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McIlvaine Hot Topic Hour
Evaporation and Crystallization of FGD Wastewater

September 3, 2009

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Innovative Process Solutions
*Utilizing **Evaporation** & **Crystallization***
as Core technologies

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ZLD for FGD as practiced today

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A2A S.p.A. (formerly Endesa Italia)

- Monfalcone Power Plant, Italy
- 336 MW Coal-Fired w/ LSFO Scrubber (MHI)
- ZLD Operational Summer 2008
- Dry Cake for Landfill Disposal

Lime-Soda Softener

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Three Major Unit Operations

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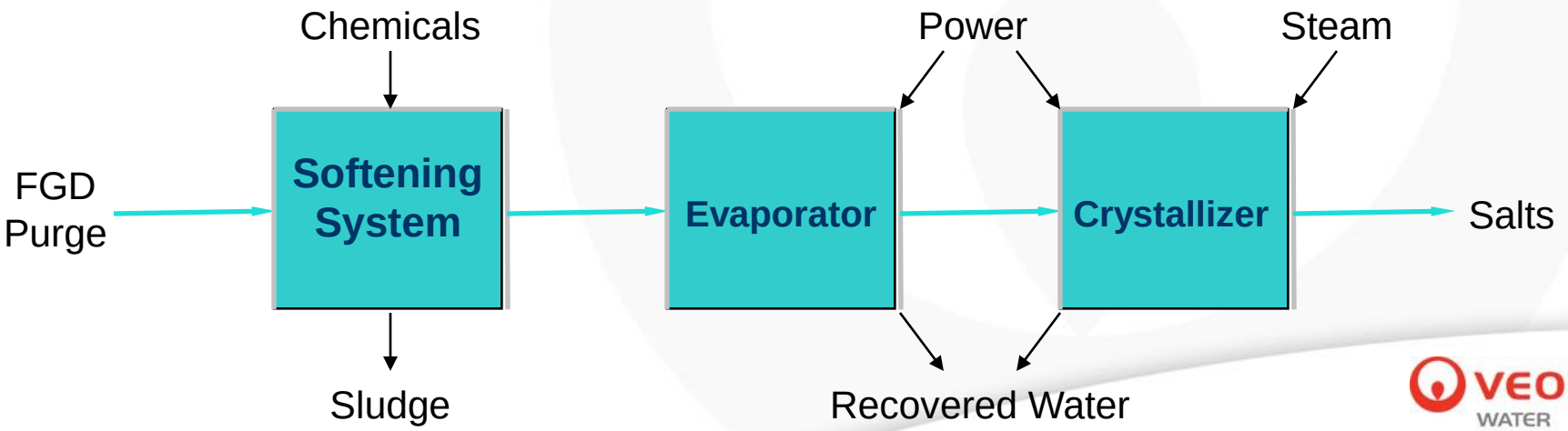
- A Softening System to reduce the overall solids and hardness content down to a level that is manageable for the evaporation system.
- A Falling Film Evaporator (MVR) to remove the major portion of water from the FGD purge stream.
- A Crystallizer (usually steam, can be MVR) to finish the process by removing the remainder of the water.



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Requires chemicals, power & steam, produces sludge

