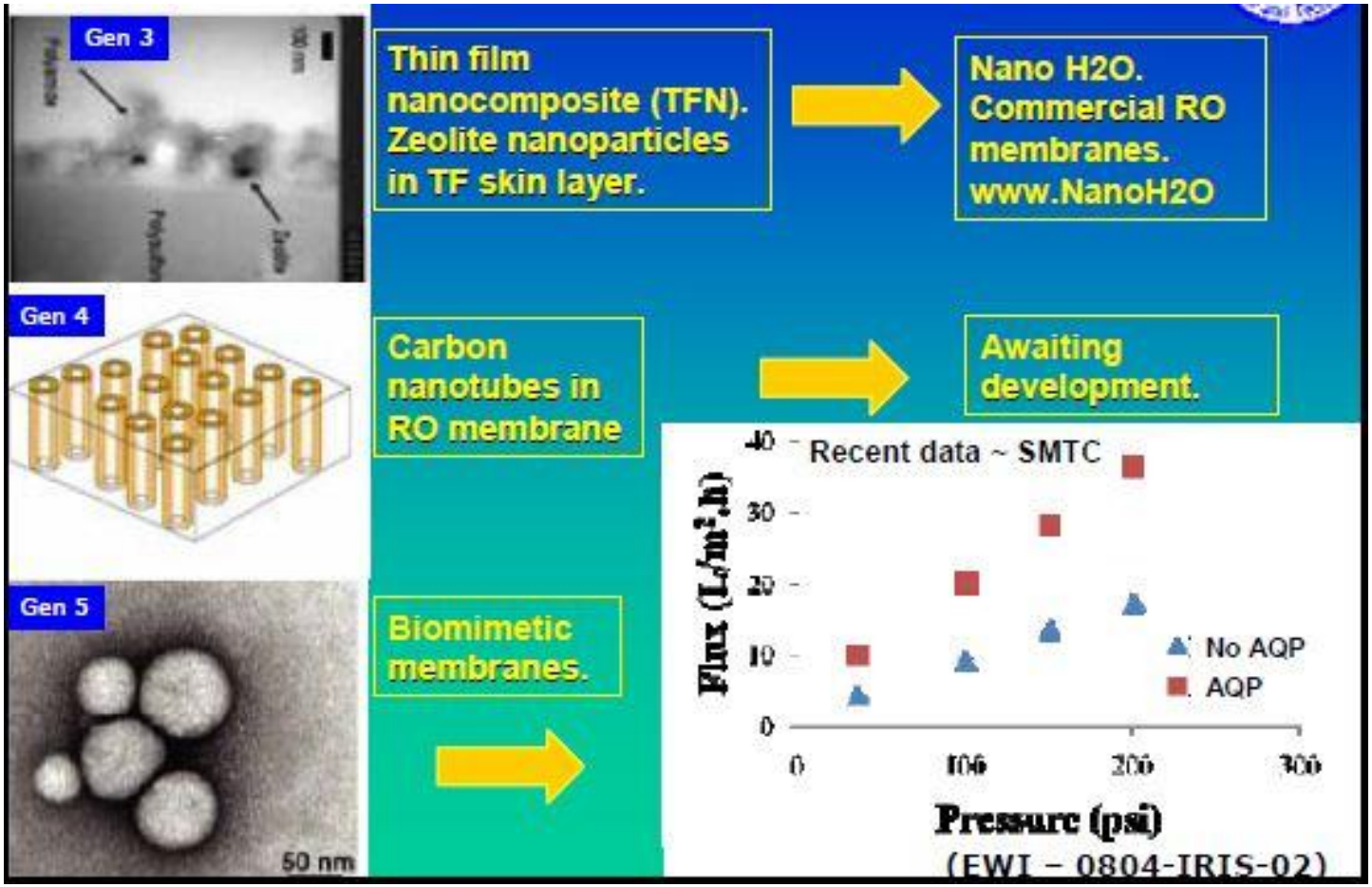
SA: Barriers to membrane technology

- Vending membranes as a “silver bullet”
  - Essential to perform cleaner production exercise first
  - Segregation of effluents
- Costs and energy - still high
- Slow regulatory framework ?

