

# **Current and Emerging Technologies for High Recovery and Zero Liquid Discharge Treatment**

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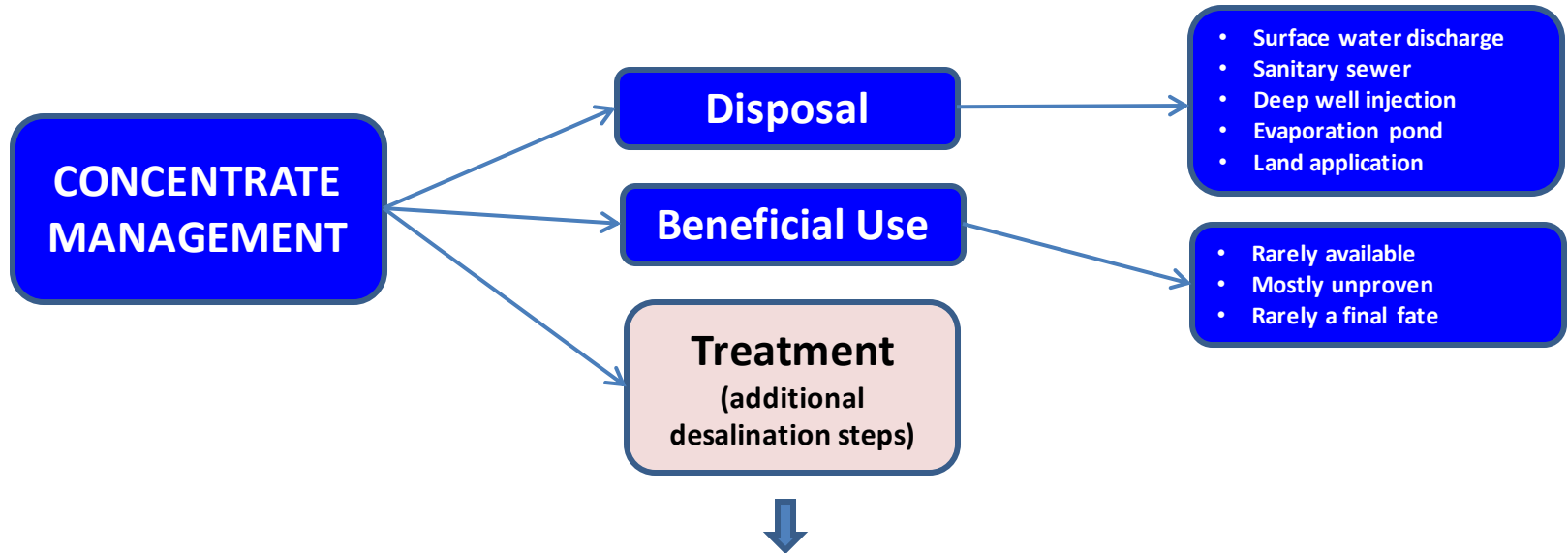
**Mickley & Associates LLC**

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# Concentrate Management



**High recovery (incl. zero liquid discharge) processing**

## Brines:

- Desalination concentrates
- Produced water (conventional & unconventional O&G)
- Frack water
- Mine drainage
- Industrial wastewater
- Others

## Reasons/drivers for treatment:

- Regulations
- No other options
- Permitting time
- Cost (rarely)
- Maximize use of water resource
- Recovery of salts, products
- Minimize corporate risk
- Combination of above

## Conventional markets:

- Overwhelmingly industrial
- Steady, slow growth
- 10-20 major systems /year
- MAJOR PLAYERS: GE (RCC), Aquatech, Veolia (HPD)
- Power: cooling water blowdown
- Power: flue gas desulfurization
- Produced water
- Coal to liquid (China)
- Others

