



Evaporative Processes in WaterTAP

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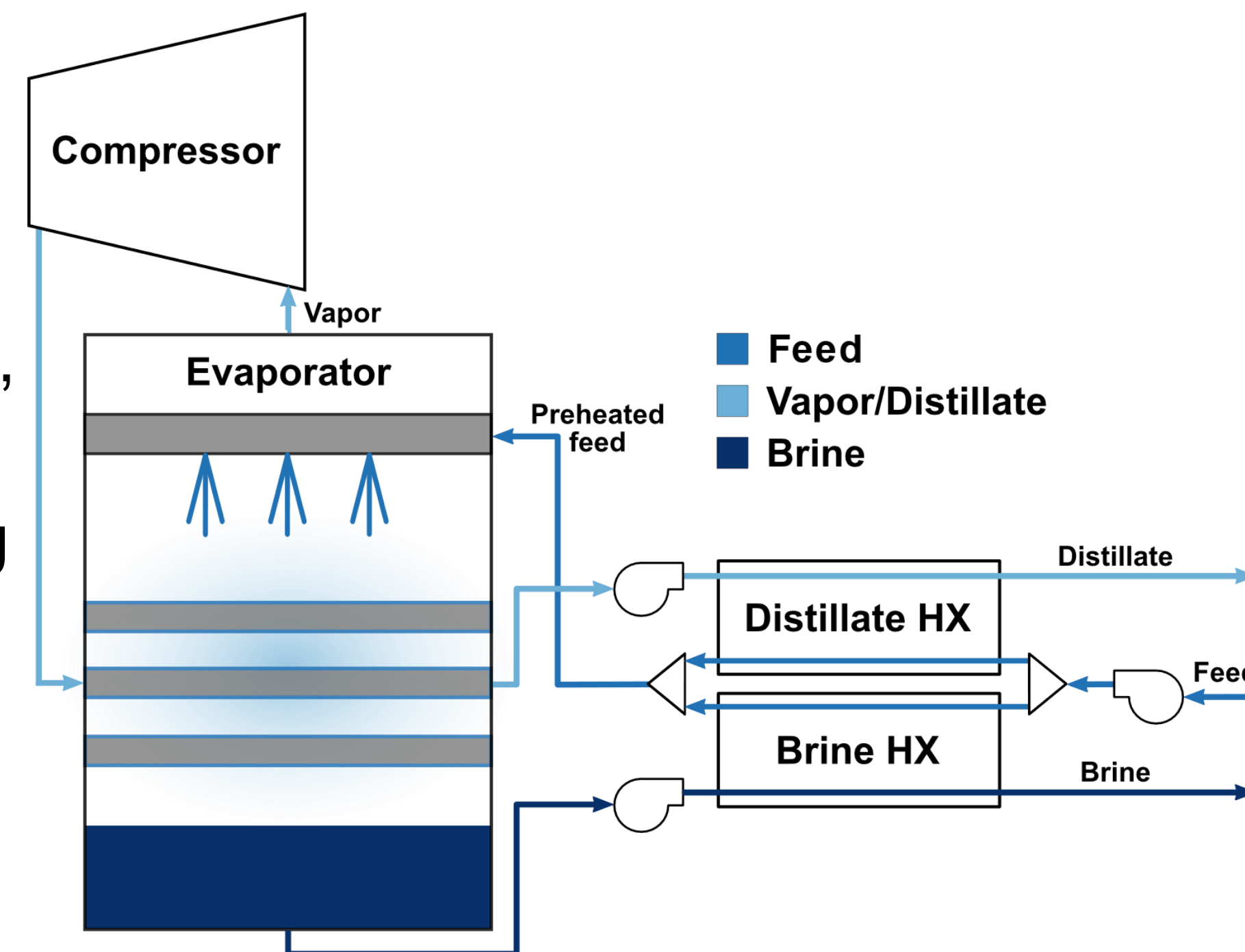
Mechanical Vapor Compression

Motivation: mechanical vapor compression (MVC) is an efficient and electrified thermal desalination process that can achieve high water recoveries

Unit models: preheater heat exchangers, evaporator, compressor, and condenser

Key properties: vapor depression/boiling point elevation in evaporator, vapor properties for the compressor and condenser

