



Water Technology Market Trends  
& Technology Directions  
of 2013



AN O<sub>2</sub> ENVIRONMENTAL COMPANY

# Introduction

Jeff Guild  
Vice President of Business  
Development & Professional  
Services



# O<sub>2</sub> Environmental & BlueTech Research

O<sub>2</sub> Environmental  
(Consultancy)

O<sub>2</sub> Technology Assessment  
Group (TAG)

BlueTech Research  
(Intelligence Service)

BlueTech Forum  
(Annual Conference)

# What we do

## Actionable Water Market Intelligence & Strategic Support

### **BlueTech Research**

- BlueTech 6.0 Intelligence Platform
- Innovation, Licensing & Patent Trackers
- Company Reports
- Monthly Intelligence Briefings
- Insight Reports on Markets & Technologies
- Webinars on Hot Topics
- Unlimited Analyst Access

### **O2 & TAG**

- Strategic Support
- Commercialization Support
- Acquisitions Pipeline Support
- Investment Due Diligence
- Business Development
- Custom Research
- Market Intelligence

# Expert Panelists



**Dr. Mike Mickley**  
Desalination Expert



**Mark Wilf**  
Membrane Technology,  
Filtration and Application Expert



**Robert Gerard**  
Electro-Separation Expert

# BlueTech® Panelists



Paul O'Callaghan  
CEO



Jeff Guild  
Vice President  
Business Development  
& Professional Services



Tyler Algeo  
Senior Technology Research Analyst



Aoife Moloney  
Water Technology Research Analyst

# Agenda

- **Introduction** to BlueTech Research & O<sub>2</sub> Environmental Technology Assessment Group (Jeff Guild)
- **Chairpersons** Opening (Paul O'Callaghan)
- **Membranes Modules & Applications** (Mark Wilf)
- **Sludge & Biosolids** (Aoife Moloney)
- **Opportunities in Electro-Separation Technology** (Robert Gerard)
- **High Recovery Water Processing** (Mike Mickley)
- **Water Treatment in the Alberta Oil Sands** (Tyler Algeo)

# BlueTech

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## Chairman's Opening

Paul O'Callaghan  
CEO





# Water Technology Market Trends & Technology Directions of 2013

Presented by:



**Environmental**

Water Technology Market Experts

# General Market Trends

- Japanese companies move outwards
  - Hitachi, Toshiba, Toray, Swing, SEI, Meiden
  - Flat growth promotes export market focus.
  - Key areas: Unconventional fossil fuels, emerging markets, MENA
- Automotive companies moving in....
  - Mahle, Mann + Hummel: Focus on Filtration
- Exit Stage Left
  - Siemens ....or did they....
  - Ashland – selling off water chemicals division
- Other New Entrants
  - Johnson Matthey
  - LG Electronics

# Acquisitions 2013

Acquirer	Company
Hutchison Water	Kinrot Technology Ventures
Maine Manufacturing LLC	GE Healthcare Laboratory Filter and Membrane Business
Aker Solutions	Separation Specialists Inc.
Bilfinger	Johnson Screens
Paine and Partners	Eurodrip
Sumitomo	Sutton & East Surrey Water
Xylem	PIMS Group
Xylem	MultiTrode
Siemens Water Technologies Hemodialysis Business Unit	Cantel Medical (through its subsidiary Mar Cor Purification)
Nijhuis Water Technology	Excellent Ozone Solutions
Aquatech	Fluid Recovery Services (FRS)
KKR	South Staffordshire plc.
Badger Meter, Inc	Aquacue
Contech Engineered Solutions	Imbrium Systems

Acquirer	Company
Contech Engineered Solutions	Imbrium Systems
World Water Works	Aquanos
Xylem	Pollman Pumpen
Kemira	3F Chimica S.p.A.
Advanced Drainage Systems Inc.	Baysaver Technologies Inc.
United Envirotech	Memstar Pte Ltd.
RWL Water	Unitek
RGF Environmental Group	AFL Industries
Nijhuis Water Technology	H2OK Water and Energy
AEA	Siemens Water Technologies
Produced Water Absorbents	ProSep
Clean Teq Holdings	Phoenix Copper

# Investments 2013

Investor	Company
Woongjin Chemical Co.	Porifera
United Envirotech	Memstar
Naesta	Nijhuis Water Technology
True North Venture Partners	Emefcy Bioenergy Systems
CLSA Capital Partners and Kleiner Perkins	Scinor Water
Wells Fargo	Imagine H2O
Low Carbon Innovation Fund, the Angel Co-fund, the LBA EIS Roundtable Syndicate Fund 2012	Syrinix
EIC Ventures and Kennington Ltd	Pasteurization Technology Group
Wheatsheaf Investments, Vantage Point, Capital Partners and Frog Capital	Ostara Nutrient Recovery
TEL Ventures	MIOX Corporation
Liberation Capital	Desalitech
Incitica Ventures II and Malin Venture, Sembcorp Industries	Biowater Technology
International Finance Corporation (IFC), WLR China Energy Infrastructure Fund LP, Huaneng Invesco, RNK Capital LLC, Gamma Capital Partners	Organica
USAID	mWater

# Some observations on Innovation

- Water Pricing is not the roadblock to water innovation
- Innovation is only innovation if it meets a clients need

# BlueTech Innovation Tracker Picks

- **Disrupt-o-meter™ Picks**

- UV LED



- Ceramic Membranes



launched with backing of TNVP



launched CeraQ™ Ceramic Membrane

**Pain Point Addressed:** The need for membranes that are tolerant to the presence of hydrocarbons for use in the oil and gas sector to treat produced water

- **Other:**



Nitrate removal – catalytic reduction

**Pain Point Addressed:**

Elimination of concentrate waste stream

- Pasteurization Technology Group

Wastewater disinfection using waste heat

**Pain Point Addressed:**

Operational costs for electricity

# Recent Insight Reports

- 1. Macrofiltration Technologies for Water and Wastewater Treatment**
  - Tail-wind opportunity
- 2. Municipal Wastewater Reuse**
- 3. Water Treatment in the Alberta Oil Sands**
- 4. Advanced Oxidation Processes: *Market & Technology Overview***
- 5. Biogas Generation and Utilization: *Technology Trends & Market Potential***
- 6. Smart Water Meters: *Technology Overview & Market Opportunities***



Introduction

Market Dynamics

Water Reuse Types

Current Municipal Wastewater  
Reuse Rates

Water Reuse Applications

Water Reuse Regulations

Municipal Wastewater Reuse  
Technology Opportunities

Technology Trends

Market Trends

Drivers

Barriers to Municipal Wastewater  
Reuse

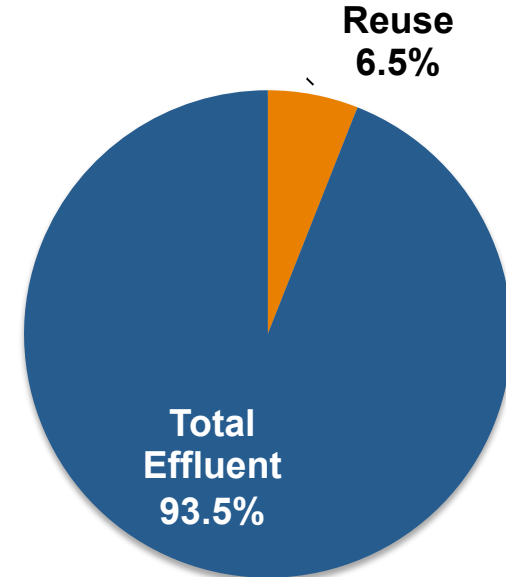


# Wastewater Reuse Rates

- Municipal Wastewater Reuse rates vary widely

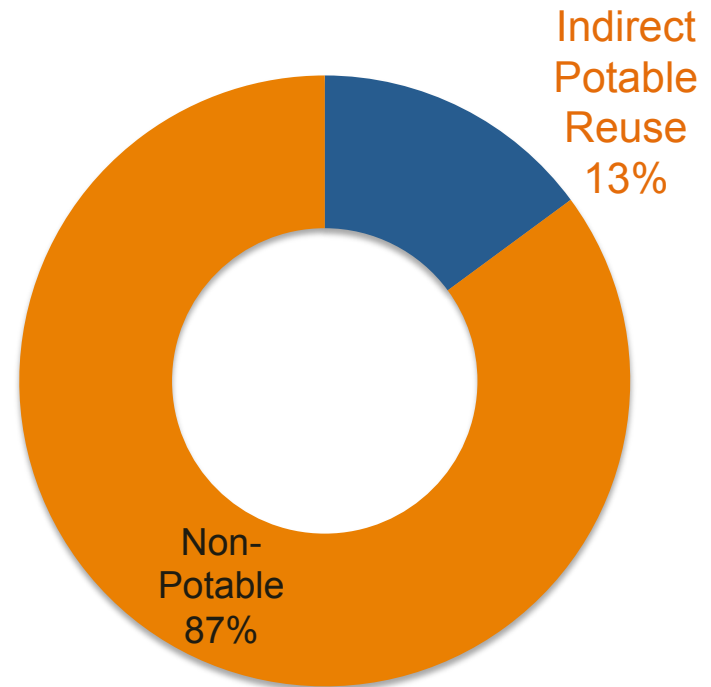
- Southern European Countries-3.5%
- Israel- >80%
- Australia- 16%
- Singapore- 35%
- China- 9%
- USA- 6.5%
  - Texas, Florida and California account for over 85% of the US wastewater reuse capacity
  - and all have water reuse rates over 10%.

