Not Just a Better Mousetrap:
Outside-the-Box Thinking in Concentrate Management

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Presentation Overview

- The Necessity of Desalination
- “Conventional” Concentrate Management
- The Problem of Contemporary Rodents
- Attributes of Innovative Strategies
- Case Studies
- The Future of Concentrate Management

The Necessity of Desalination

What water treatment applications require desalination?

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- Brackish groundwater
- Seawater

Obviously.

The Necessity of Desalination

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- Seawater
- Non-potable reuse

General recycled water for irrigation, industrial use, etc.

The Necessity of Desalination

What water treatment applications require desalination?

- Brackish groundwater
- Seawater
- Non-potable reuse
- Indirect potable reuse

OCWD Groundwater Replenishment System:

92 MGD

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The Necessity of Desalination

What water treatment applications require desalination?

- Brackish groundwater
- Seawater
- Non-potable reuse
- Indirect potable reuse
- Direct potable reuse

Coming soon in Texas…

•Colorado River MWD

•City of Brownwood

The Necessity of Desalination

What water treatment applications require desalination?

- Brackish groundwater
- Seawater
- Non-potable reuse
- Indirect potable reuse
- Direct potable reuse
- Saline surface water

Average TDS of Colorado River water imported to SoCal:

650 mg/L

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The Necessity of Desalination

What water treatment applications require desalination?

- Brackish groundwater
- Seawater
- Non-potable reuse
- Indirect potable reuse
- Direct potable reuse
- Saline surface water
- Produced water

Produced water salinity can exceed 400,000 mg/L

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Limiting Factors

Cost

Less an issue of *ability* to overcome as willingness to overcome

Concentrate

May not be feasible to overcome

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“Conventional” Concentrate Management

What are the five commonly cited management strategies?

Surface Water Discharge

Deep Well Injection

Evaporation Ponds

Land Application

Zero Liquid Discharge (ZLD)

“Conventional” Concentrate Management

“Conventional” Options
Surface Water Discharge
Deep Well Injection
Evaporation Ponds
Land Application
Zero Liquid Discharge (ZLD)

"Conventional" Concentrate Management

"Conventional" Options
Surface Water Discharge*
Deep Well Injection
Evaporation Ponds
Land Application
Zero Liquid Discharge (ZLD)

* Includes transfer to WWTPs

Issues / Limitations

- Environmental permitting
- Availability of suitable receiving bodies
- Impact on downstream water supplies

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"Conventional" Concentrate Management

"Conventional" Options
Surface Water Discharge
Deep Well Injection
Evaporation Ponds
Land Application
Zero Liquid Discharge (ZLD)

Issues / Limitations

- Environmental permitting
- Potential for inducing earthquakes

"Conventional" Concentrate Management

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Surface Water Discharge
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Zero Liquid Discharge (ZLD)

Issues / Limitations

- Environmental permitting
- Available area
- Capital cost

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“Conventional” Concentrate Management

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Surface Water Discharge
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Issues / Limitations

EXAMPLE:

- 4 MGD BWRO plant
- 80% recovery
- Evaporation rate = 160”/yr

(~ Death Valley)

~84 acres required

"Conventional" Concentrate Management

"Conventional" Options
Surface Water Discharge
Deep Well Injection
Evaporation Ponds
Land Application
Zero Liquid Discharge (ZLD)

Issues / Limitations

- Environmental permitting
- Distribution
- Requires salt-tolerant crops
- Micropollutant toxicity
- Increase in soil salinity

"Conventional" Concentrate Management

"Conventional" Options
Surface Water Discharge
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Issues / Limitations

COST

"Conventional" Concentrate Management

"Conventional" Options
Surface Water Discharge
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Issues / Limitations

- Very high operating cost (~$2 - $25 / kgal recovered)*
- Only one (?) municipal application

* Bond &Veerapaneni, *JAWWA*, Sept. 2008

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Summary of "Conventional" Limitations

Availability

Permitting

Cost

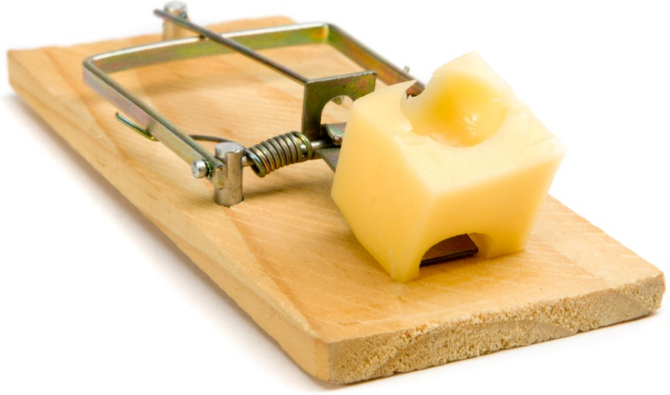
Environmental Impact

Building a Better Mousetrap

"Conventional" options are getting better

- ZLD is getting cheaper (in theory…)
- More salt-tolerant crops are being grown
- Engineered wetlands are being developed
- …etc.