Additional configurations: multi-stage, brine recirculation



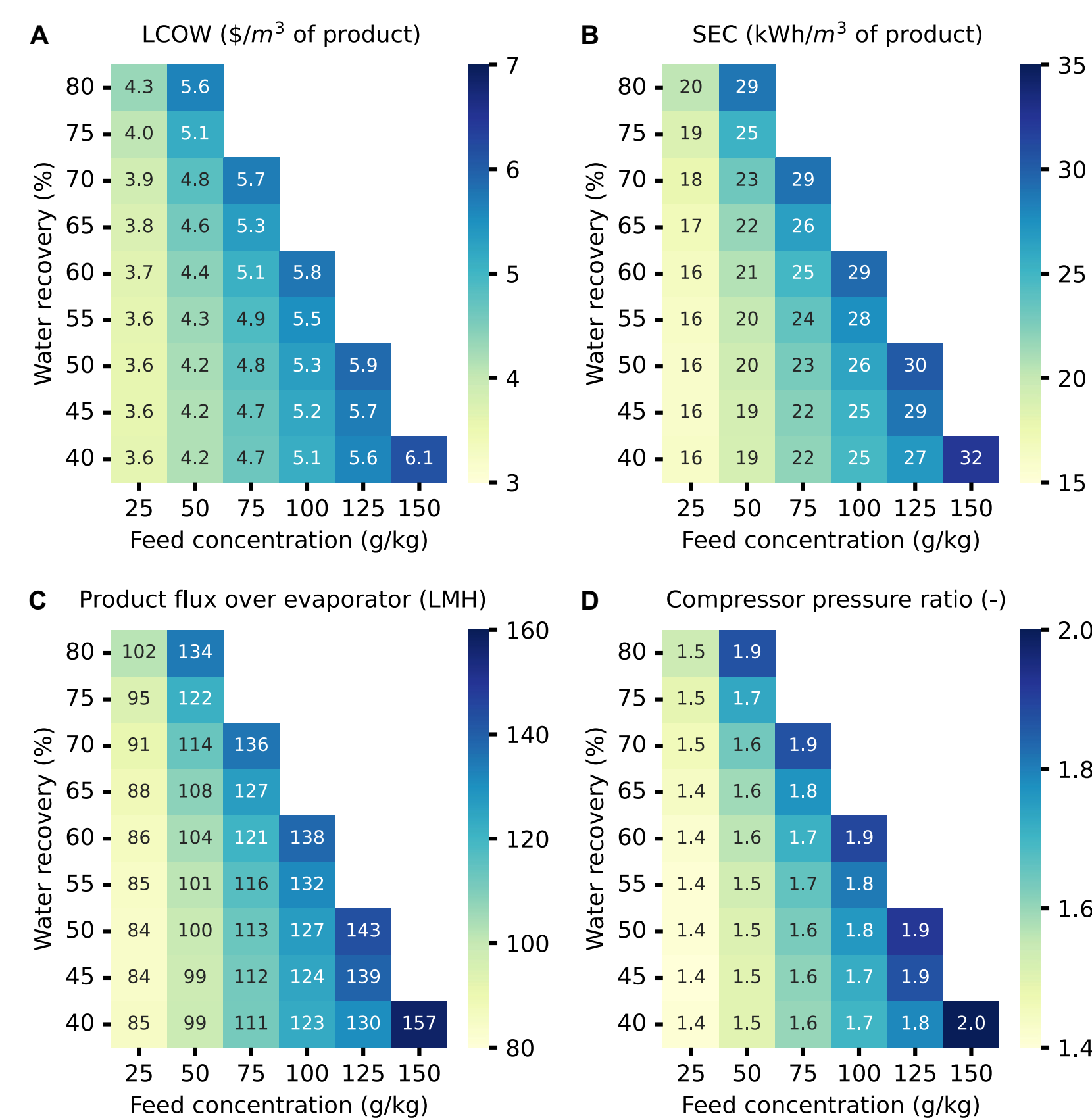
Cost-optimization of MVC treating seawater

Costing: evaporator material factor is a linear function of the brine salinity to reflect increased cost of corrosion and scaling resistant materials

Input parameters: evaporator and preheater overall heat transfer coefficients, compressor and pump efficiencies, maximum evaporator temperature (75°C shown)

Decision variables: preheater areas, evaporator area, evaporator temperature and pressure, compressor pressure ratio

Results: LCOW, SEC, product flux per evaporator area, and pressure ratio



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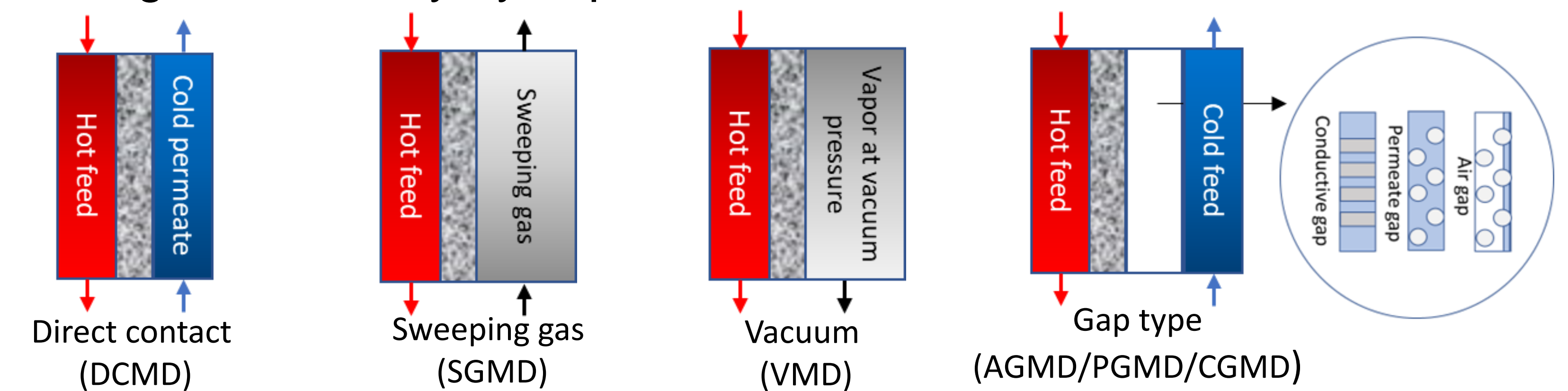
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Membrane Distillation