## % of Total Wastewater Collected That is Reused in the USA



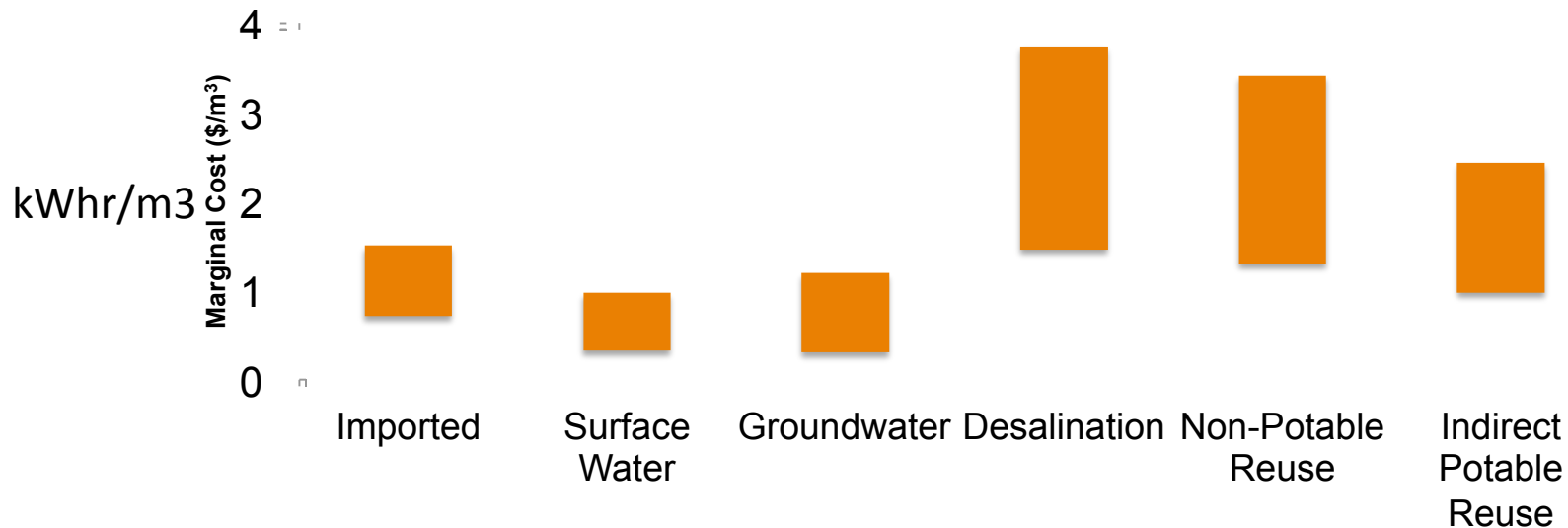
# Types of Water Reuse

- Non Potable Reuse
- Potable Reuse
  - Indirect Potable Reuse (IPR)
  - Direct Potable Reuse (DPR)
- Non Potable Reuse by far the most dominant form of water reuse
  - USA- 87%
  - Singapore- 89%
  - Europe- >99%



# Types of Water Reuse

- Non Potable Reuse more publicly acceptable
- However has higher marginal costs than Indirect Potable Reuse if significant (>30 km) additional distribution is required



# Non-Potable Treatment Requirements

- Vary depending on reuse application however generally required:
  - Filtration (membrane filtration or macrofiltration)
  - Disinfection (chlorination or UV disinfection)
  - **California Department of Public Health Title 22** Regulations the “Industry Standard” across the world

# IPR and DPR Treatment Requirements

- Not as well developed as Non Potable Regulations
- Multi- barrier pathogen and trace organic removal treatment trains
- No “Industry Standard” regulations but CDPH have issued draft regulations regarding IPR
  - Stipulate **F**ull **A**dvanced **T**reatment (FAT)
    - RO Membrane Treatment and Advanced Oxidation Required

# Technology Opportunities

- IPR is set for explosive growth
  - Growing public acceptance
  - Lower marginal costs
  - Decreasing number of sites with potential to provide cost effective non potable reuse to nearby end users
- If FAT becomes industry standard then AOP, MF/UF and RO Technologies will dominate technology market
- UV disinfection set to become the disinfection method of choice for IPR and Non- Potable Reuse Projects.
  - Combination with oxidants for AOPs
  - Cost comparable to chlorine in many cases
- Regulatory demands for monitoring will drive growth in demand for real-time sensors

# A look forward....

## Next years BlueTech Insight Reports & Webinars

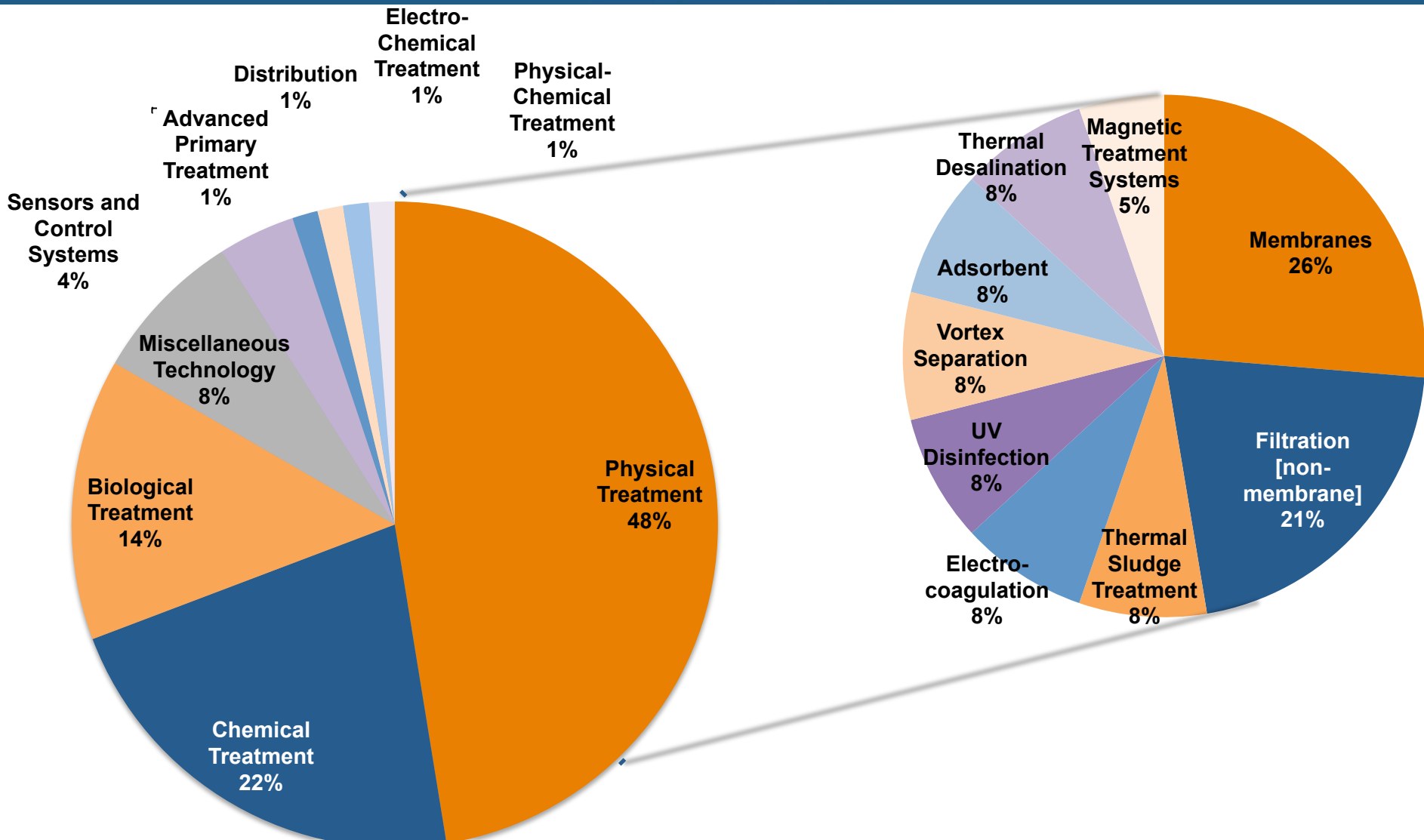
### BlueTech Webinars

- New Opportunities in Ultrapure Water - Technologies for the Semi-Conductor Industry **Jan 2014**
- Ammonia Recovery & Ammonia to Energy
  - Feb 2014
- Groundwater Treatment Markets
- Osmotic Power
- Nanotechnology in Desalination
- Ballast Water Treatment
- Deammonification
- High Rate Recovery in Oil and Gas/ Mineral Recovery
- Reverse Osmosis Energy Recovery
- Water Technology Market Trends & Technology directions 2014

