Operating model and innovative technologies for the sustainable future of the private desalination industry:

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SAWACO Water-Desalination

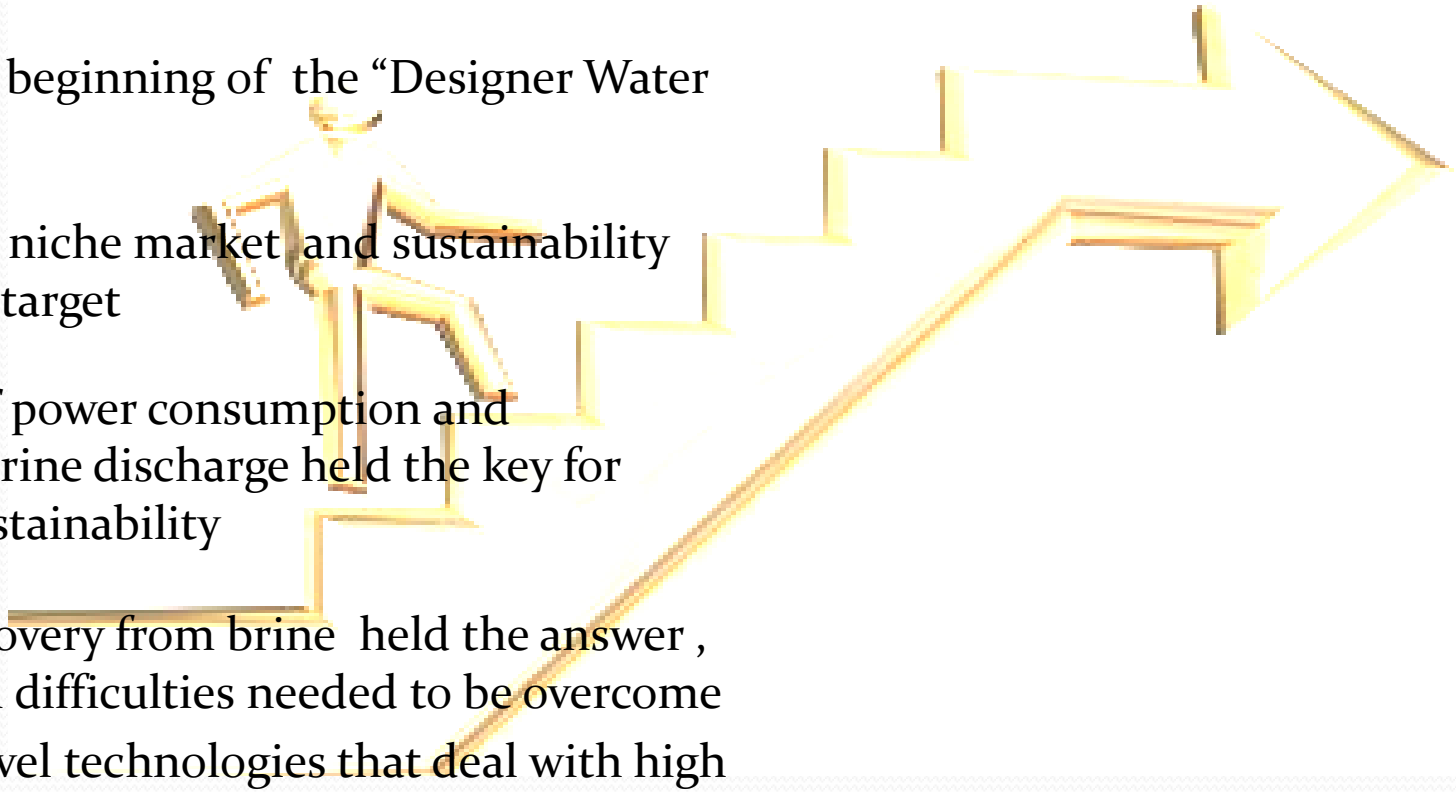
- SAWACO -Water Desalination is among the first private water utilities in K.S.A. License granted in 1999.
- SAWACO operates and maintains its own and third party desalination plants in addition to its water transportation fleet and pipelines
- Current production capacity exceeds 32,000 m^3 /day distributed between 3 sites on the Red Sea- 5,000 m3 expansion to come on stream by May 2014 and another 10,000 m3/day by Q2 2015
- SAWACO produces and distribute different grades of water to a variety of industrial , commercial and domestic users.
- SAWACO returns around 64,000 m3/day of brine to the Red Sea (Opportunity!)