# CONTEXT

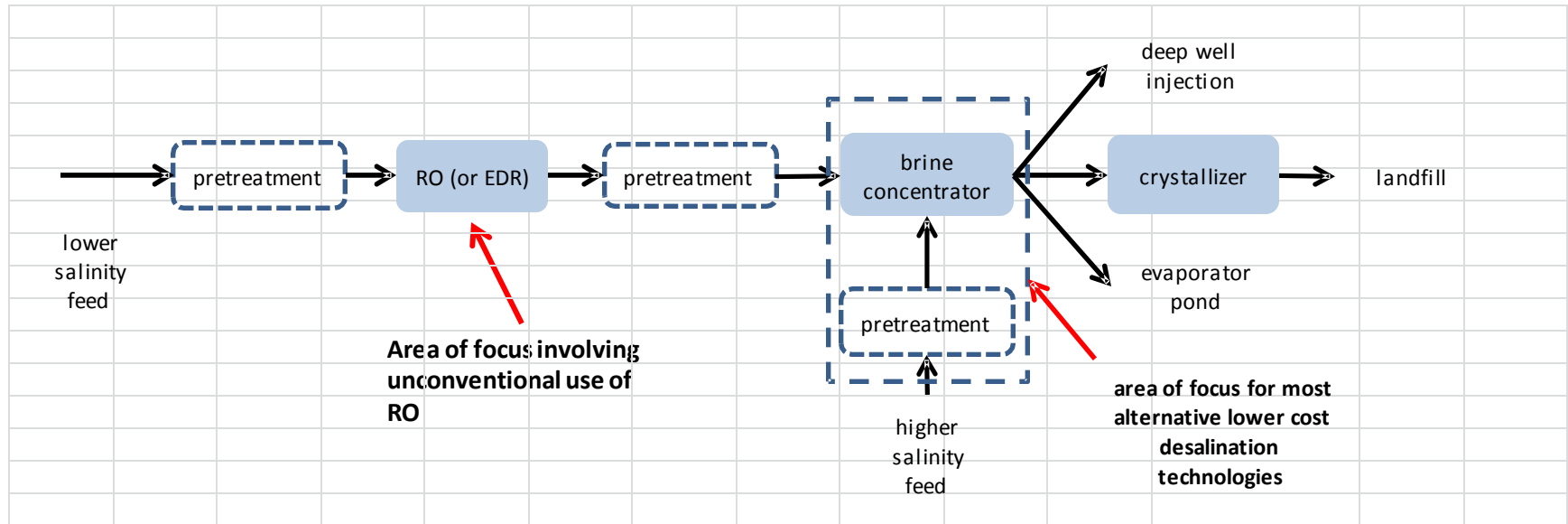
## NON-MUNICIPAL MARKET

- Most new technologies and related processes in the area of high recovery (HR) and ZLD processing are being **researched and developed for markets OTHER than the municipal market.**
  - **Reasons include:**
    1. The municipal market is not considered a large market for higher recovery and ZLD processing.
      - Utilities rarely can afford high costs associated with HR and ZLD processing.
    2. Companies do not like the bidding process and long time line before a contract is secured.
- **But technological gains in other market areas will eventually impact the municipal industry.**

## MUNICIPAL MARKET

- A subset of new processes involves creative use of conventional treatment technologies (RO, EDR, pretreatment steps, etc.). R&D is usually done by established companies already servicing the municipal industry.
- 
- The presentation focuses on **R&D efforts in the HR and ZLD area from a high level view.**

# Conventional High Recovery Processing (of wastewater)



## CONSTRAINT FOR INCREASED APPLICATION

High cost - both CAPEX and OPEX (energy) associated with evaporative steps

Possible recovery of salts and other products – at BC and Cryst. steps

## MAJOR POINT

Considerable interest and activity in reducing costs

# Increased Interest and R&D

## Drivers for increased interest and activity

- High potential (as of ~ 5+ years ago) for unconventional O&G applications
- Increasing regulation of disposal options
- Expansion of existing markets - if costs are reduced
- Opening up of other and smaller applications – if costs are reduced
  - Increased consideration of recovering water for reuse