### Insight Reports

- Shale Oil
- Alternative Energy
- Desalination
- Coal Bed Methane
- Low Energy Wastewater
- Industrial Water Reuse
- E-Separation Technologies
- Zero Liquid Discharge
- Ballast Water Treatment

# 2013 BlueTech Tracker Patent Trends





# BlueTech Licensing – top picks

- Technique for catalytic oxidizing of dissolved matter in water
  - Technion, Israel
- Measurement of Crop Water Use (Evapotranspiration) Over Broad Areas
  - UC Davis, CA
- Method for Copper Recovery from Aqueous Solutions
  - NUS, Singapore
- Phosphate and Arsenate Removal
  - University of Queensland, Australia

# Technion – Israel Institute of Technology



<b>Research Institute:</b>	Technion – Israel Institute of Technology
<b>Technology Offering:</b>	Technique for catalytic oxidizing of dissolved matter in water
<b>Technology Concept:</b>	Adsorption/catalytic regeneration process for regeneration of absorbing material such as active carbon, as well as treatment of fluids containing undesired contaminants.
<b>Type of Licensing Partner:</b>	Available for Licensing
<b>Uniqueness / Novelty (out of 3):</b>	1/3
<b>Unmet Need in the Market (out of 3):</b>	1/3
<b>Size of Market Opportunity (out of 3):</b>	2/3
<b>Website:</b>	<a href="http://t3.technion.ac.il/pdf_files/1220775151.pdf">http://t3.technion.ac.il/pdf_files/1220775151.pdf</a>
<b>Contact:</b>	Tzachy Tal
<b>Job Title:</b>	Director of Business Development - Life Sciences & CleanTech
<b>Telephone:</b>	+972.4.829.4856

## Latest Licensing

- University of Sydney**  
Reverse Osmosis Subsurface Drip Irrigation [Read more](#)
- Weizmann Institute of Science**  
Water Treatment in Aerobic Conditions [Read more](#)
- Weizmann Institute of Science**  
Method for Extracting and Upgrading Heavy Oil and Other Heavy Hydrocarbons [Read more](#)
- Tel Aviv University**  
Identifying and Measuring Genotoxins in Water [Read more](#)
- Technion – Israel Institute of Technology**  
Technique for catalytic oxidizing of dissolved matter in water [Read more](#)
- Technion – Israel Institute of Technology**  
Biological brine denitrification [Read more](#)
- Tel Aviv University**  
Submerged Arc Plasma for Water purification [Read more](#)

# Innovation Impact Analysis

<b>Current Paradigm</b>	<b>Aerobic biological wastewater treatment</b>
<b>Current Market Size</b>	<b>\$10Bn CAPEX &amp; \$20Bn OPEX</b>
<b>Pain Points</b>	Energy Use – North American Wastewater treatment energy use 20 Million MH hours.
<b>Potential for Break-through :</b>	Move from energy consumptive to neutral or net energy positive.
<b>Market Impact</b>	This would have the potential to disrupt an industry worth \$30Bn. It would affect the market for aeration devices, blowers, diffusers, sludge treatment technologies such as dewatering equipment, dewatering chemicals.
<b>Timeline for Impact</b>	Early Adopters are already moving to energy neutral. Time-line to Impact <b>Early Majority</b> section of market: 15 years.

# Innovation Impact Analysis

## Barriers to Shift

The incumbent infrastructure is entirely built around aerobic wastewater treatment. To change this would require re-investment in capital. It is likely that these technologies will see themselves rolled out in retrofits and new-builds in the developed world initially, followed then with roll-out to the new-build market in the developing economies.

## Disruptive / Enabling Technologies

Low Temperature Anaerobic Treatment

Microbial Fuel Cell / Bioelectrochemical System

Advanced Primary Treatment

Sludge Pre-treatment and Anaerobic Digestion

## Companies Developing These Technologies

**Emefcy, ABR Source, Salsnes, Cambi, OpenCell**

## Research & Development Activity

Perry McCarthy is leading a group focused AD at Stanford and in Korea. Nancy Love at the University of Michigan received a WERF Award to develop low temperature AD.



# Environmental

Water Technology Market Experts

Dr. Mark Wilf, O<sub>2</sub> TAG Partner and  
RO Technology

Membrane technology, filtration  
and application expert



**BlueTech Webinar: Reverse Osmosis Energy Recovery**  
November 13th, 2014



# RO & FO Applications



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- **RO/NF:**
  - Brackish water desalination
  - Seawater desalination
  - Municipal wastewater reclamation
  - Process water for industrial applications
- **FO/PRO:**
  - Renewable Energy Production





# RO/NF

## Membrane Development

- **Aromatic polyamide chemistry continues to dominate the RO market with small margin left for future improvement of performance.**
- **In SWRO applications reduction power requirement is limited by osmotic pressure of the concentrate**

## Module Development

- **Spiral modules configuration continues to dominate the RO market with acceptance of large diameter elements (16")**
- **Improved feed and permeate spacer materials and increased use of “low fouling” construction components**



# FO/PRO

## Membrane Development

- Potential for very large renewable energy market
- Intensive work on developing effective FO membranes and elements
- Significant challenges ahead

## Module Development

- Developing effective module configuration
- Significant challenges ahead





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# Biogas Generation and Utilization

Aoife Moloney, M.Eng  
Water Technology Research Analyst





# BLUETECH INSIGHT REPORT

Biogas Generation and Utilization:  
Technology Trends and Market Potential

[www.bluetechresearch.com](http://www.bluetechresearch.com)

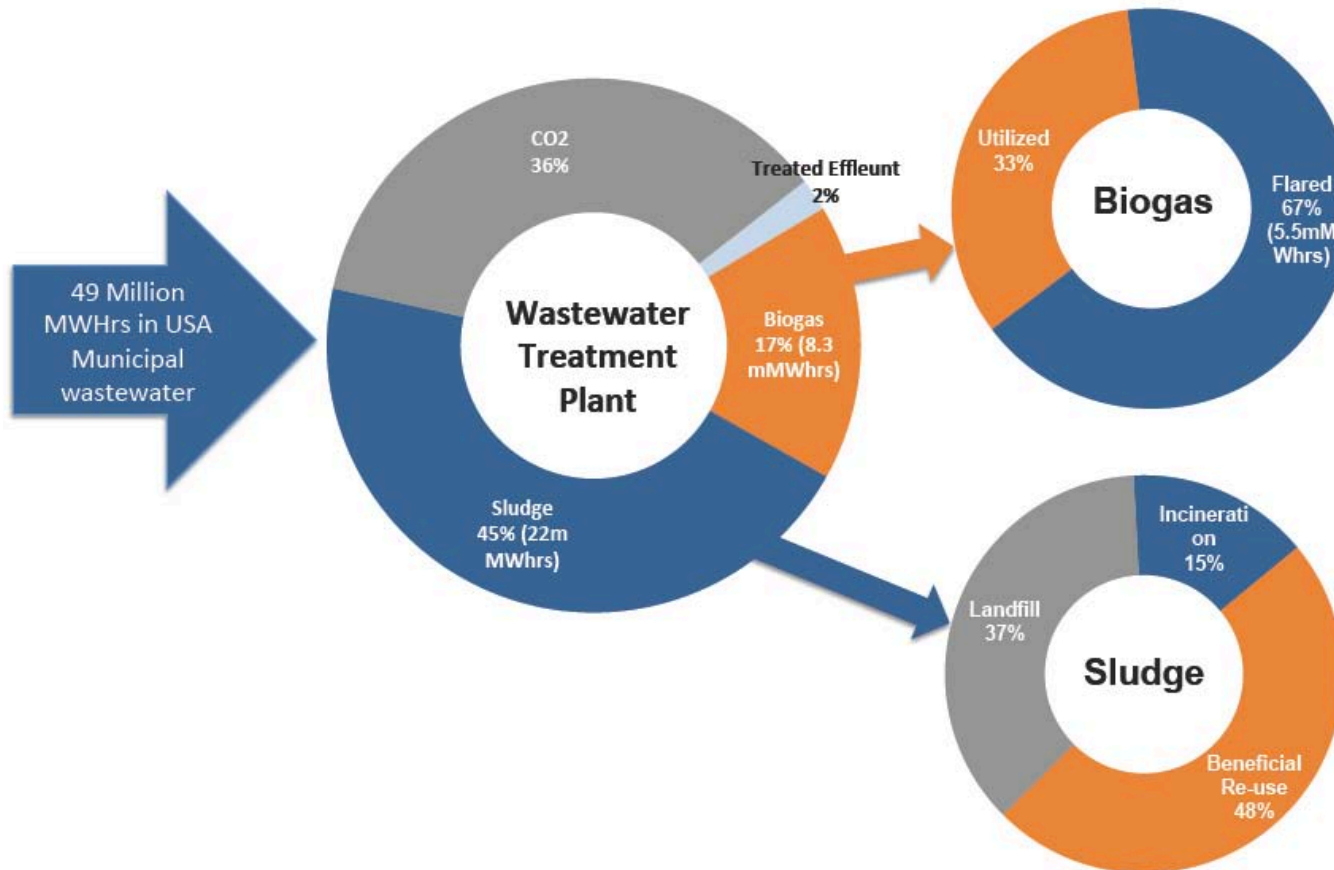
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# USA Municipal WWTP Energy Flow