Process overview: Membrane Distillation (MD) leverages the temperature gradient-induced vapor pressure differential across a hydrophobic membrane.

MD configurations vary by vapor collection and condensation method:

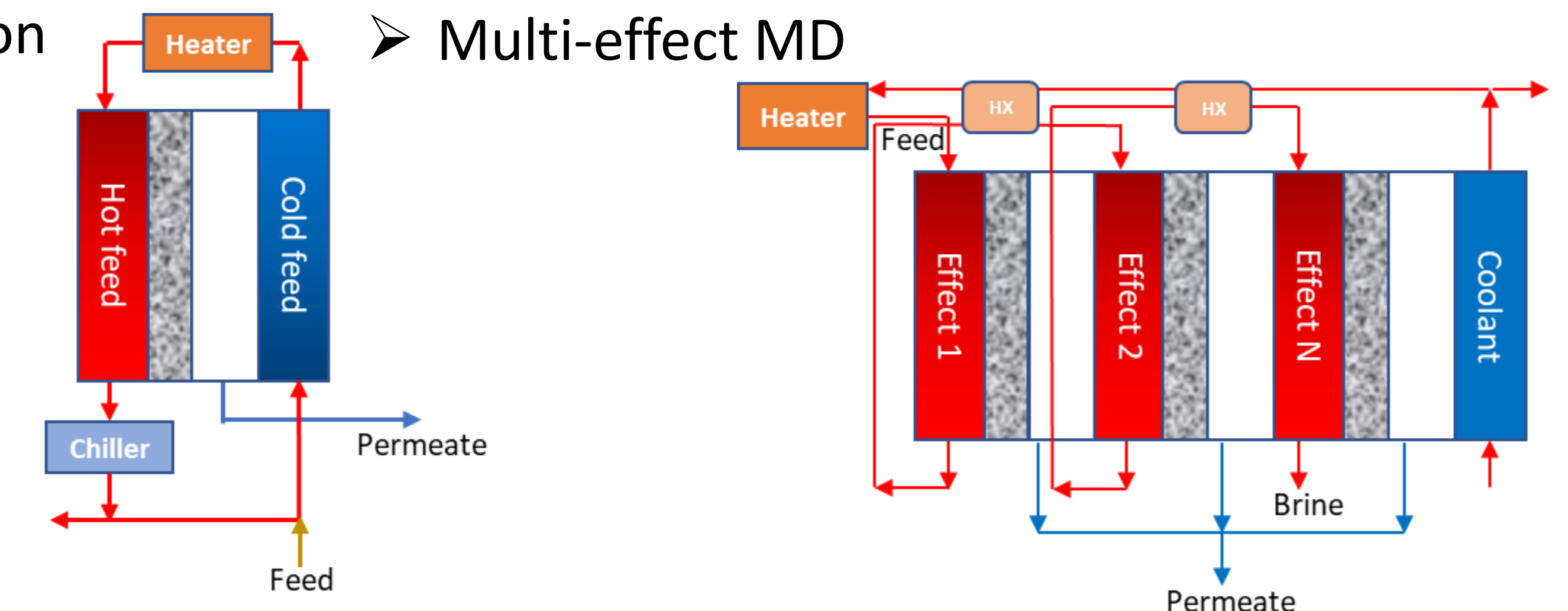


Membrane Distillation Operation Modes

Single pass recovery in MD is typically low. Methods to enhance Recovery:

➤ Brine recirculation

➤ Multi-effect MD



*The single-pass DCMD model is currently available in WaterTAP, with other configurations and operation modes still in development.

Membrane Distillation Modeling Approach

➤ 0-D: Module behavior via inlet-outlet properties

➤ 1-D: Finite difference discretization-lengthwise

➤ Boundary layer modeling:

➤ Concentration and temperature polarization

➤ Core mass/energy balance equations:

▪ Vapor flux

$$J = B(P_f - P_p) \text{ and } q_v = h_{fg}J$$

▪ Conductive heat

$$q_m = \frac{k}{\delta}(T_{fm} - T_{pm})$$

▪ Convective heat

$$q_f = h_f(T_f - T_{fm}) \text{ and } q_p = h_p(T_{pm} - T_p)$$