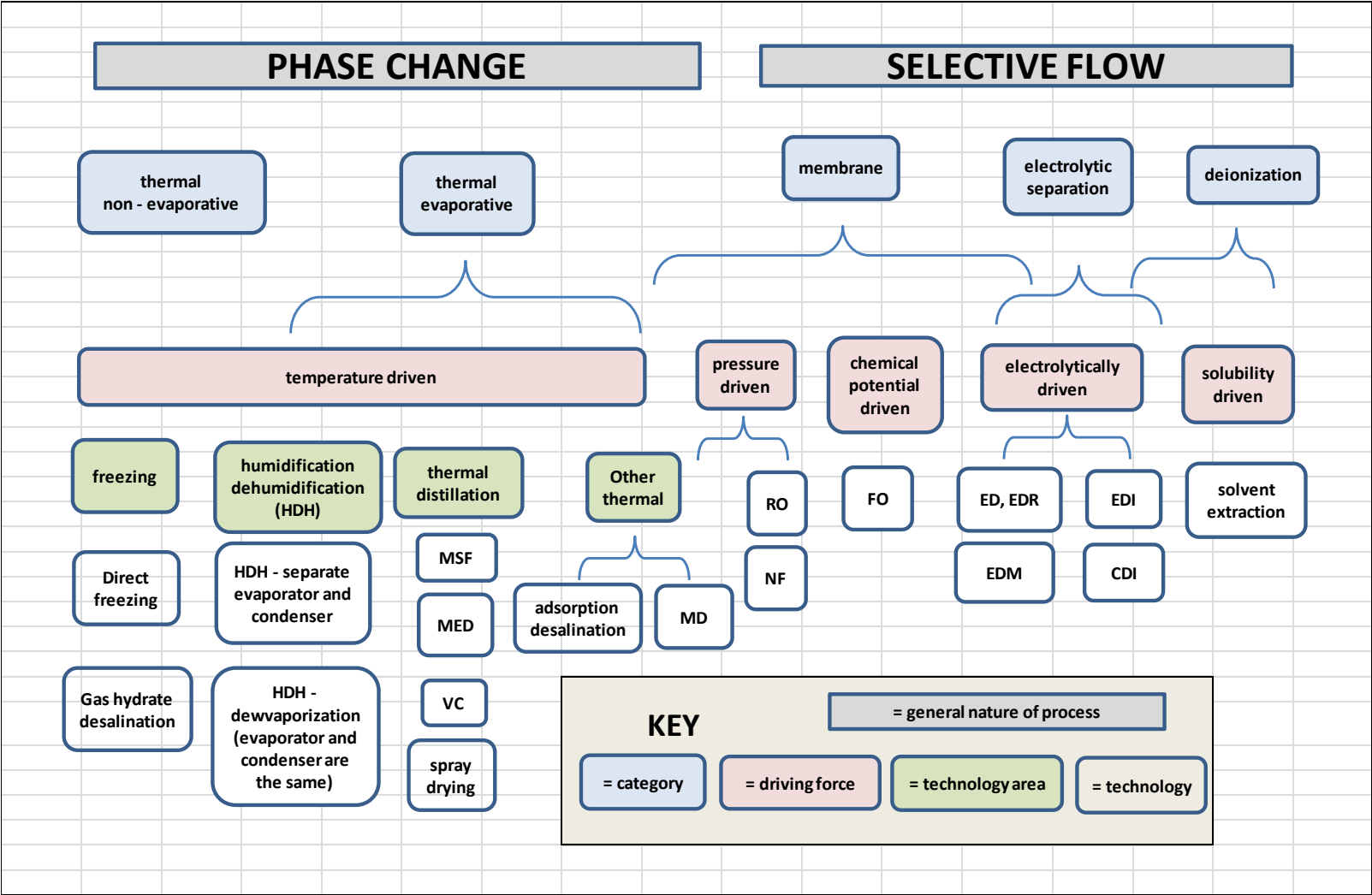


### **Significant amount of R&D involving**

- Many new companies
- New technologies
- Modifications of conventional technologies
  - Unconventional operation and configuration of RO & EDR systems