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# Key Takeaways

## 1. AD is the principal Sludge to Energy Technology

- Stabilize Sludge and Generates Biogas
- Does not require a dewatered sludge thus reducing energy associated with dewatering

## 2. ICE Technology dominates the CHP market

Factors which could change this include:

- Underutilization of biogas at smaller plants
- Tightening air regulations

Alternative CHP technologies:

- Microturbines or Fuel Cells

# Key Takeaways

## 3. Sludge Pre-treatment Technologies key to unlocking additional energy

### Drivers:

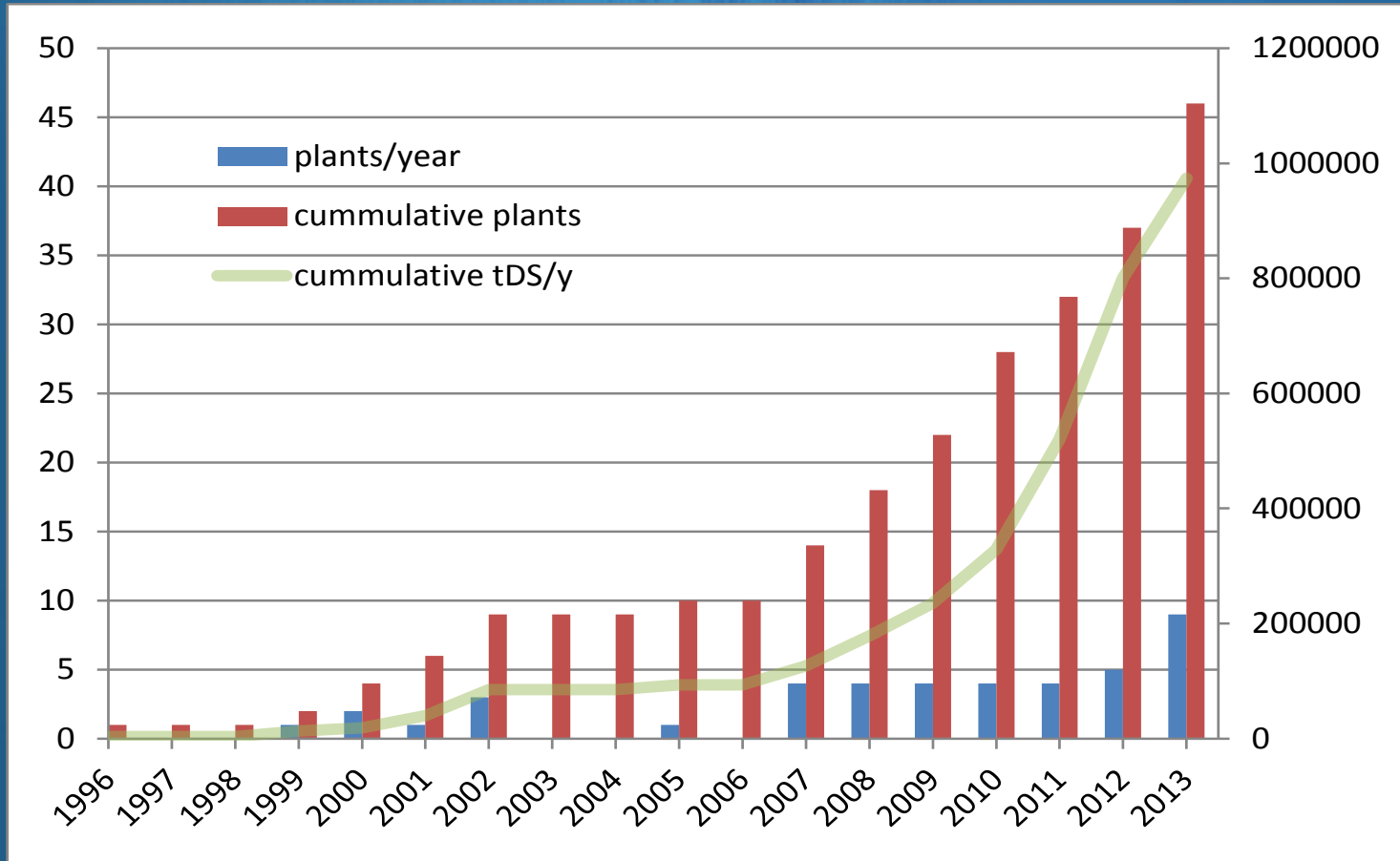
- Rising Sludge Disposal Costs
- Increasing Energy Costs
- Tightening Regulations

### Technology Advantages:

- Sludge Pasteurization
- Sludge Volume Reduction
- Enhanced Sludge Digestibility & Dewaterability
- Improved Biogas Yields
- Deferred CAPEX on AD due to sludge volume reduction

# Key Takeaways

## 4. Cambi's THP dominating sludge pretreatment market





PRACTICE AREA ▶

THEMES ▶

APPLICATION ▼

- AGRICULTURAL WASTEWATER TREATMENT
- BALLAST WATER TREATMENT
- COOLING TOWERS / BOILER WATER
- DESALINATION
- DISINFECTION
- DISTRIBUTION AND COLLECTION INFRASTRUCTURE
- DRINKING WATER TREATMENT
- INDUSTRIAL PROCESS WATER
- INDUSTRIAL WASTEWATER TREATMENT
  - PRODUCED WATER TREATMENT
  - MINING WASTEWATER TREATMENT
- IRRIGATION APPLICATION
- MEASURING / CONTROL / LABORATORY TECHNOLOGY
- MISCELLANEOUS APPLICATION
- MUNICIPAL WASTEWATER TREATMENT
- NUTRIENT REMOVAL APPLICATION
- POINT OF USE (POU) AND POINT OF ENTRY (POE) TREATMENT
- SLUDGE TREATMENT
  - SLUDGE DEWATERING
  - SLUDGE DIGESTION AND CO-DIGESTION
  - SLUDGE PRE-TREATMENT



## Paradigm Environmental Technologies

[READ MORE](#)

**Technology Offering:** MicroSludge®

**Technology Concept:** MicroSludge is a waste activated chemical pre-treatment technology that uses caustic solution to weaken cell membranes followed by a high-pressure cell disruption to lyse the bacterial cells in waste activated sludge. The resulting liquefied WAS is readily converted to biogas in an anaerobic digester.



## Siemens Water Technologies

[READ MORE](#)

**Technology Offering:** Cannibal®

**Technology Concept:** Side-stream bioreactor technology to achieve destruction of sludge produced in secondary biological treatment.



## Lysatec

[READ MORE](#)

**Technology Offering:** Baker Process: Lysate-Thickening Centrifuge

**Technology Concept:** Mechanical cell disruption using a modified centrifuge with a sludge disruption device located at the discharge of the dewatered sludge.