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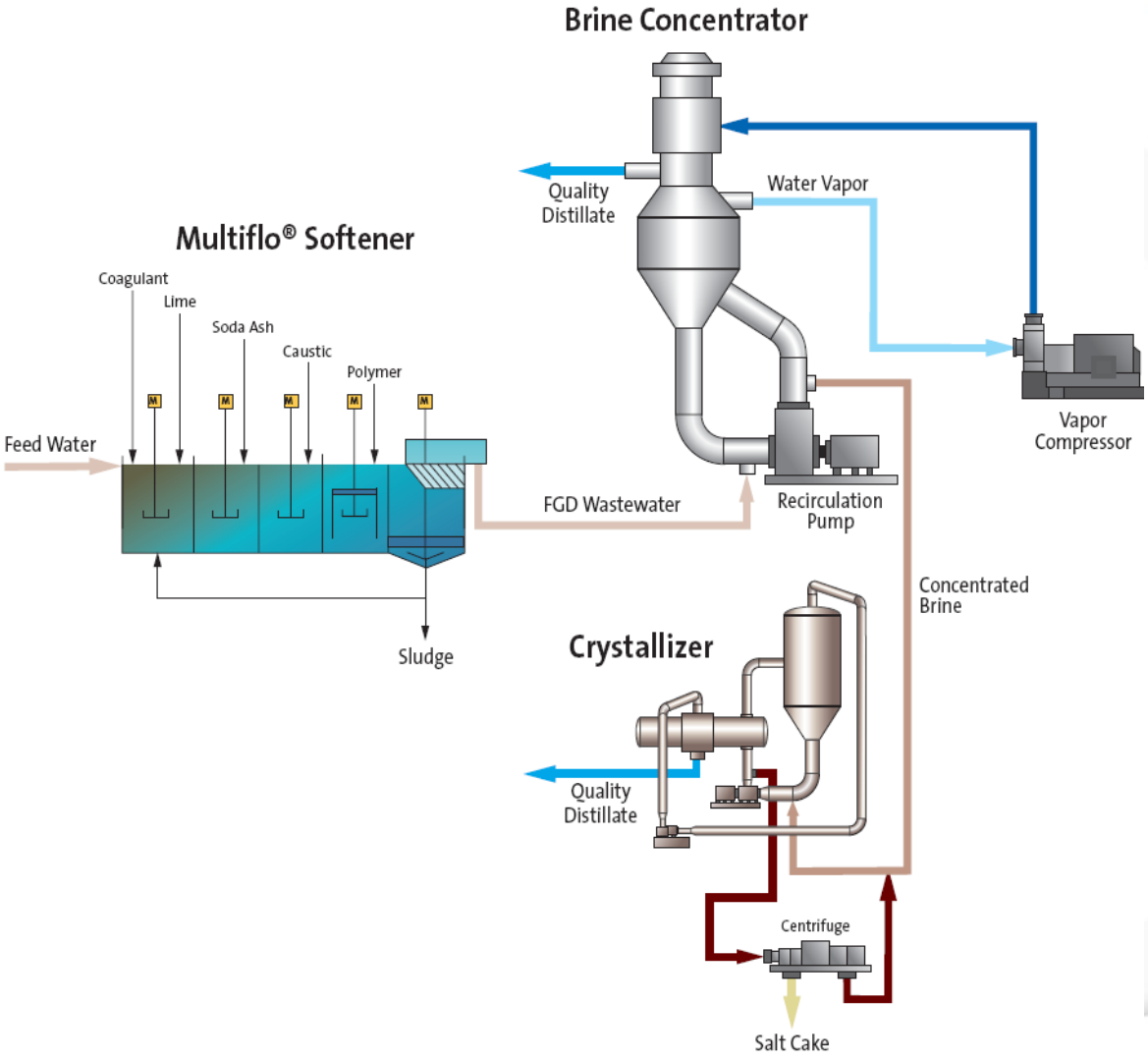

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Softening aids crystallization

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Softening FGD wastewater with lime and soda ash substitutes sodium ions for most of the calcium and magnesium ions.

CaCl2 and MgCl2 have very high solubility – difficult to crystallize out. Softening changes the chemistry of FGD wastewater to NaCl, which crystallizes easily.

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Softening Reactions

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- $Mg^{+2} + Ca(OH)_2 \longrightarrow Mg(OH)_2\downarrow + Ca^{+2}$
  (lime) (sludge)

- $Ca^{+2} + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2\ Na^{+1}$
  (soda ash) (sludge)