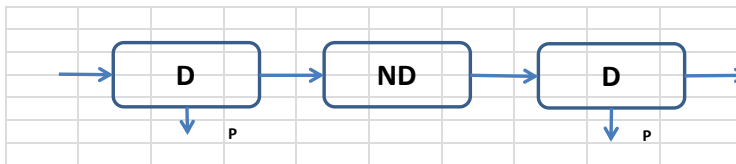
# Brine Management Desalination Technologies

(includes newer technologies and modification of older technologies)

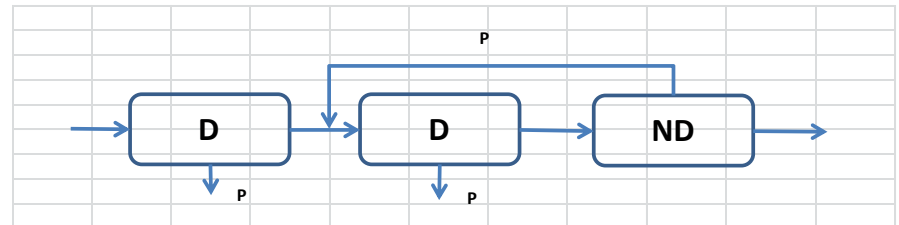


# Technologies vs. Processes

- In addition to desalination technologies there are advances in pretreatment and in developing multi-step integrated processes.
- Processes (can include):
  - Integration of **DESALINATION** and **NON-DESALINATION** technologies
  - Integration of multiple **DESALINATION** steps
  - Linear processing sequences; non-linear processing sequences



linear

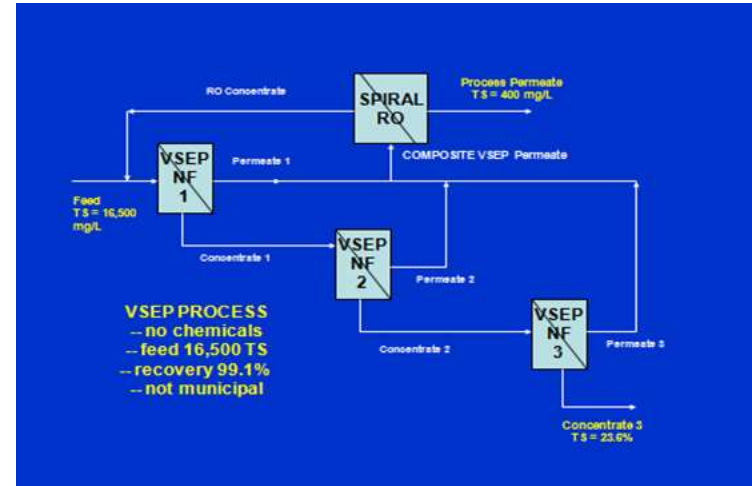
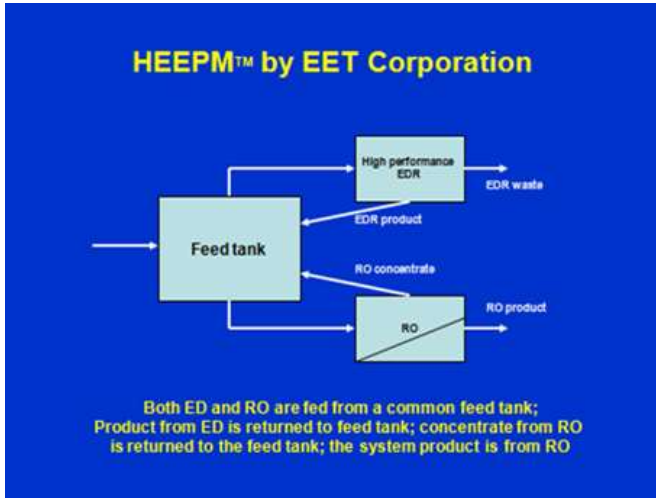