## Cambi

[READ MORE](#)

**Technology Offering:** Thermal Hydrolysis Process (THP)

**Technology Concept:** Sludge Destruction using thermal hydrolysis for pre-treatment prior to anaerobic digestion



## Veolia

[READ MORE](#)

**Technology Offering:** BioThelys

**Technology Concept:** Sludge pre-treatment technology based on thermal hydrolysis.

# Chart the selected companies

Chart Companies by

Technology



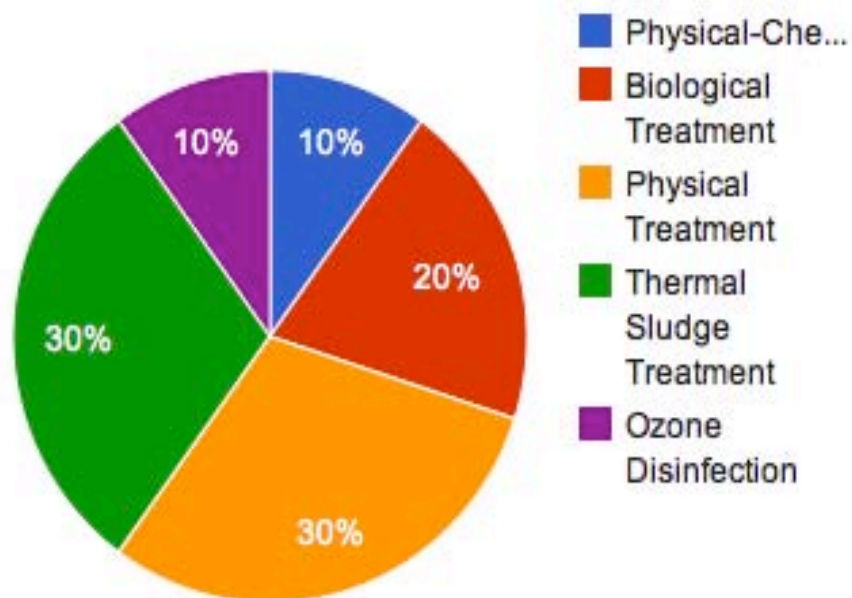
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Pie



GENERATE CHART

## Companies by Technology



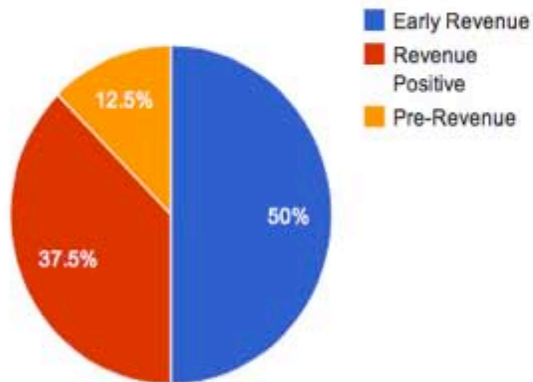


### Chart the selected companies

Chart Companies by  Select Chart Type

GENERATE CHART

#### Companies by Company Revenue Stage



Charting 8 Companies  
Including Companies in Sludge Pre-Treatment : Application

FILTER BY

PRACTICE A

THEMES

APPLICATIO

TECHNOLO

DISRUPT O

BLUE TRUF

REVENUE S

COUNTRIES

RESET ALL

EXPLORER

category.

OF 9 RESULTS

MORE

MORE

# Key Takeaways

## 5. Co-Digestion Proves to be problematic in practice

### Advantages:

- Waste management solution for food waste
- Synergistic benefit of sewage sludge digestion process – thus increase in biogas yield

### Challenges:

- Lack of clarity regarding regulations
- Waste collection methods
- De-packaging and pre-treatment of wastes
- Guaranteed digester capacity into the future



# Environmental

Water Technology Market Experts

Robert Gerard, O<sub>2</sub> TAG Partner and  
Aqualogy

Electro-Separation Technology Expert





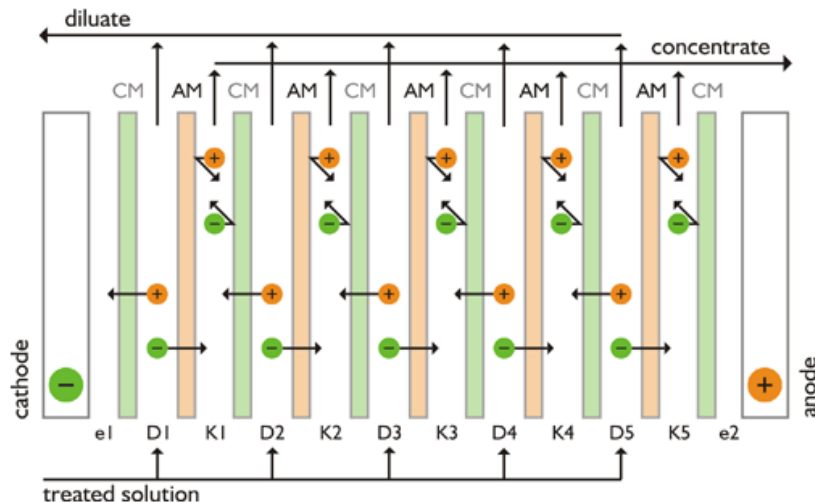
# Electro-Separations

Robert Gerard



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## E-Separation processes



Combination of IX Membranes, Electrodes and Spacers or Resin common for:

**Electrodialysis (ED)**

**Electrodialysis Reversal (EDR)**

**Electrodeionization (EDI)**

**Electrodialysis Metathesis (EDM)**

**Bipolar Electrodialysis (BP ED)**

**Capacitive Deionization (CDI)**

Main features of E-Separation:

- Fouling tolerance
- High TDS
- High Recovery



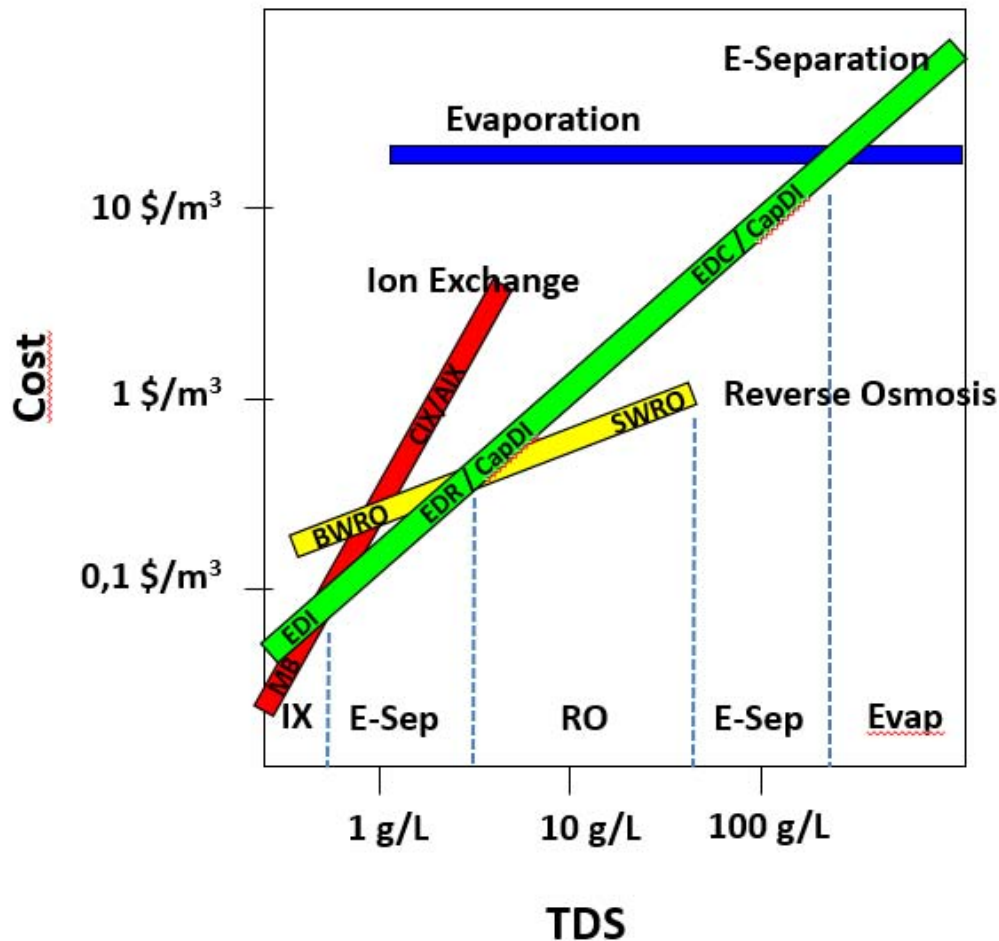
# Electro-Separations

Robert Gerard



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## Cost of various desalination technologies