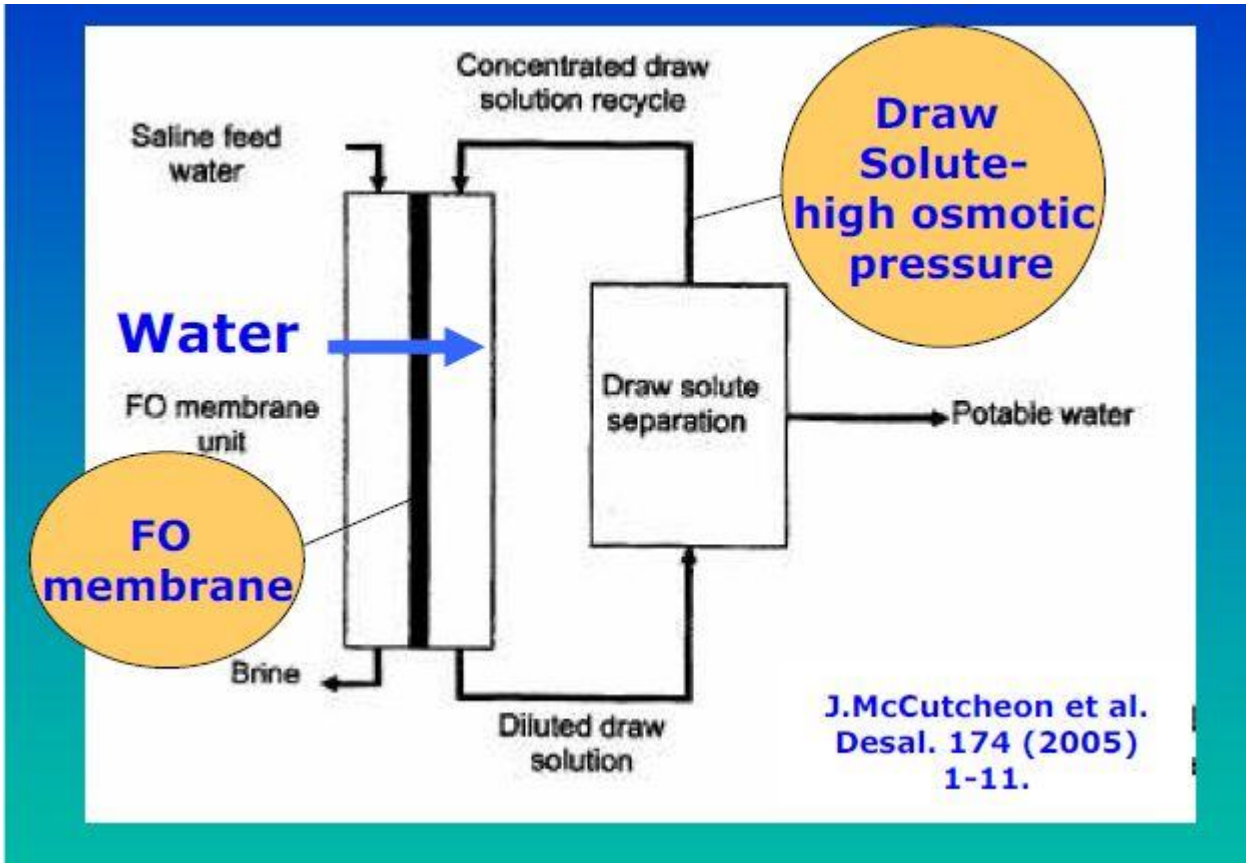




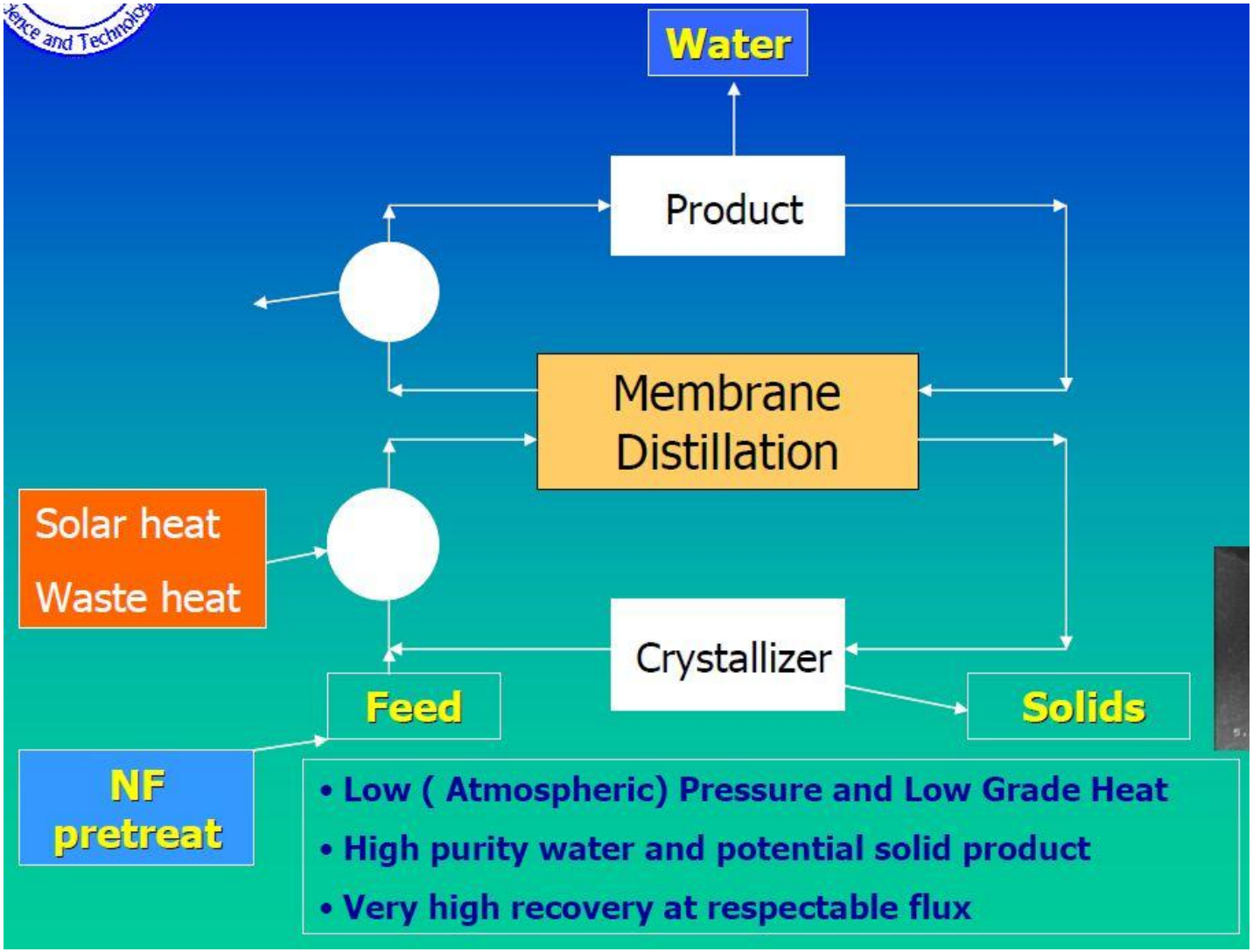
Future trends – New generation RO