non-linear

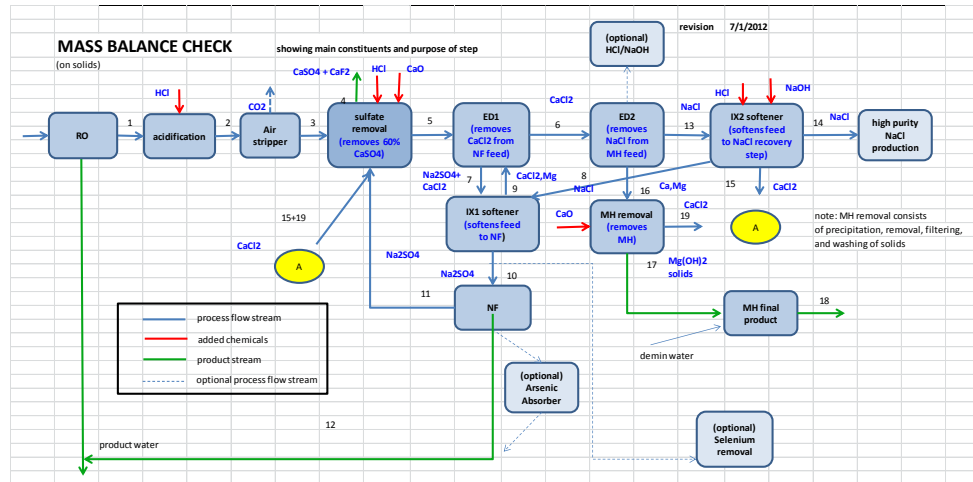
Most non-linear processes to date involve more conventional non-thermal desalination technologies AND are researched for the municipal market.

# Non-Linear Processes

(examples)



EDR  
RO



NF (3)  
RO



RO, ED (2), NF,  
IX, LS





# Selected List of Companies

(doing R&D in this area)

Klaren	Hydration Technologies Innovations
SolDeSal	Aquatech (AquaR2RO)
212 Resources	EET Corporation (HEEPM)
SaltTech	Desalitech
Purestream Technology	New Logic Research (VSEP)
ZanAqua Technologies	Nanyang Technical University (EERO)
Vacom Systems	CH2M MAX RO)
Aqua-Pure Ventures	OsmoFlo (Brine Squeezer)
AquaExplorer	King Lee Technologies (Tandom RO)
Saltworks	ROTEC (RORO)
Gradiant	O'Brien & Gere (ARROW)
Altela	Aveng Water (HIPRO)
TMW Solutions	Adionics
TerraWater GmbH	Solex
MAGEWater Management GmbH	CryoDesalination
Creative Water Technology	EFCseparations
WaterVap	GE
Heartland Technology Partners	GE_Ionics
Memsys Clearwater	MEGA
Aquaver	Veolia (EDM)
Ceramipore	Evoqua Water Technologies
SolarSpring	MEDAD (adsorption desalination)
MemStill	Atlantix Technologies
Oasys	Voltea B.V.
Trevi Systems	Enpar
Porifera, Inc.	Aqua EWP
Modern Water	TPTec

# R&D Directions and General Status

- **Common R&D thrusts for new or modified technologies:**
  - Re reducing CAPEX:
    - Increasing water recovery of desalination steps
    - Use of plastics and resin-based materials of construction
      - Light weight materials also decrease installation costs
    - Modular construction to facilitate scale-up
  - Re reducing OPEX:
    - Linkage with waste heat and solar
    - Increasing heat transfer efficiency
    - Reducing /eliminating use of pretreatment chemicals
- **But...**
  - New companies have had little impact; many still trying to find their niche
  - Depressed economy; Low oil & gas prices
  - Less costly (temporary) options found (examples: Marcellus Shale; Australian coal seam gas)
  - Other reasons (example China and CTX market)
  - **High potential still exists & new technologies ARE coming**