# Electro-Separations

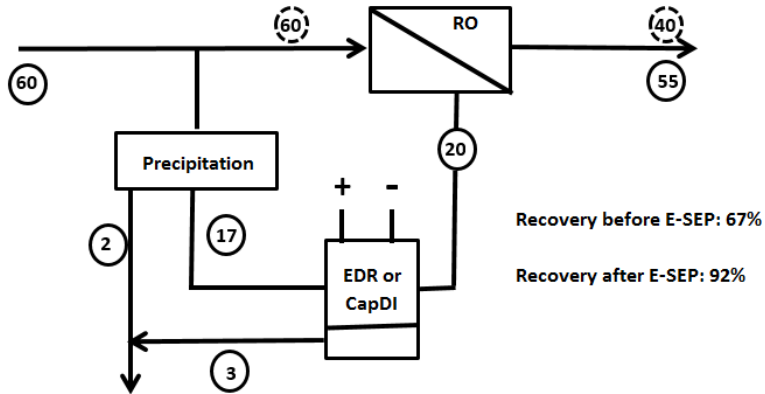
Robert Gerard



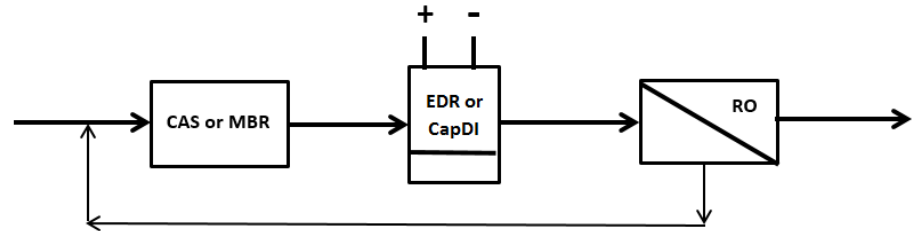
Environmental  
Water Technology Market Experts

## Examples of Hybrid Solutions

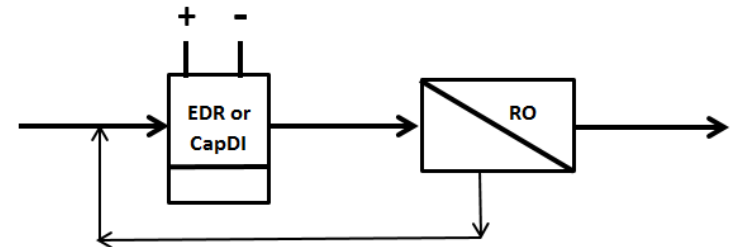
Increase overall system recovery



Feed water with high fouling potential



Feed water with high TDS





# Environmental

Water Technology Market Experts

Dr. Mike Mickley, O<sub>2</sub> TAG Partner and  
Mickley & Associates

Desalination Expert



**BlueTech Webinar: High Rate Recovery in Oil and Gas**  
September 18<sup>th</sup>, 2014





# HIGH RECOVERY WATER PROCESSING

- **What is high recovery (HR) processing?**
- **Why is it important?**
- **Drivers**
  - Source water scarcity, competition, transportation
  - Increasingly stringent wastewater disposal regulations
  - Heightened scrutiny about wastewater – sustainability issues
- **Original applications versus new applications**
- **Limiting factor = cost**
- **Oil and gas applications considered here:**
  - Coal bed methane/coal seam gas
  - Gas shale
  - Oil sand
- **Water issues include source water and wastewater**





# HRR Drivers and Technology Needs Are Very Local

Sector	Issue	Driver	Status
CBM (U.S.)	Produced water	<ul style="list-style-type: none"> <li>Limited disposal options</li> </ul>	Limited application of HR; lower TDS produced water; use for livestock; SAR off for irrigation use
CSG (Australia)	Produced water	<ul style="list-style-type: none"> <li>'Forced' to go ZLD due to legislation against new evaporation ponds</li> <li>Queensland Gov. Legislation requiring centralized treatment and management of CSG brines AND clean up of existing ponds</li> <li>Limited experience with deep well injection</li> </ul>	HR is a necessity
Marcellus gas shale (U.S.)	Source water and wastewater (flowback and produced water)	<ul style="list-style-type: none"> <li>Large water volume need; supplies are in competition with other needs</li> <li>Large scale deep well injection not available in many locations</li> <li>Risk – hauling of large water volumes</li> </ul>	Virtually no evaporative use yet much discussion, research, and anticipation
Gas shale (Australia):	Source water and wastewater (flowback and produced water)	<ul style="list-style-type: none"> <li>Severe limitations with water availability</li> <li>Limited experience with deep well injection</li> </ul>	At early stage of development – but HR seen as a need
Oil Sand (Alberta, Canada)	Source water and waste water (for steam for SAGD approach)	<ul style="list-style-type: none"> <li>Better boiler feed water quality</li> <li>Stringent regulations</li> </ul>	Accepted application; first ZLD systems installed between 1999 and 2003



# High Rate Recovery is coming – *its only a matter of time...*

- **Only solution addressing both source water and wastewater issues is HR processing.**
- **Unconventional O&G industries are evolving → regulation and other drivers will change and will favor HR.**
- **Many companies, major players and new, are developing more efficient and less costly treatment steps and systems in anticipation of this.**

# BlueTech

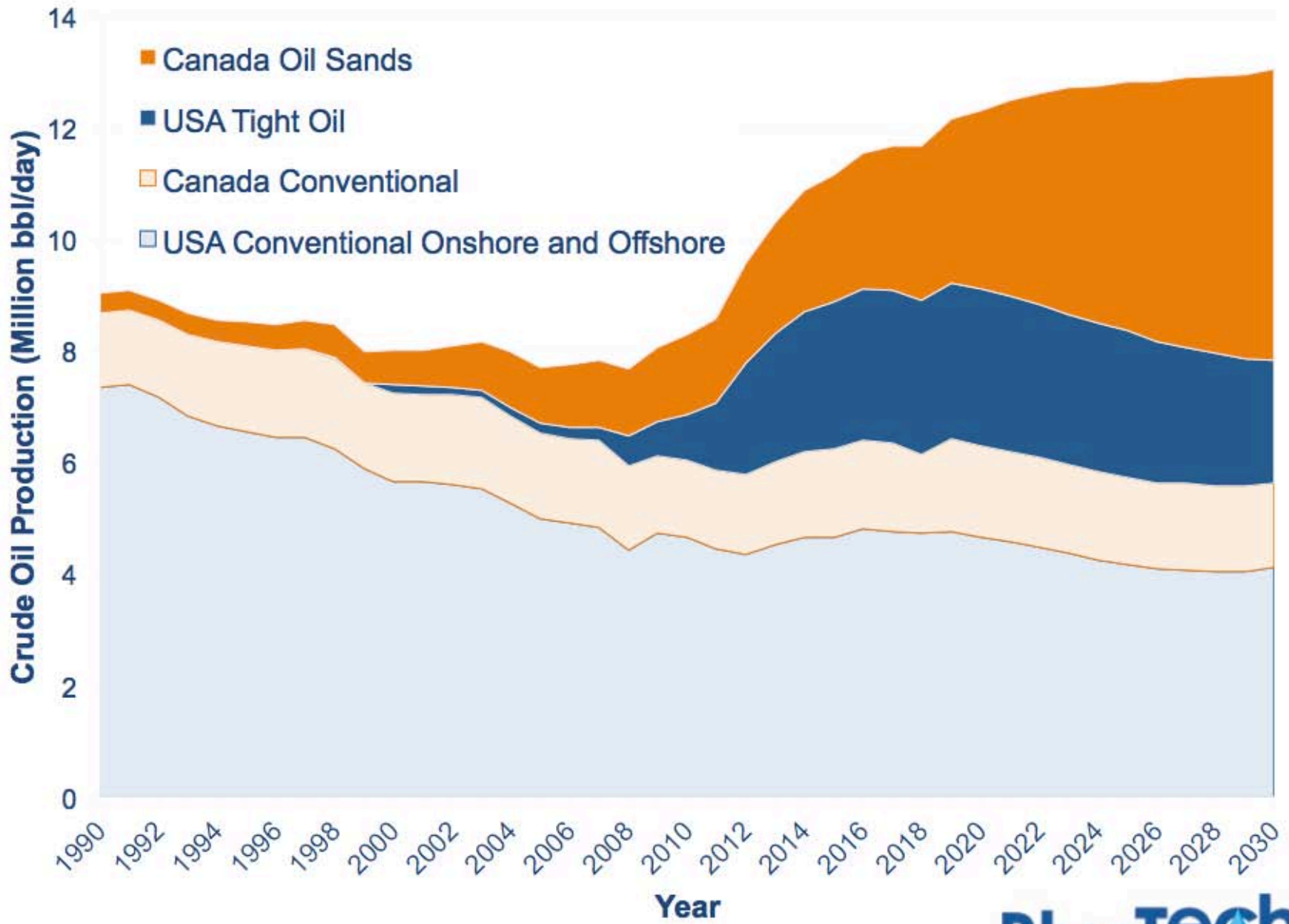
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## Water Treatment in the Alberta Oil Sands