The Need for a New Approach

- SAWACO started its business when water was scarce in Jeddah.-Saudi Arabia.
- Recently, Government water supplies improved drastically due to new plants and networks
- Industrial Clients held the key for survival
- The answer was in designing water for different industrial needs
- Something government extensive /complicated networks cannot possibly achieve
- Hence the concept “Designer Water” was created
- This concept can be applied when industrial clients are clustered anywhere in the world
- This is a concept that is infrastructure-resistant and water abundance-resistant!!

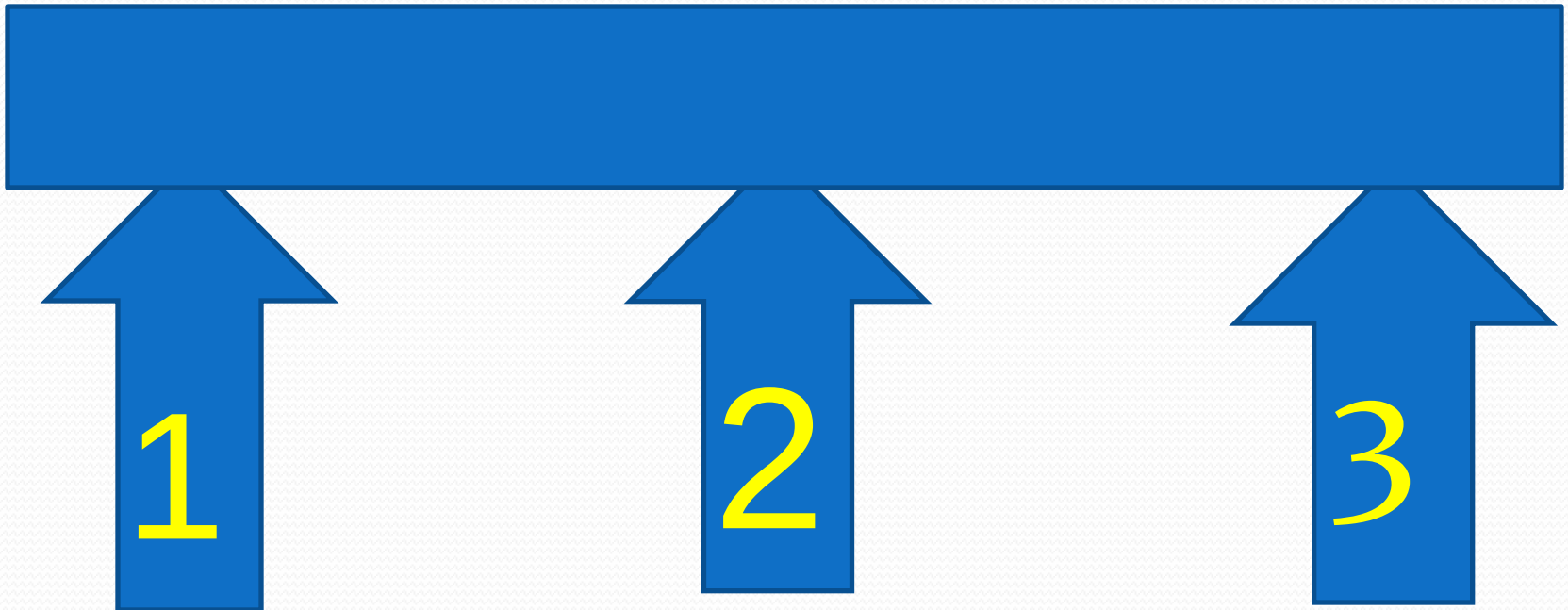
More Needed to Be Achieved

- O&M capabilities + Good analytical skills + expertize in water treatment = customization of water
- That was the beginning of the “Designer Water “concept
- We created a niche market and sustainability was the next target
- Reduction of power consumption and controlling brine discharge held the key for achieving sustainability
- Resource recovery from brine held the answer , but technical difficulties needed to be overcome
- Adopting novel technologies that deal with high salinity at lower power consumption needed to be investigated



Three Pillars for Seawater Desalination
SAWACO WAY

- **Designing Water using traditional and Innovative Technologies for diverse applications**
- **Sustainability : lower power consumption and resource recovery from brine**
- **Deploying new innovative technologies to improve efficiency**



1-Design Water to Suit All Needs

- SAWACO uses its own O&M techniques to produce several grades of water
- Always searching for new technologies to enhance water customizing capabilities
- ESD by Enpar (Ontario) is currently piloted to produce pure and possibly ultra pure water