The mousetrap is improving.



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Building a Better Mousetrap

“Conventional“ options are getting better

- ZLD is getting cheaper (in theory…)
- More salt-tolerant crops are being grown
- Engineered wetlands are being developed
- …etc.

But it’s still a mousetrap.

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The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

Bigger

Genetically diverse

Smarter

The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

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Genetically diverse

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The number of desalination / concentrate management applications is growing quickly.

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The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

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Genetically diverse

Smarter

Desalination plants are getting larger.

The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

Bigger

Genetically diverse

Smarter

Non-traditional desalination applications are both increasing and increasingly important.

The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

Bigger

Genetically diverse

Smarter

Desalination applications are more challenging and complex.

The Problem of Contemporary Rodents

Characteristics of modern mice

More numerous

Bigger

Genetically diverse

Smarter

Truly innovative concentrate management strategies are needed.

Attributes of Innovative Strategies

Applicability

- More focused / limited…
- …but part of toolbox

Scalability

- Matches scale of application
- Batch vs. continuous flow

Economy

- Economical vs. affordable
- Cost vs. “no water” option

Sustainability

- Environmentally friendly
- Neutral impact is positive

Feasibility

- Similar to conventional options
- Site- / application-specific

Synergy

- Ideally characteristic
- Represents dual solution

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Case Studies

Case Studies: Overview

Important considerations

- Good concentrate management options, but imperfect
- Not intended to be an endorsement
- Focus should be less on these specific cases and more on their innovative characteristics and approach

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Goals

- Provide examples of alternative approaches
- Stimulate innovative thinking!

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Case Study #1:

Calera MAP Process

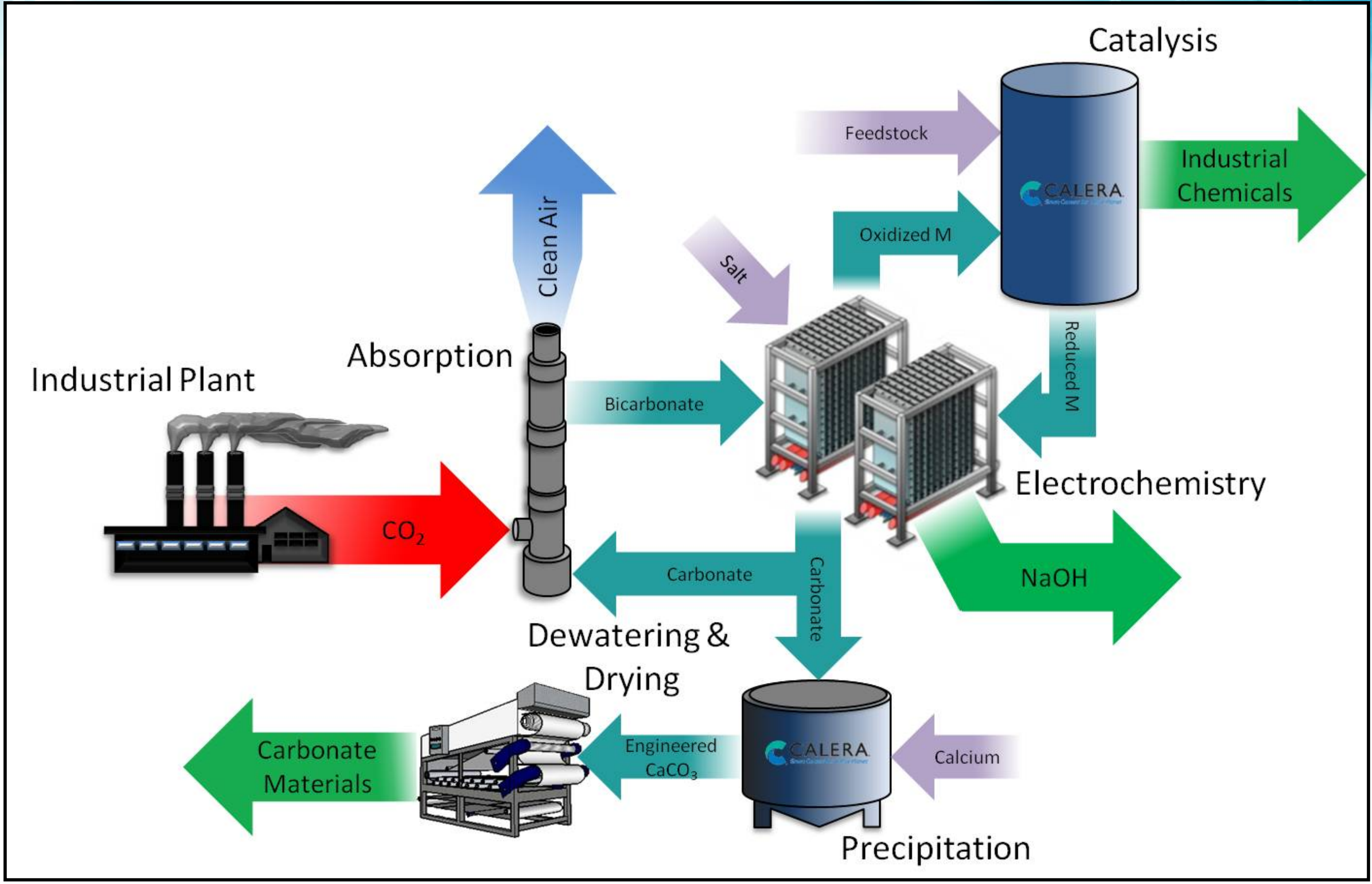
Calera MAP Process

Overview

- "Mineralization via Aqueous Precipitation"
- Combines saline water and CO_2 emissions to produce cement
- Piloted at Moss Landing (Monterey) on seawater and power plant flue gas
- Could concentrate from proposed SWRO plant improve the process…?
- Profiled by NY Times (2011), Scientific American (2008), and other sources

CALERA
Green Cement for a Blue Planet

Calera MAP Process



Source: www.calera.com

Calera MAP Process

Applicability

- Theoretically deployable at almost any power plant or carbon-emitting industrial operation
- Broadens benefits of co-location
- Potential for wide applicability from SWRO to inland BWRO
- Use as a concentrate management option depends on both salinity and ionic composition

Calera MAP Process

Economy

- No detailed economic analysis has been released
- Magnitude of cost would be site-specific and vary widely
- Potential to be less expensive than other concentrate management alternatives
- Generation of “green cement” as a saleable product
- Sequesters flue gas, reducing the cost of power plant emissions scrubbing
- Not a ZLD process, so there is still a cost for managing less saline residual stream

Calera MAP Process

Feasibility

✓ Minimal infrastructure integration

- Tests are needed
- Limited by:
  - Proximity to source of CO_2 emissions
  - Means to manage residuals stream

? Acceptance of "green cement" by conservative building industry

? Linking concentrate management strategy to demand for a commodity (permitting?)

Calera MAP Process

Scalability

- No theoretical limitations identified
- Low concentrate flow may yield adverse economy of scale
- Scale dependent on market for usable product (“green cement”)

Calera MAP Process

Sustainability

- Reduces global warming
  - Demonstrated 86% CO_2 capture
  - Offsets non-green concrete mfr.
  - **Negative** carbon footprint (-1,000 lbs. CO_2 / yd^3 concrete mfrd.)
- Removes flue gas pollution
  - SO_2 (>95% capture demonstrated)
  - Mercury
- Does not eliminate concentrate
- Waste stream composition…?

Calera MAP Process

Synergy

- Could facilitate desalination in locations with no other viable concentrate management options
- Reduces pollution
- Reduces global warming
- Generates salable product

Calera MAP Process

Outlook

- Unproven
- More data / study is needed
- Promising for SWRO and some inland BWRO applications

Could set the standard for outside-the-box concentrate management

…if viable

Case Study #2:

Upstream Oil & Gas Application

Upstream Oil & Gas Application

Overview

- Booming unconventional production
- Potential for significant water demand
- Some applications allow or *require* saline water; examples include…

Kill fluid
- Prevents outward flow from well
- Requires brine

Completion fluid
- Protects hardware from damage
- Typically comprised of brine

Fracking fluid
- Fractures subsurface formations
- Increasingly comprised of saline water

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Upstream Oil & Gas Application

Overview

Example: Kill Fluid

- Fluid is use as passive, non-mechanical means of preventing fluid flow
- Solution must be heavier than the force exerting upward pressure

Water Supply	Weight	Column Pressure (per 100 ft.)
Fresh Water	8.3 lbs/gal	43.3 psi
Seawater[1]	8.6 lbs/gal	44.7 psi
Saturated Water[2]	10 lbs/gal	52.0 psi

1 Variable concentration not significant for the purposes of this analysis
2 "Ten pound brine"

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20% heavier than fresh water

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Upstream Oil & Gas Application

Applicability

- Only viable in areas with areas with ongoing O&G sector activity (?)
- Production is expanding widely and rapidly, and so is water demand

