The MBD™ System

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WATER TECHNOLOGIES

Veolia: the leader in environmental solutions

VEOLIA

The **only company** in the world able to cover the entire range of environmental solutions

$25.7 billion
163,000 employees

Activities:

Water

The global benchmark for water services and technologies

Energy

The global benchmark for energy optimization

Waste Management

The global benchmark for waste management and **resource recovery**

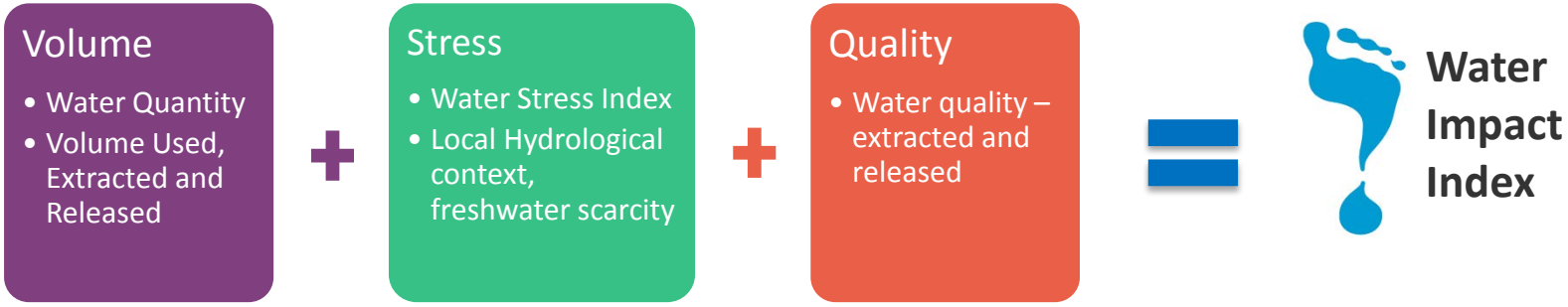
Veolia – Water Impact Index

Understanding and quantifying the impact on water resources is essential to maintain the sustainability and future prosperity of the planet: there is no substitute for water.

Are we operating within our Social License?

- ***No matter how much we believe in our project, we cannot self ascribe Social License. Trust must be earned and granted by the community of stakeholders***
  - ***Do we have broad stakeholder acceptance within the community?***
  - ***Does the project have legitimacy and credibility?***

Veolia evaporator technology represents a credible response to the increasing problem of water shortage and waste mitigation through water reuse and recycling.



Water Impact Index expands on existing volume-based water measurement tools by factoring in three essential elements: quantity of water used, level of stress upon water resources and overall water quality. It provides additional parameters needed to make informed choices about effective water management.

MBD - What is it?

Application of the technology depends on treatment objectives.

- *Robust design, forced/plug flow circulation*
- *Bulk handling of solids*
- *Standardized modular design, +/- 2000 bpd*
- *Semi-permanent*
- *Heat recovery*

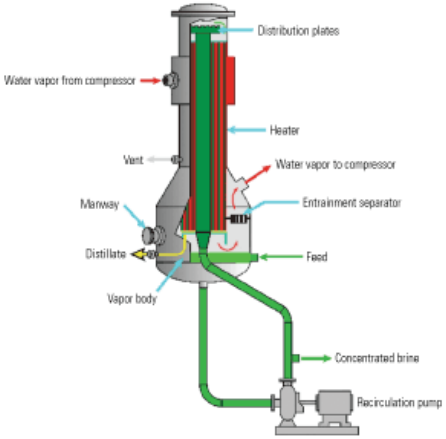
What it is not

- *Segregated salts*
- *Custom design*

The process begins with an analysis of the influent water and discharge specification. Pretreatment and emission recovery options expands application of the standard modular design.