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FGD ZLD Current Practice

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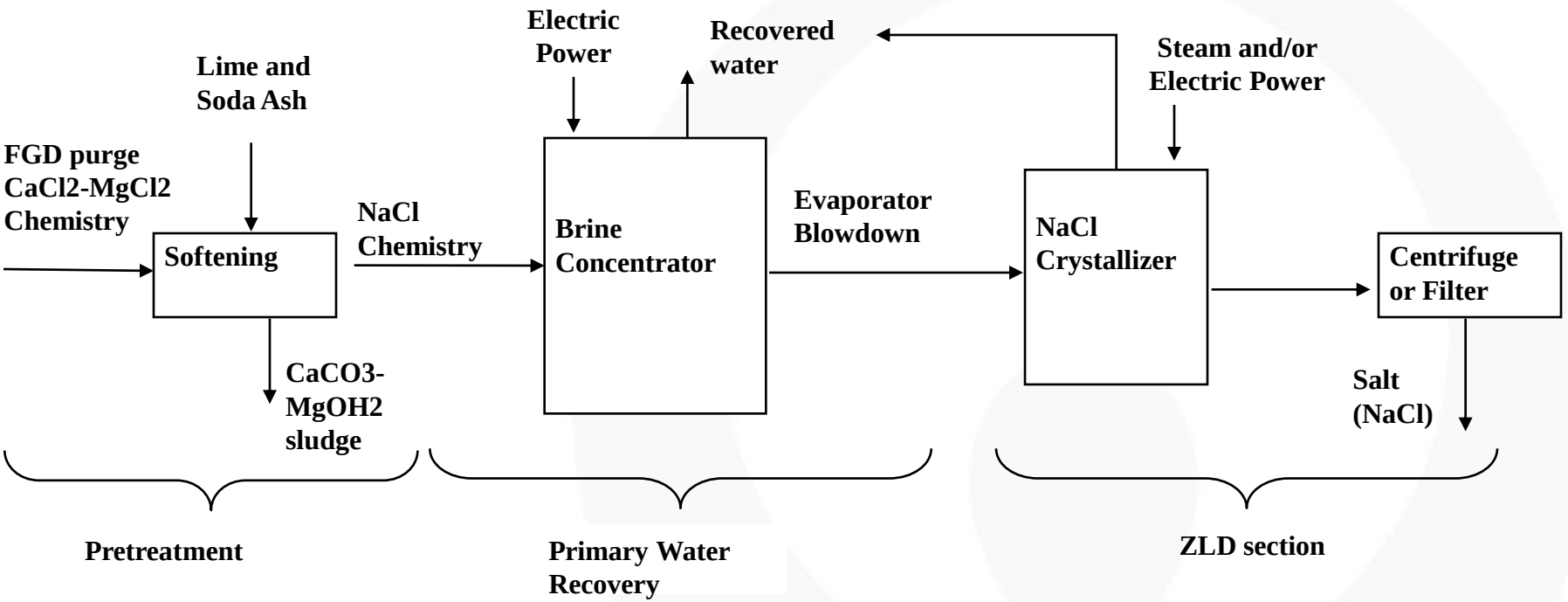
Soften the FGD purge - create a NaCl based chemistry



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What's new?

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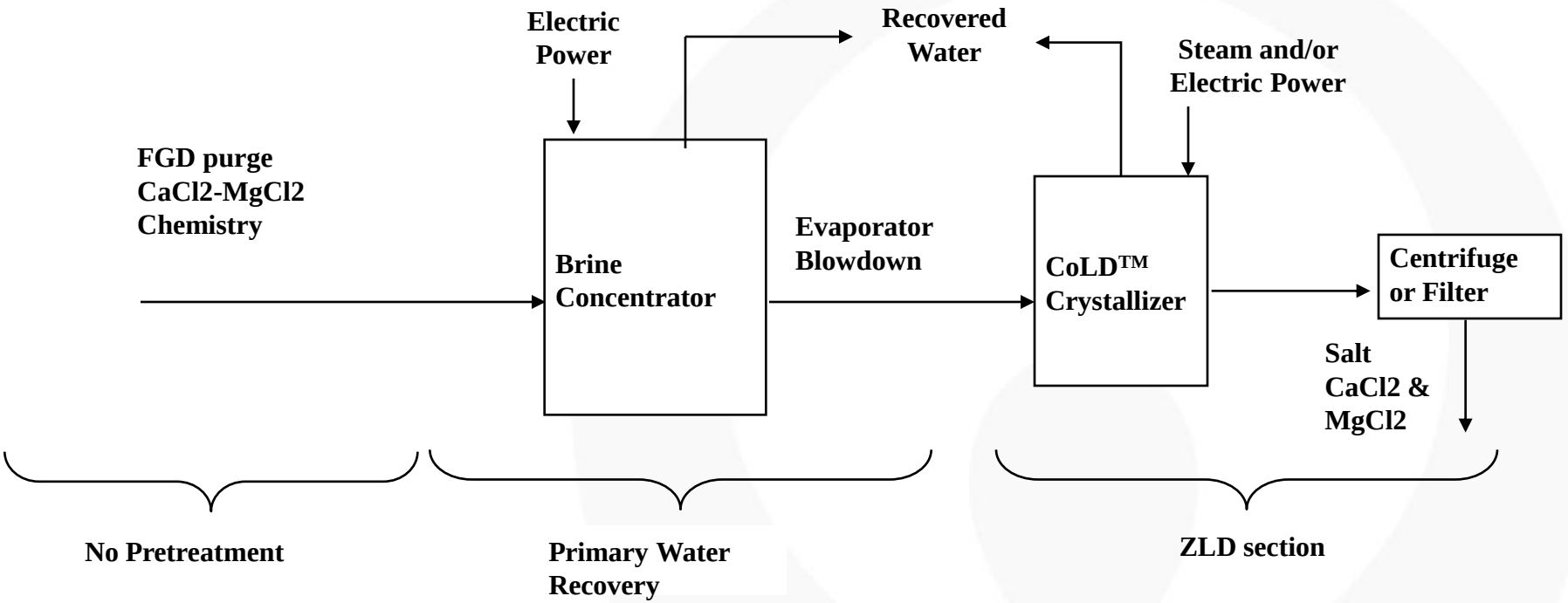
No pretreatment –
Crystallizer based on industrial $CaCl_2$ production