Tyler Algeo  
Senior Water Technology  
Research Analyst





# In-Situ or Mining Depends on Depth of Overburden

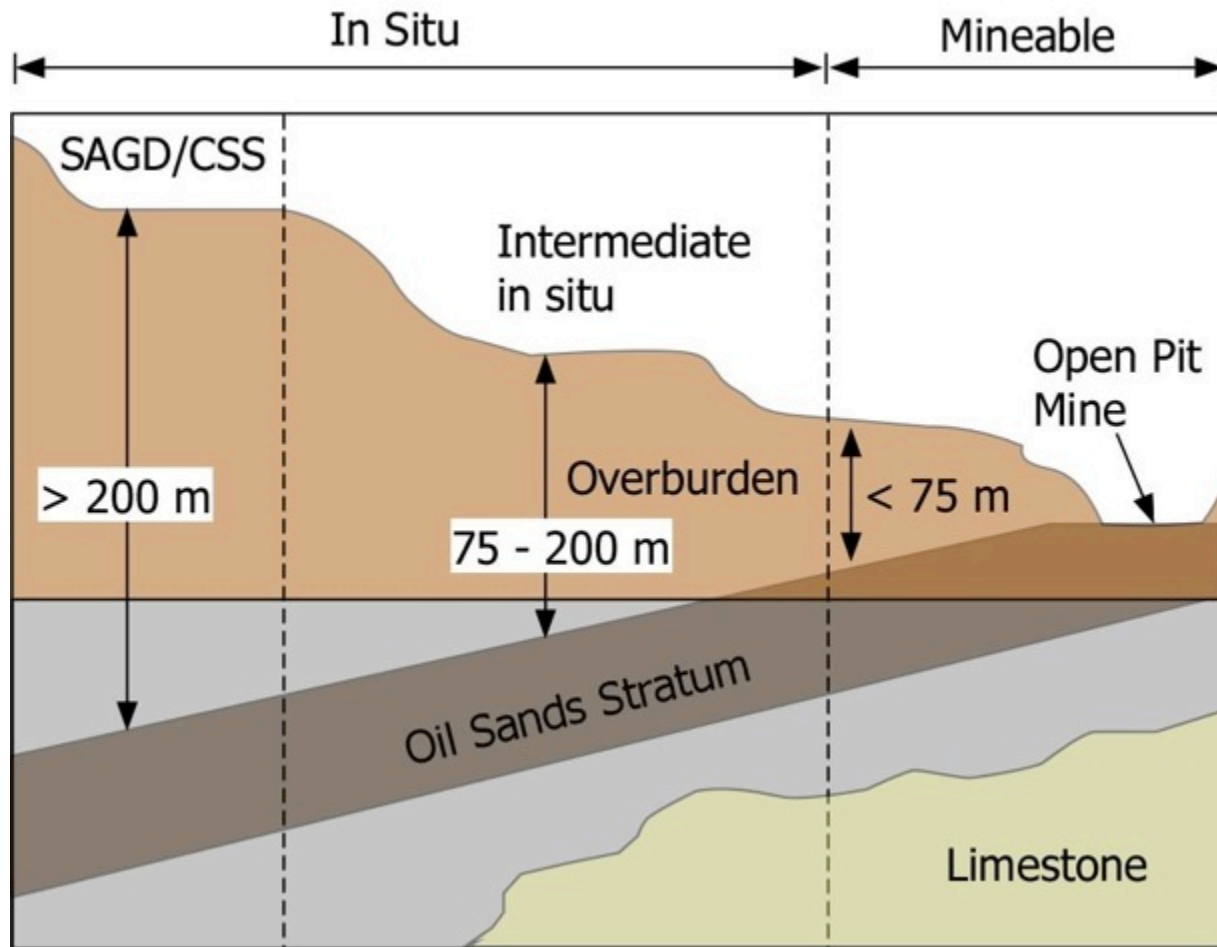
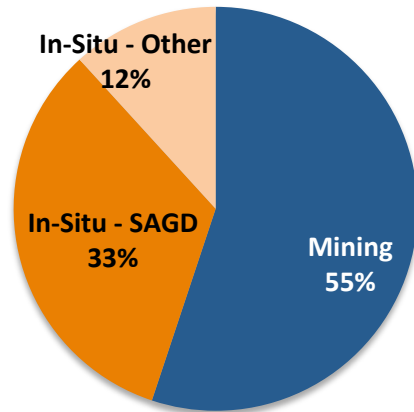


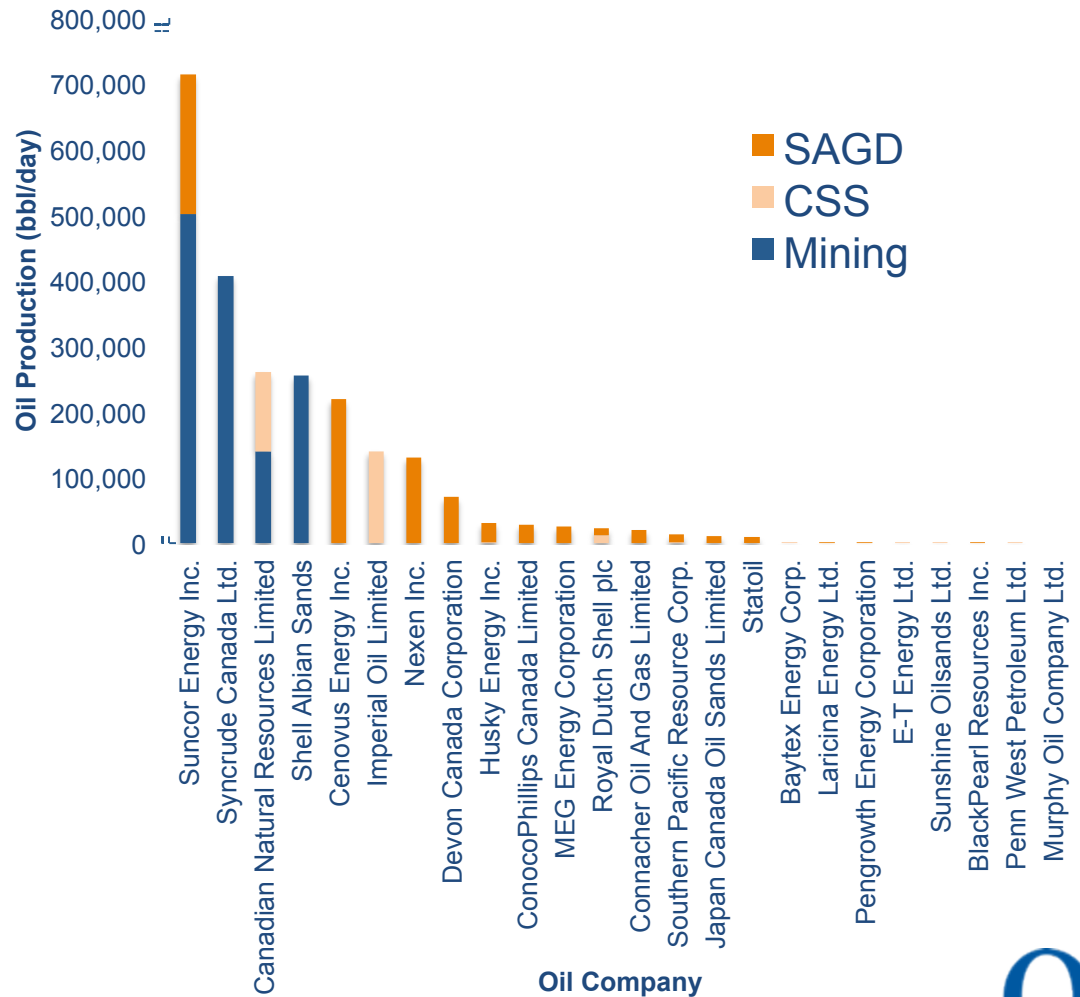
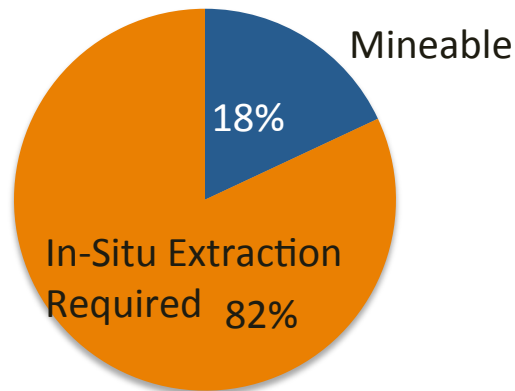
Photo Source: University of Alberta