Evap/ Crystallizer Variations

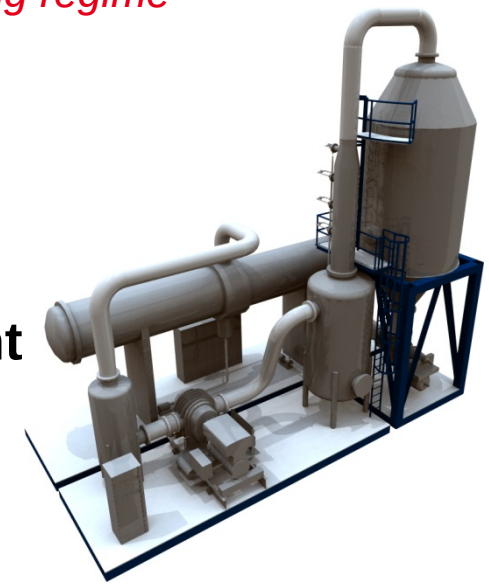
Type	Technical Design	Objective
Direct Contact	Utilize waste heat	Reduce Vol, min CapEx, higher OpEx
MVR	Falling film, distillate recovery	Higher CapEx, Lower OpEx via energy recovery
MBD	Forced flow, distillate recovery	Higher CapEx, Lower OpEx via energy recovery
Spray	Latent heat, low volume	Reduce Vol, very low CapEx, higher OpEx



MBD™ System – Environmental Considerations

Regulatory Compliance - Local, state and federal jurisdictions define MINIMAL siting, construction and operational standards.

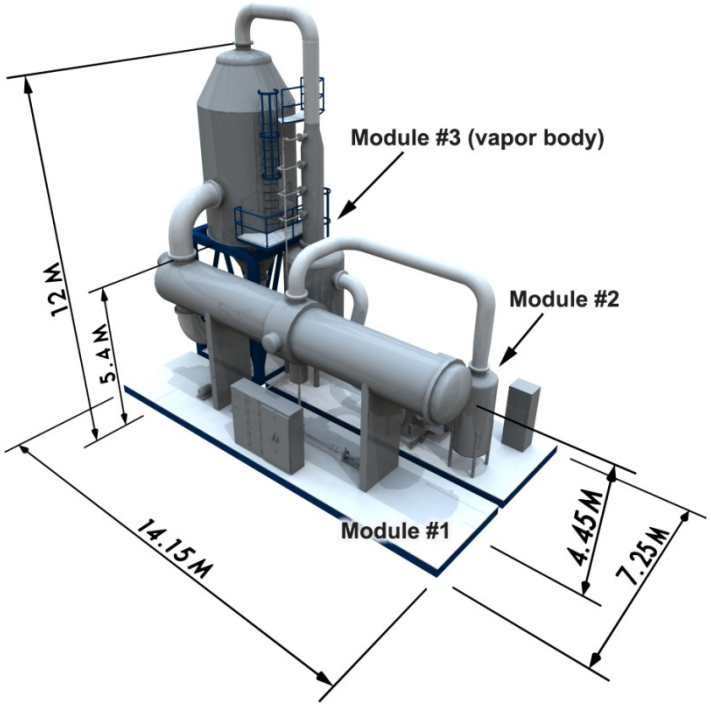
- **Influent and Effluent Evaluation**
  - *Influent quality defines system pretreatment and operating regime*
    - Materials of construction, VOCs, resource recovery
  - *Effluent management defined by*
    - Toxicity in gas (VRU), liquid and solid
    - Resource recovery
- **Site access: human, wildlife and containment**
- **Environmental and Community Benefits**
  - Reduced truck traffic
  - Opportunity for resource recovery or minimization – water/ salt
  - Transport fresh water versus salt water
  - Reduce disposal well volumes
  - Support fresh water management
  - Alternate frac water supply



MBD™ System – Brine Crystallizer System

Modular Bulldozer Design – CSG Produced Water

- **Modular Evaporation System**
  - *Supplied as (3) modules*
  - *Can be shipped by over-the-road transport*
  - *Rapid deployment, ability to relocate*
  - *Small footprint design*
  - *Mixed salt management supplied as skid*
- **Robust, Forced Circulation "Bulldozer" Design**
  - *High-efficiency, MVR driven*
  - *Capacity: 60 gpm*
  - *Scaling-resistant design*
  - *Corrosion resistant materials of construction*
- **Applications**
  - *Pond volume reduction*
  - *Eliminates need for new ponds*
  - *Pilot well testing*
  - *Zero Liquid Waste (ZLW) capabilities*