US expected to rival Saudi Arabia in hydrocarbon production in 2013

- Use of concentrate avoids the need to compete for other limited water supplies

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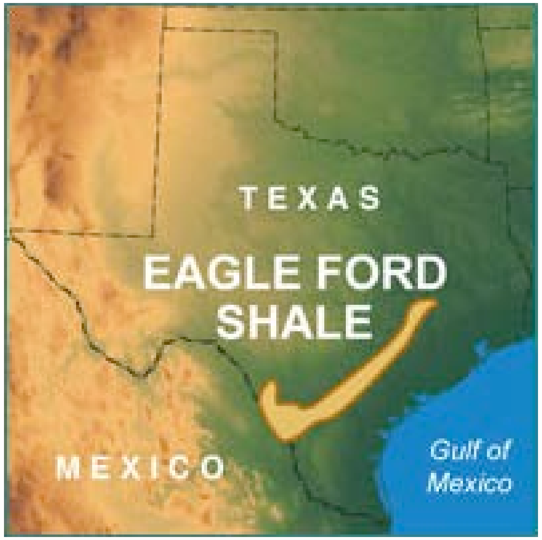
Upstream Oil & Gas Application

Applicability



Example: Kill Fluid

- Confidential operator of a produced water desalination system sells **all** of its concentrate for use as kill fluid (Eagle Ford shale play in Texas)
- Operator adds salt to increase the salinity for its customer
- Recycles water within the shale play

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Upstream Oil & Gas Application

Economy

- Competition for water resources could make desalination concentrate a valuable commodity
- Possible financial windfall for desalination plant owner (rare!)
- Shifts ultimate concentrate disposal cost to end user

Upstream Oil & Gas Application

Feasibility

Governed by three factors:

1. Presence of significant market
   - Proximity of desal plant to O&G plays
   - Supply vs. demand
2. Logistics of conveyance
   - Economics
   - Environmental impact
   - Permanent vs. temporary facilities
3. Water quality
   - Concentrate compatibility with use
   - Requirements vary by application

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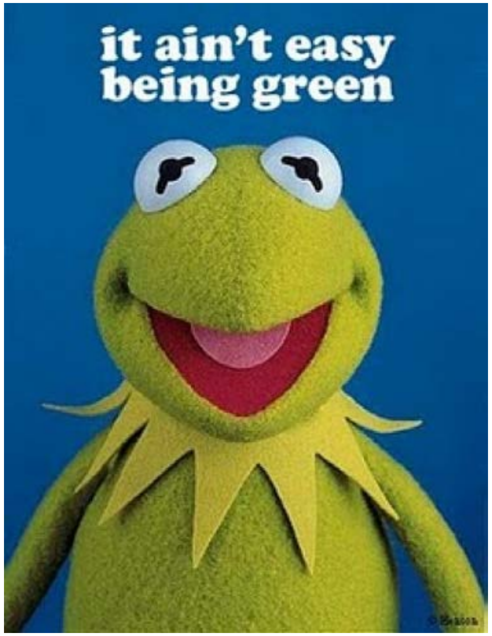
Upstream Oil & Gas Application

Scalability

- Matching scale of concentrate flow to demand may be the most limiting factor
- Strategy best suited for areas with significant O&G activity
- Significant considerations include:
  - Number of O&G wells / sites / pads
  - Well depth
  - Temporary nature of operations
  - Development of new technology / procedures with different quality and quantity requirements

Upstream Oil & Gas Application

Sustainability



- Reduces some or all of the desal plant residuals
- Eases competition for better quality supplies
- Allows increased environmental flows
- Concentrate could be used multiple times (**but**…reduces demand)

Disadvantages:

- Likely transport by truck
- Ultimate disposal of saline waste laced with hydrocarbons

Upstream Oil & Gas Application

Synergy

- Reduces supplier waste…
- …meets purchaser need
- Mutual economic benefit for supplier and purchaser
- Mutual permitting benefit for supplier and purchaser

Upstream Oil & Gas Application

Outlook

- Opportunities expanding:
  - Booming O&G production
  - Increasing need for desalination
- Most significant impediments:
  - Variable demand
  - Shifting customer base as O&G operations evolve

Increasingly important option to consider

Summary

Four Fundamental Factors

Potential for economic benefit

Existing market demand,
uniquely (or more efficiently) satisfied

Significant sustainability advantages

Synergistic solutions

The Future of Concentrate Management

The Situation

- “Conventional” strategies will remain the core viable options
- New strategies must be developed to facilitate increased use of desalination in diverse applications and geographies
- Innovation cannot be limited to simply variations on conventional ideas
- Increasing shift to toolbox approach

The Future of Concentrate Management

Our Commission

- Truly think “outside-the-box”
- Investigate other industries and their water and resource needs to identify markets and synergies
- How can we solve the concentrate problem?

The Future of Concentrate Management

Our Commission

- Truly think "outside-the-box"

- Investigate other industries and their water and resource needs to identify markets and synergies

- Ho[illegible] solve the concentrate problem?

What problem(s) can concentrate solve?

Questions?

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