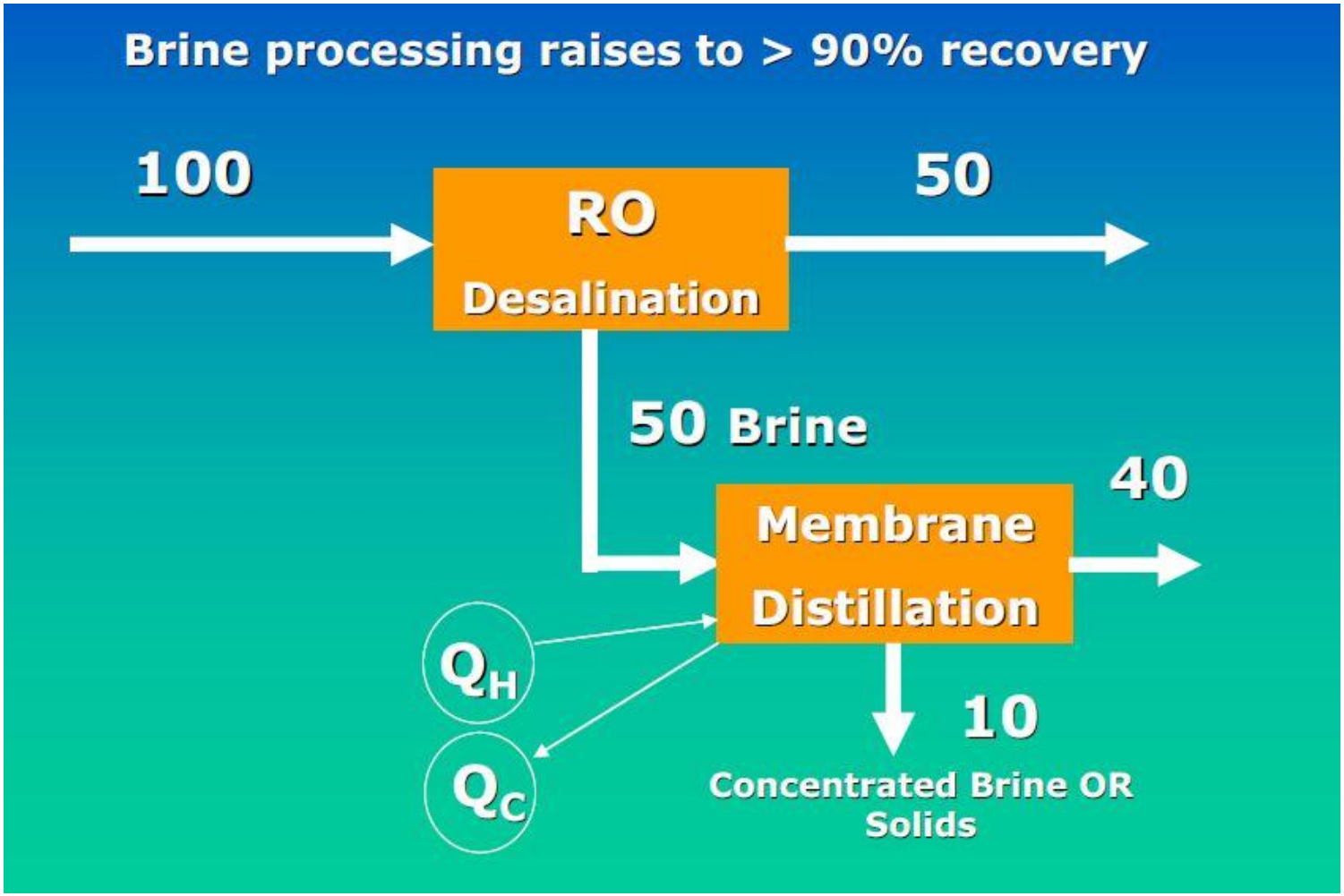
Future trends – Forward Osmosis



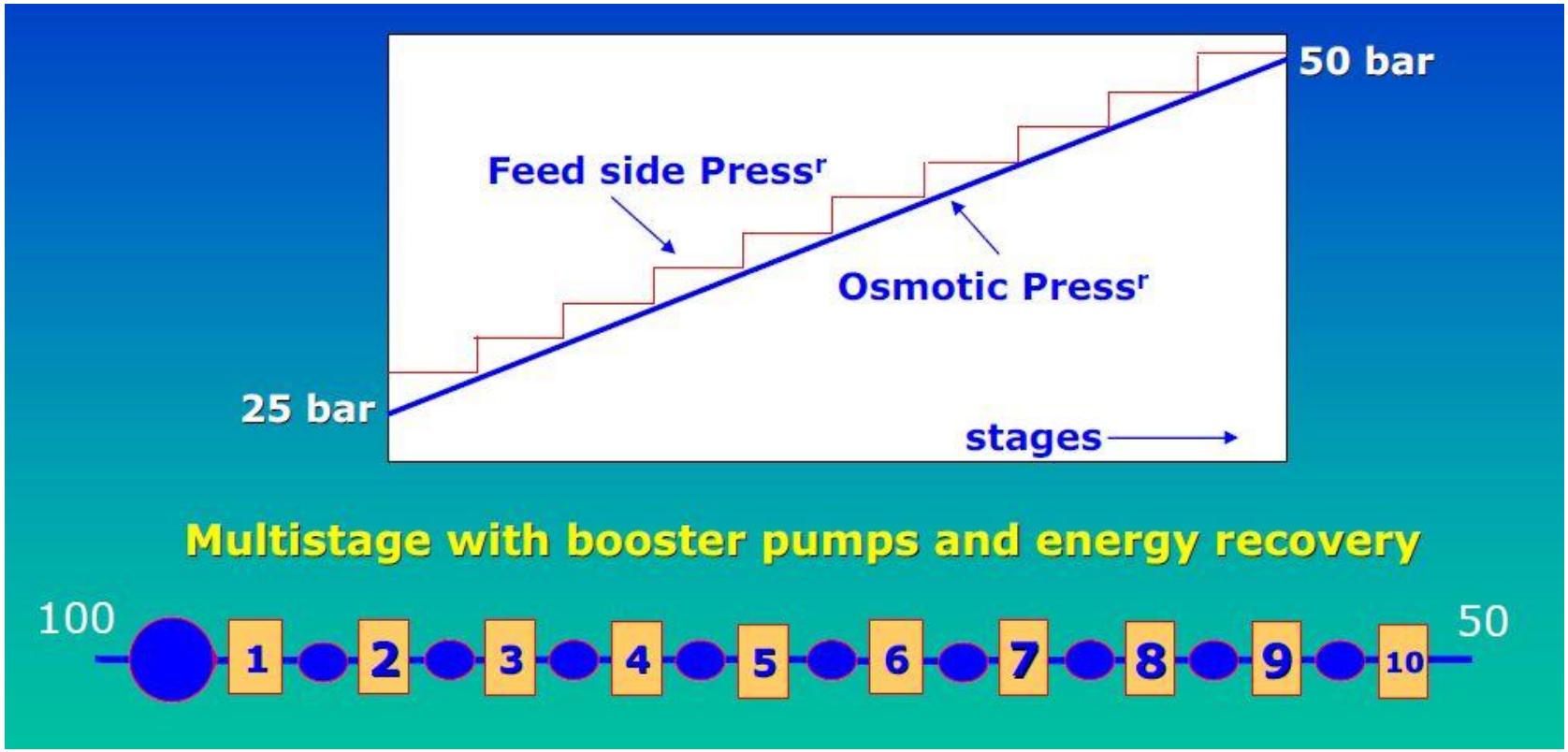
Future trends – Membrane Distillation