MBD™ System - Brine Crystallizer System

- **Ability to Treat Variable Feed Water Qualities or Feed Sources**
  - *Robust Forced Circulation design reduces concerns with scaling and corrosion*
  - *Can be moved to new sites with little modification*
  - *Reduces need for complex pretreatment*
- **Advantages**
  - *Modular system reduces transportation and installation costs*
  - *Significantly more cost effective than additional ponds*
  - *Eliminates additional costs of pond remediation*
  - *Environmentally friendly solution*
- **Risk Mitigation for CSG Sites**
  - *Mechanical solution for adverse rainfall conditions*
  - *Evaporation reduces EPA and local community concerns*
  - *Surety against project delays*

Challenges expanding Evap

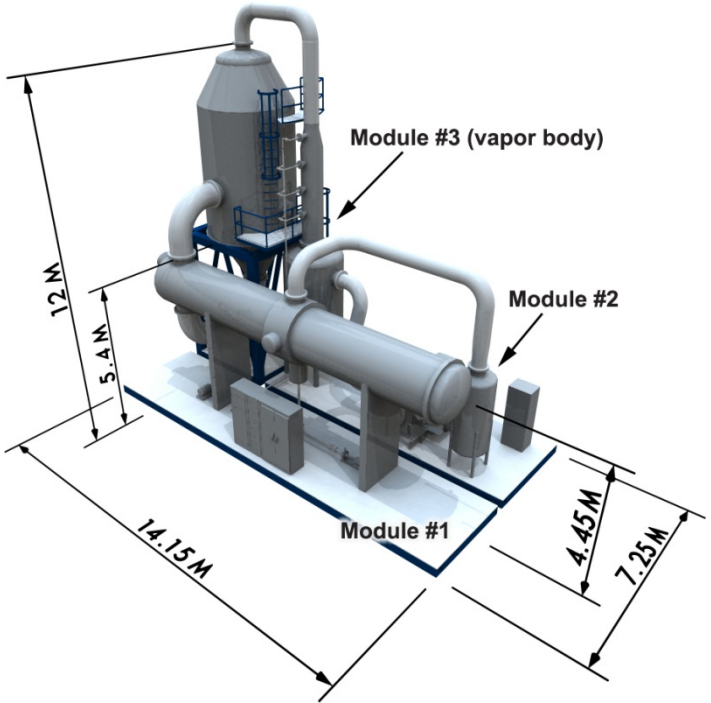
- Water quality can be too good
- Crystallization is energy intensive
- Liability of effluent steams (liquid/solid)