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Requires power and/or steam, no chemicals, reduced sludge

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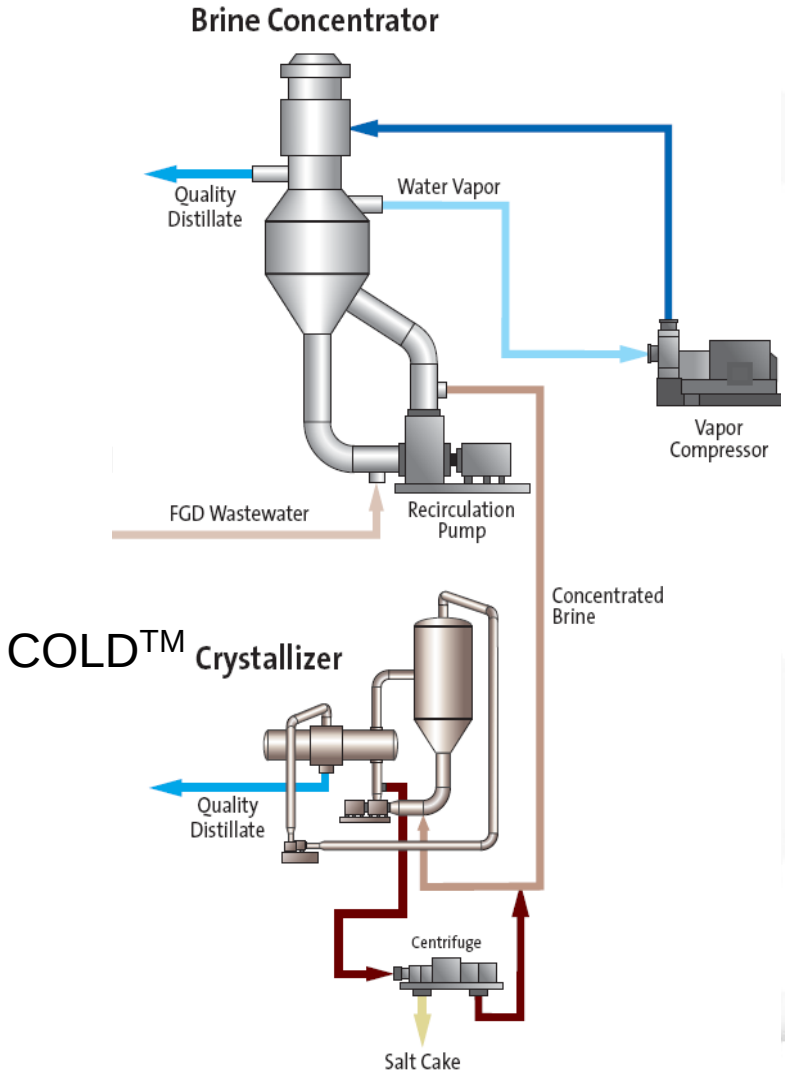

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Two Options for Evaporation of FGD Wastewater

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- Option 1: Pretreat FGD Wastewater Using Lime-Soda Ash softening
  - Replace Ca and Mg with Na
  - Chemistry is based on NaCl
- Option 2: Evaporate FGD Wastewater Directly
  - Chemistry is based on $CaCl_2$ and $MgCl_2$