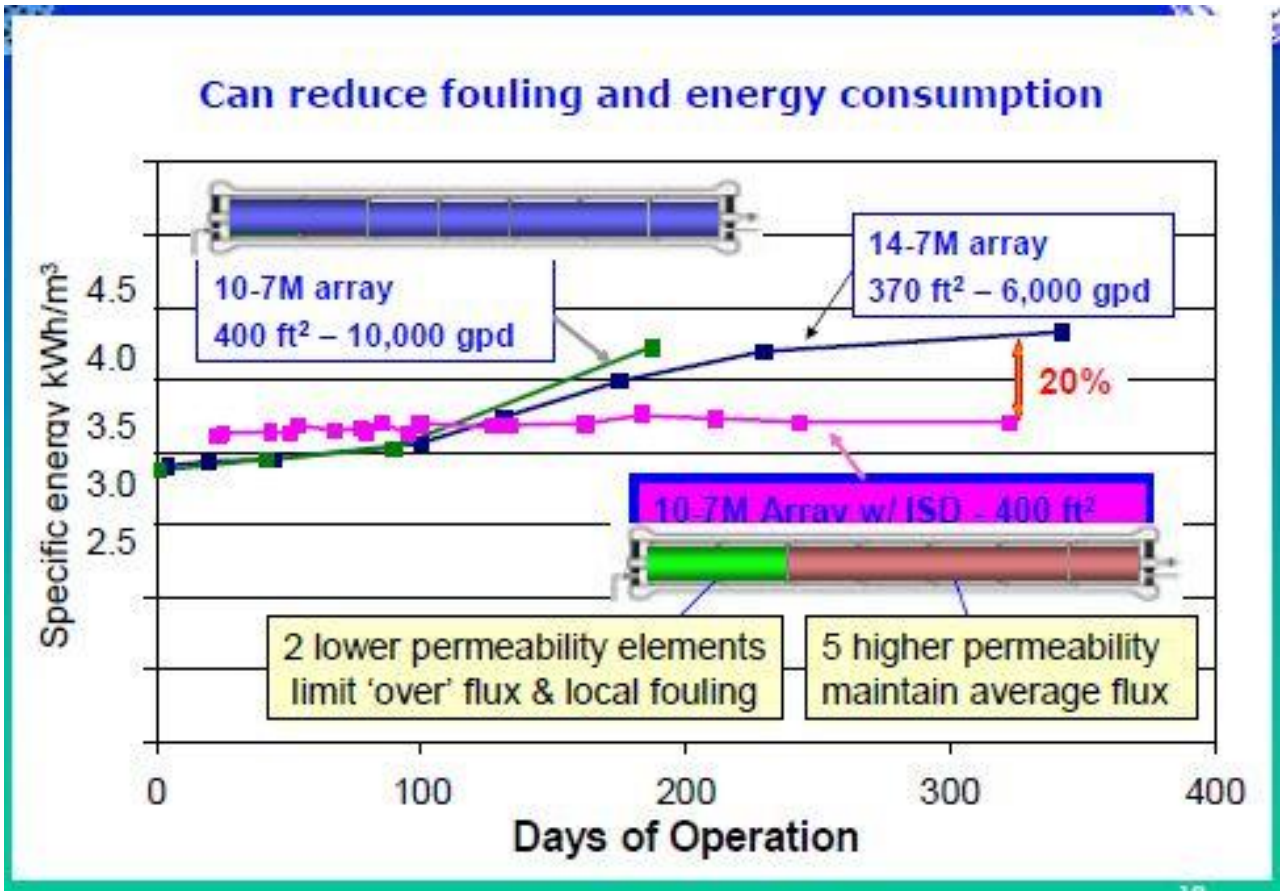
Future trends – Membrane Distillation



Future trends – Energy efficient RO



Future trends – Energy Efficient RO



Future trends – Acknowledgements

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