MBD™ System - Brine Crystallizer System

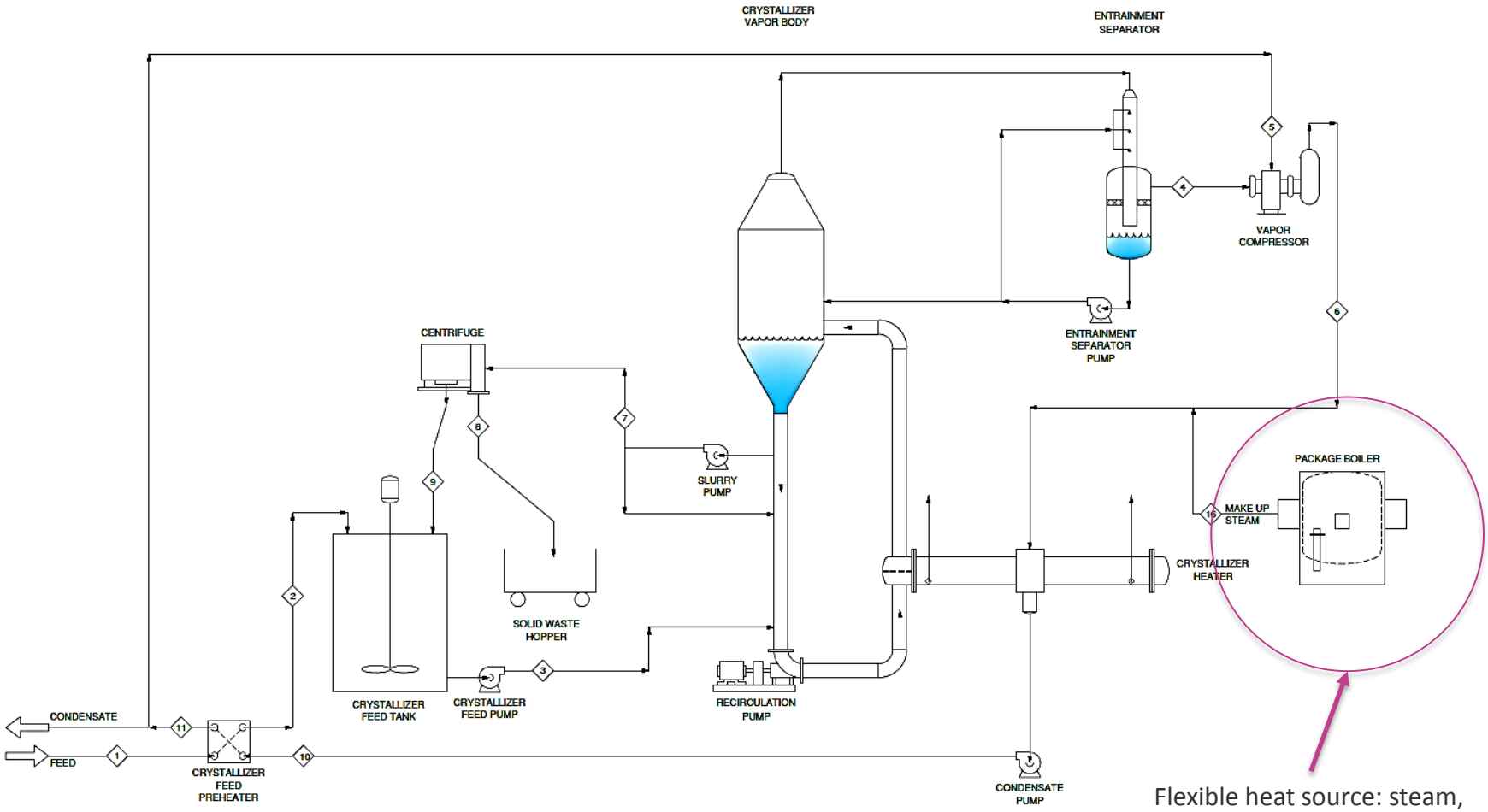
System Modules and Components

Components	Description
Module #1	Heater/heat exchanger
Module #2	Blower/compressor
Module #3	Crystallizer vapor body
Skid	Centrifuge / filter press

Ancillary Equipment Included	
Platforms and decking	Pumps
Instrumentation, control panels	Insulation
PLC and motor starters	Piping
Electrical, wiring	Valving



MBD™ System - Brine Crystallizer System



Simplified flow diagram

Flexible heat source: steam, electric, MVR, field gas, waste heat

MBD™ Design Advantages

- Can handle large quantities of suspended solids without plugging
- No internal distributors prone to plugging
- No areas where flow is slow or stagnant
- No need for clarification or filtration before evaporator
- No need for seeding since silica will precipitate in the flash tank, not as scale in the tubes

95%

Recovery in the Bulldozer Evaporator

Thermal Case Study

- Location: Canadian Oil Sands
- Treatment: SAGD Evaporator Blowdown Treatment
- Objective: (1) Volume Reduction to decrease off-site disposal cost
  (2) Increase water recycling for increased oil production

Case Study - Evaporator Blowdown Waste

Composite evaluations define influent quality and system design.