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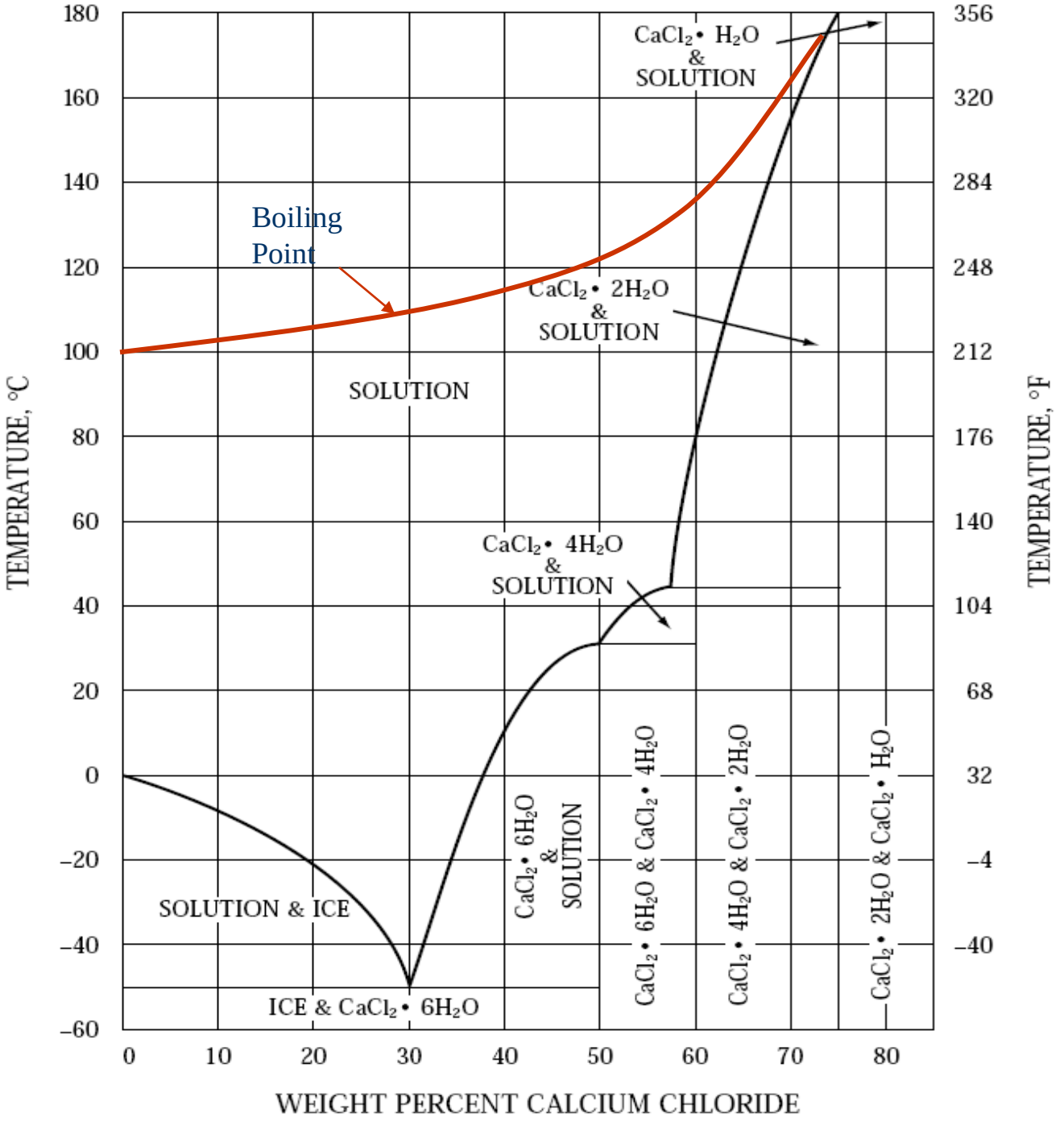