# Technology Evaluations

## CAUTION

- **Development status of a technology depends** not only on the technology principles BUT also on:
    - Driving forces that create markets
    - State of the economy
    - Company particulars:
      - Position on commercialization path
      - Piloting/demonstration/commercial plants
      - Market strategy
      - Other factors
- Funding to date  
Management team  
Intellectual property
- **Performance and cost of HR and ZLD processing** are highly dependent on the water quality being treated. Generalizations on performance and cost are speculative.
  - **Most relatively new companies** with new technologies or modification of conventional technologies:
    - Have limited technical data from which to evaluate technical factors; limited data based on bench-scale testing or limited pilot testing
    - Have limited experience with treating a wide range of water qualities and field conditions.
    - → **optimistic to exaggerated statement of performance and cost capabilities**

# CAUTION ON WASTE HEAT USE CLAIMS

- **Benefit: energy costs may be lower (energy requirements are not lower).**
- **Linkage of desalination process is often assumed by companies with technologies in development phases – without including associated costs in OPEX listings.**
- **There are several issues that can limit realization of the benefit:**
  - Type of waste heat
  - Amount of waste heat
  - Quality - temperature
  - Availability (not likely in remote areas; not always available in location of need)
  - Cost

# TAKE-AWAYS

- **1 – HIGH CONSTRUCTION AND PROCESSING COSTS**
  - **Limits implementation at municipal sites**
  - Markets overwhelmingly industrial
- **2 – INCENTIVES FOR NEW PLAYERS**
  - Potential new markets (primarily unconventional O&G)
  - Potential for reduced costs (CAPEX and OPEX) to expand any market
  - Result:
    - **Many companies with scattering of newer technologies and modification of conventional technologies**

# TAKE-AWAYS

- **3 - TWO GENERAL GROUPS DOING R&D**
  - **Very large group**
    - New companies
    - Newer technologies and modification of thermal technologies
    - Focus on non-municipal markets
  - **Small group**
    - Companies already providing services to municipal desalination
    - Focus on municipal market
    - Innovative use of membrane processes (RO, NF, ED)
- **There are, of course, exceptions to this grouping**

# TAKE-AWAYS

- **4 – MAJOR CURRENT MARKETS**
  - Power (cooling tower blowdown & flue gas desulphurization – FGD)
  - Produced water (conventional and unconventional plays)
  - Coal to liquids (in China)
- **5 – MARKETS HAVE NOT SIGNIFICANTLY INCREASED**
  - Depressed economy
  - Low prices of oil and gas
    - **Anticipated wastewater applications slow to evolve**
  - Slow implementation of high recovery and ZLD processes due to lower cost, interim, or temporary solutions.

# TAKE-AWAYS

- **6 – NEW COMPANIES HAVE MADE LITTLE IMPACT**
  - Many companies have not yet established a strong track record demonstrating performance and cost capabilities.
  - Many companies struggling to find market niche.
- **7 - HIGH POTENTIAL REMAINS**
  - Growing applications within the O&G industry
  - Continued and increasing regulatory pressure that limit other wastewater disposal options
  - **Industries increasingly considering recycle – particularly in regions of limited water resources and drought**
  - **New and modified brine management technologies can lower CAPEX and OPEX and significantly affect the market place – including municipal applications**



# TAKE-AWAYS

- **8 –IMPACT ON THE MUNICIPAL SECTOR**
  - **Short-term: from processes being developed by companies (engineering and equipment) already supplying services to the municipal sector.**
    - Improved RO/EDR recovery in treatment of lower salinity feed water
      - Modifications/use of RO and EDR technologies
      - Modifications/use of pretreatment technologies
  - **Later: technologies and processes being developed for other industries**

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