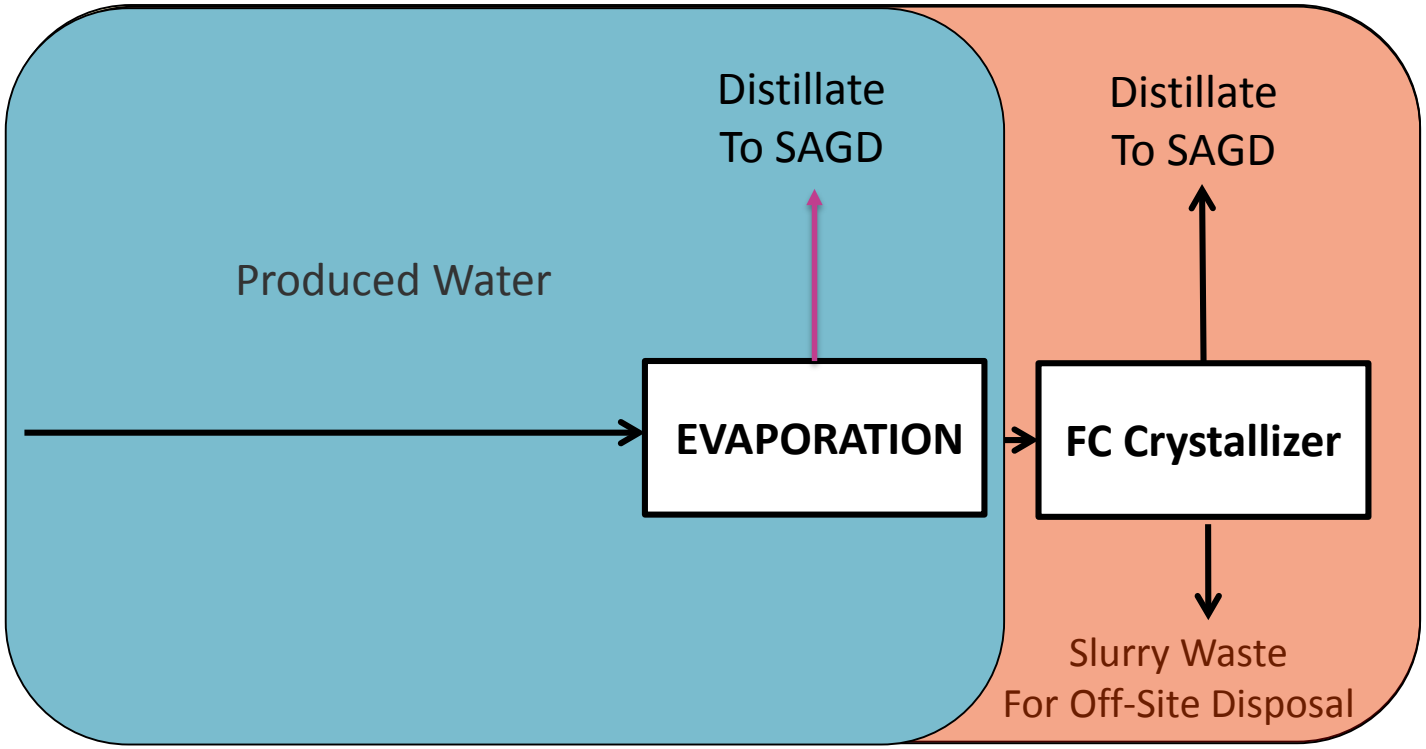
Table 1: Feed Design Chemistry

Component	Units	Design Composition
Temperature	°C	98 normal; 105 max.
Ca	mg/L	370
Mg	mg/L	20
Na	mg/L	50,500
K	mg/L	905
Al	mg/L	1.44
Sb	mg/L	0.12
As	mg/L	5.29
Ba	mg/L	19.6
B	mg/L	875
Cd	mg/L	0.00079
Fe	mg/L	7
Mo	mg/L	0.78
Se	mg/L	0.101
Cl	mg/L	50,000; 60,000 max.
NO_2	mg/L	795
SO_4	mg/L	532
F	mg/L	45
Br	mg/L	146
CO_3	mg/L	11842
SiO_2	mg/L	6,000; 9,000 max.
TIC	mg/L	2370
TDS	mg/L	109200; 135,000 max.
pH		12.6

Case Study - Evaporator Blowdown Waste

Parameter	Case	Comment
Capacity	1500 BPD waste from existing evaporator	
Technology Selected	Forced Circulation (FC) Evaporation	Forced Circulation required due to the bulk precipitation of NaCl when concentrated
Energy source	Electricity Compressor Driven Mechanical Vapor Recompression (MVR)	800 HP compressor
Water Recovery	80%	Concentrates feed up to 60% TS
Evaporator Blowdown	Off site disposal of 60% slurry	

Case Study - Volume Reduction



Economics:

300 BPD waste disposal

$12/barrel disposal cost

$110,000/month disposal cost

= $ 4.7 MM/year savings

Module Installation at Site

Final Installation

West Virginia, CoLD® Crystallization

Thank you for your kind attention

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