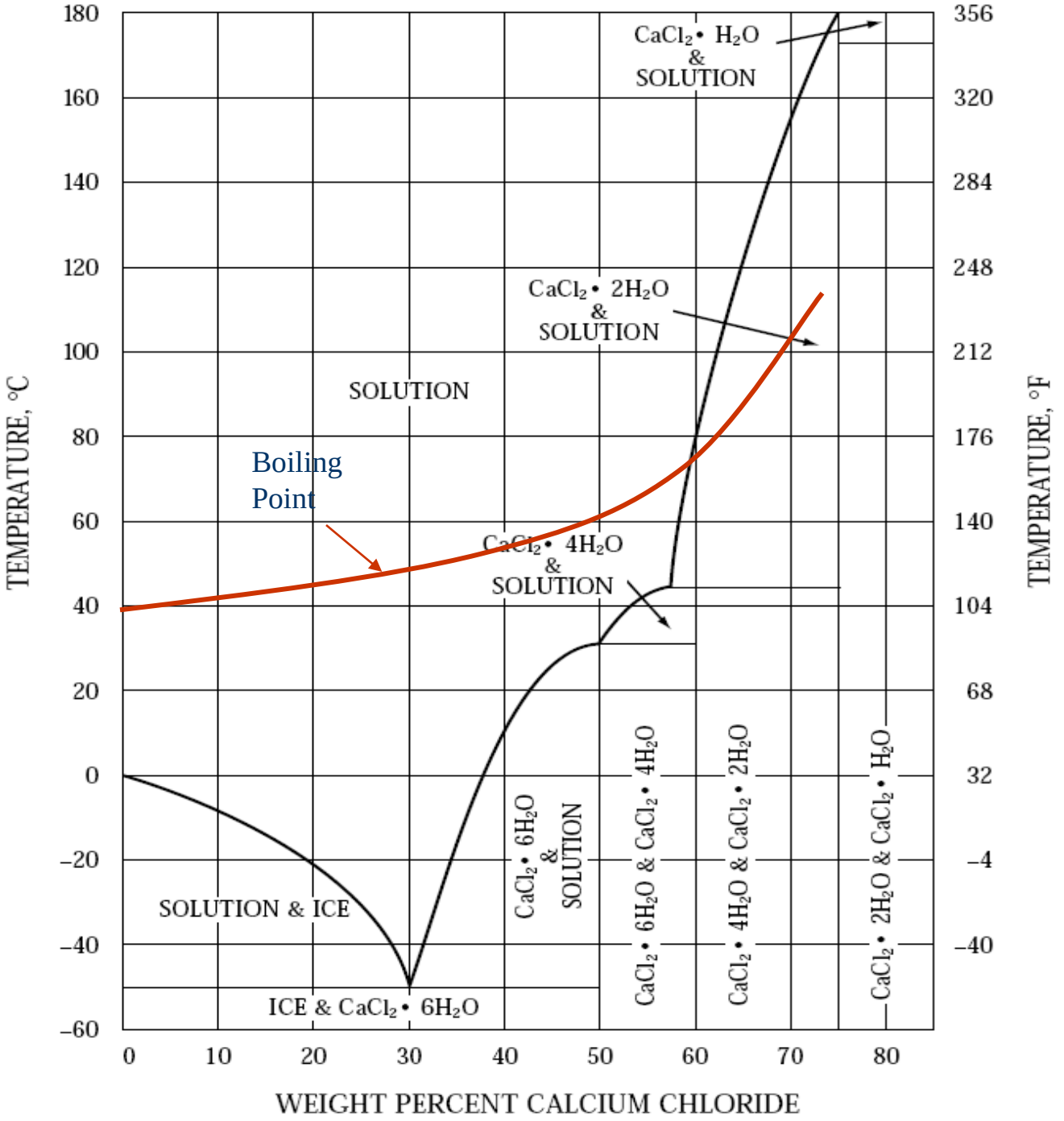
At atmospheric pressure, the boiling point curve chases the solubility curve