# Bitumen in Alberta Oil Sands

## Current Production

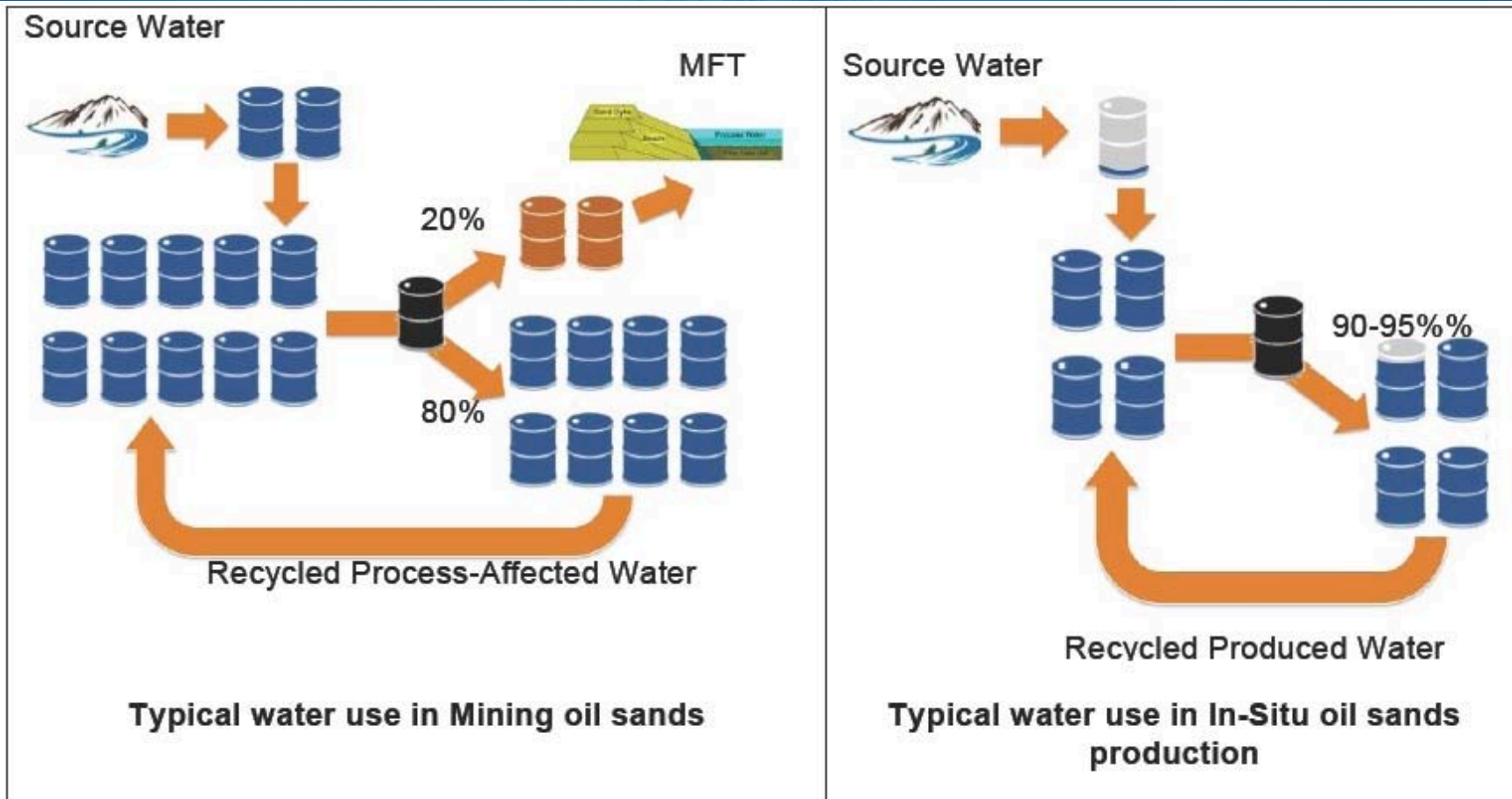


## Ultimate Recoverable





# Water Use in the Alberta Oil Sands





# SAGD Treatment Train Options

Makeup Water

Produced Water Treatment (Deoiling)

- Skim Tank
- Induced Gas Flotation
- Depth Filter

Water Treatment (Conventional)

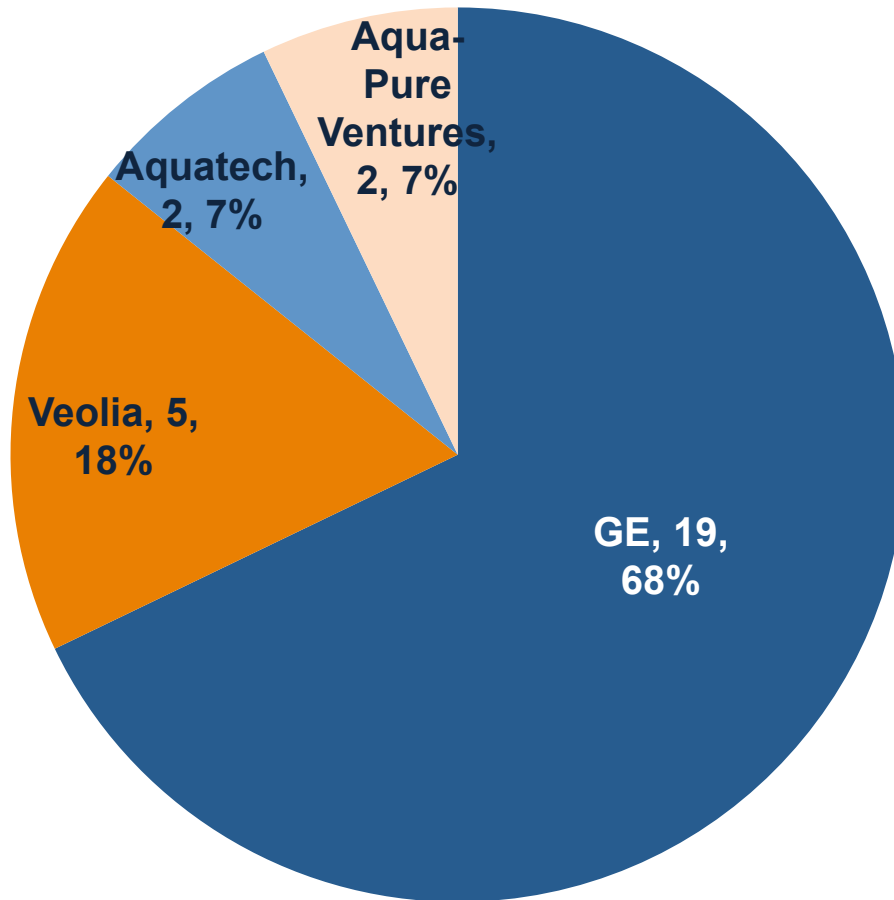
- Warm Lime Softening (WLS)
- Depth Filter
- Weak Acid Cation Softener

Water Treatment (Alternative)

Evaporator

Steam Generation

# GE Dominates the Evaporator Market in the Oil Sands



- **Aqua-Pure Ventures**
  - EnCana (now Cenovus) Foster Creek Site
  - JACOS Hangingstone Pilot Evaporator
- **Aquatech**
  - Shell Orion Site (Shell is paying GE due to patent infringement)
  - Recently awarded Pengrowth Contract
- **Veolia**
  - One commissioned and operating
  - One pending startup and commissioning
  - 2 in various stages of execution
  - One in engineering phase
- **GE**
  - 19 Projects of various sizes including 27 evaporator units and 7 crystallizers

# Key Takeaways

- SAGD is expected to become the dominant extraction method
- DRUM boilers are set to become the dominant means of generating steam for SAGD.
- Oil production is dependent upon steam production, which is dependent upon water treatment. No unnecessary risks to water treatment will be taken.
- There are unmet needs with no simple solution for water treatment.
- The water treatment technology customer is the Oil Company not a service provider.



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