By lowering the pressure, the boiling point is lowered and a solid phase can form



CoLD™ Process

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Crystallization

of high solubility salts at

Low Temperature and

Deep Vacuum

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What is the CoLD™ Process?

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- A conventional forced circulation crystallizer fitted with a vacuum system
- Energy for evaporation can be provided by a conventional indirect heat pump, using a refrigerant fluid.
- Alternately, energy for evaporation can be provided by steam, and low temperature sink can be provided by chilled water.
- Low operating temperature lowers the solubility of the dissolved salts, so they crystallize at a lower concentration.
- CoLD™ Process suited for waste streams containing highly soluble salts (e.g. FGD and IGCC blowdown, produced water, landfill leachate)

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Steam Driven CoLD™ Crystallizer

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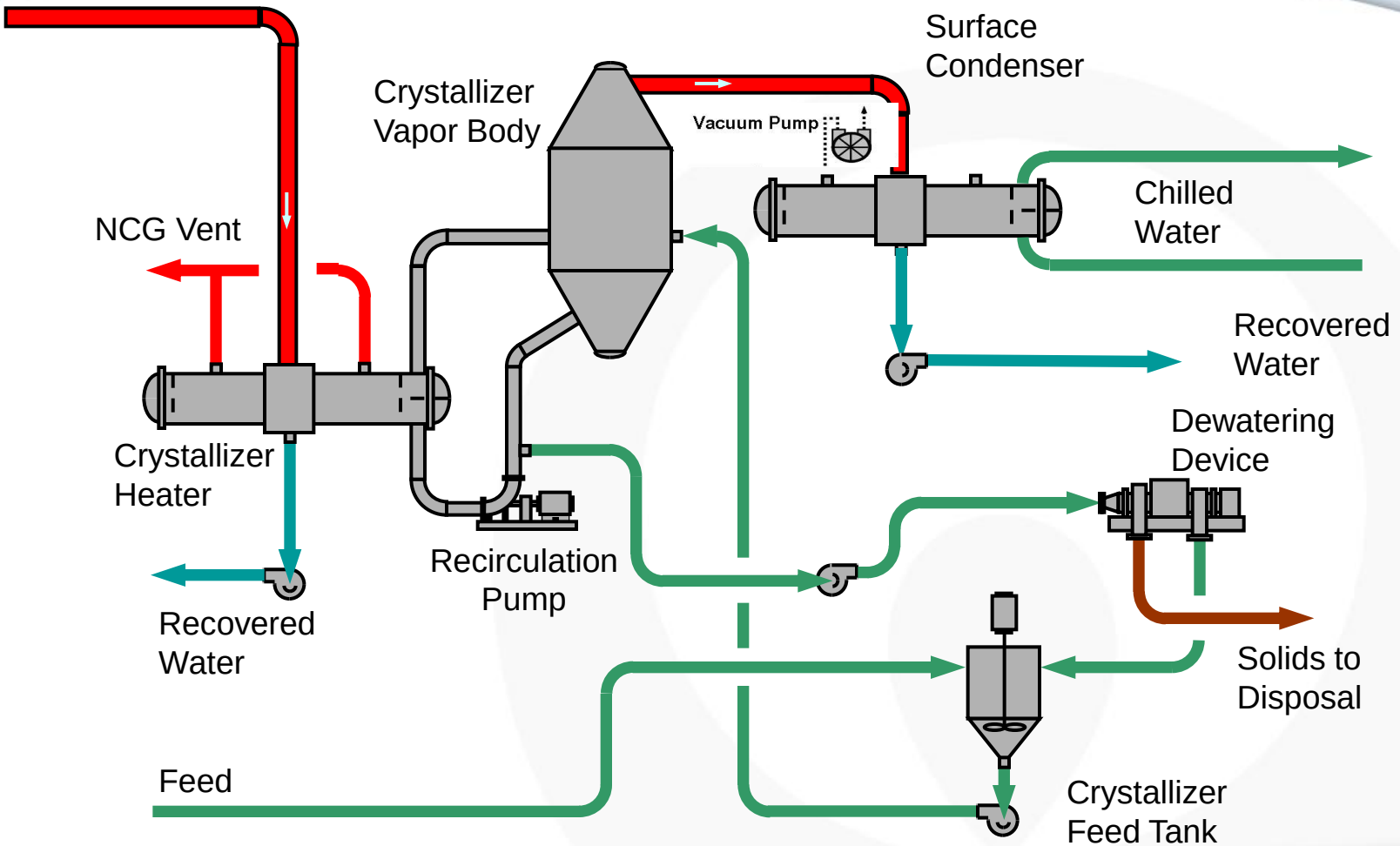

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Indirect Heat Pump CoLD™ Crystallizer

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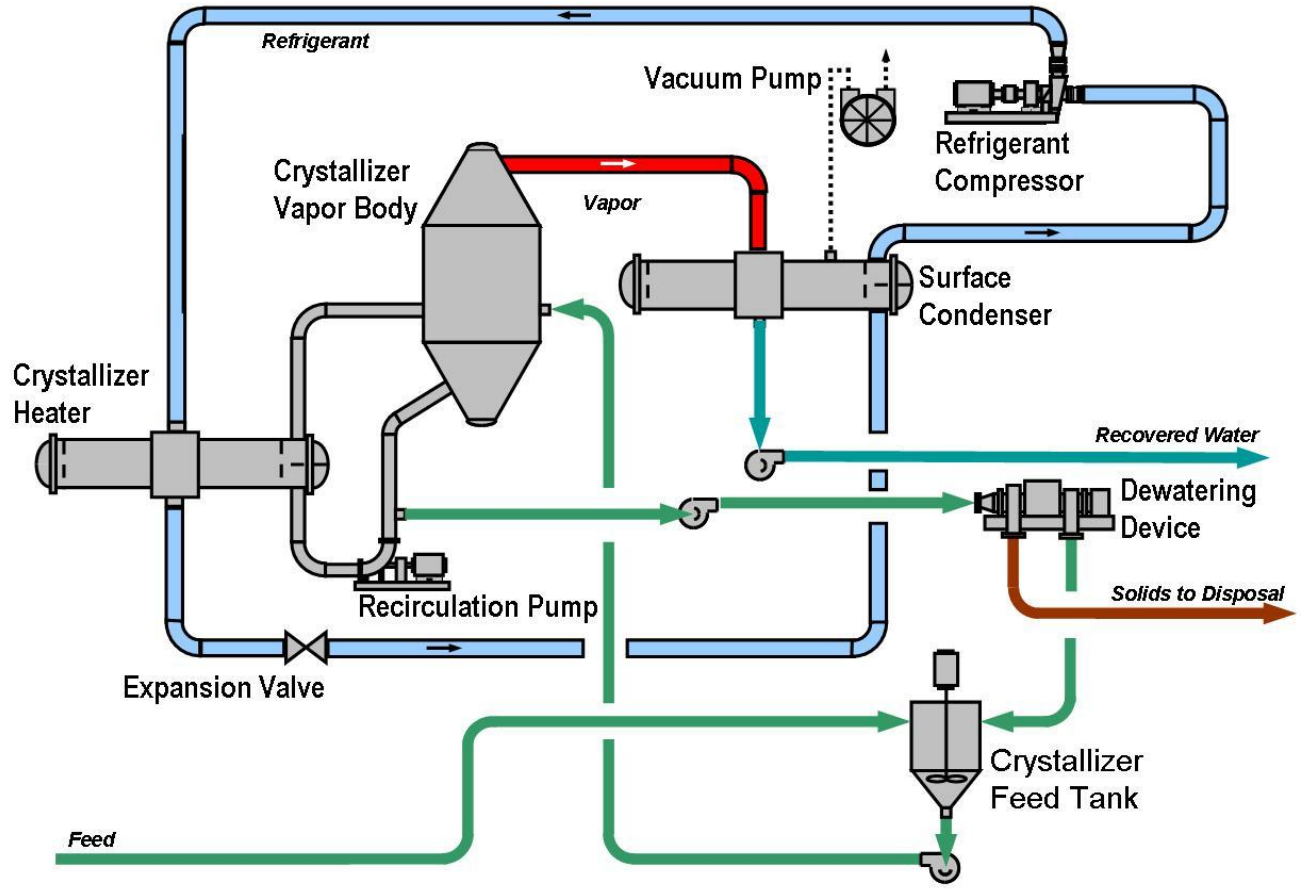

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Advantages of New HPD Process

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- No softening required => No chemicals required, no sludge produced.
- A stable, solid product is produced directly using only electric power.
- Chemical costs are eliminated and solids disposal costs are greatly reduced.
- Energy costs are still low.
- Complexity and footprint of equipment are greatly reduced.
- Materials of construction can be reduced

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Result of CoLD™ Process ZLD

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Economic comparison of FGD ZLD Options

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Facility Comparison

- ZLD #1: 350 gpm capacity, Softening, Evaporator, Crystallizer
- ZLD #2: 350 gpm capacity, Evaporator, CoLD™ Crystallizer

Economic Comparison

	ZLD #1	ZLD #2
Cap - Amor	$5.4MM	$5.4MM
O&M	$2.8MM	$2.8MM
Chemicals	$6.3MM	$250k
Disposal	$4.5MM	$1.0MM
Energy	$1.8MM	$2.3MM
Total Opex	$15.4MM	$6.4MM
Net Annual Cost	$20.8MM	$11.8MM
$/gal	$0.125	$0.071

NPV savings of $88MM over 15 yrs at 7% discount rate

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Thank You

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