1.1 O&M Capabilities: first ingredient

Beach Well

Ultra Filtration

Raw Tank

Feed Tank

Cartridge Filters

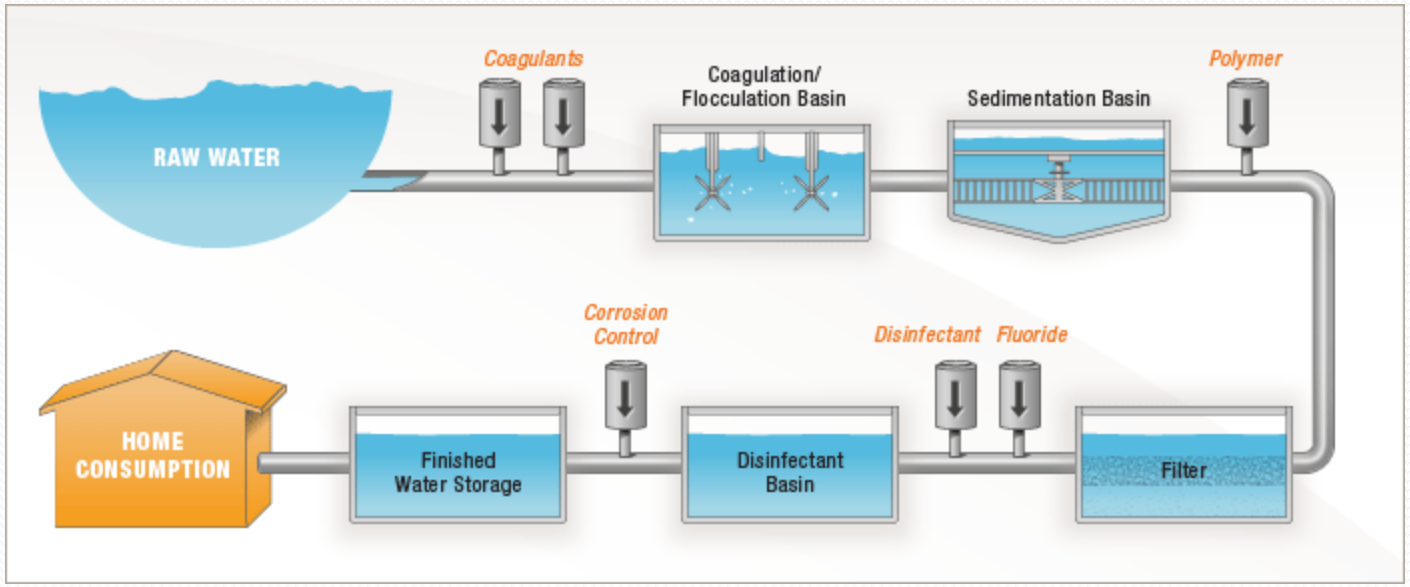
High Pressure Pumps

Reverse Osmosis

Product Tank

1.2 Good Labs Facilities : second ingredient

1.3 Expertize In Water Treatment : third ingredient



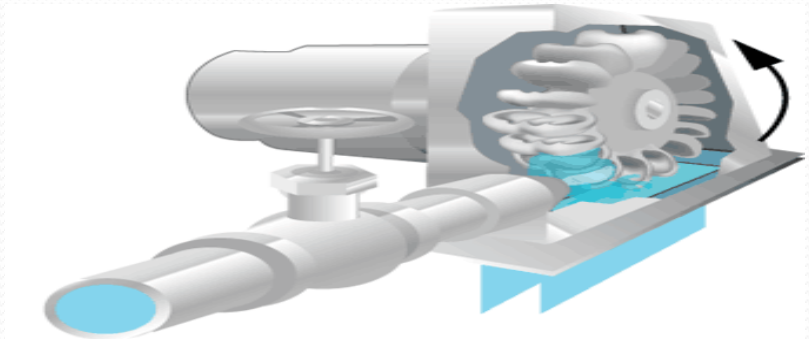
1.4 “Designer Water” : designs to suit all tastes!

SAWACO Produces 10 different types of Water

Water Type	TDS Value in ppm	PH
Type I	280<TDS<350	7.0 <pH<7.8
Type II	200<TDS<250	6.8<pH<7.5
Type III	150<TDS<200	6.5<pH<7.5
Type IV	100<TDS<150	6.3<pH<7.5
Type V	50<TDS<100	6.3<pH<7.2
Type VI	25<TDS<50	6.0 <pH<7.2
Type VII	TDS<10	6.0 <pH<6.5
Type VIII	280<TDS<350	Zero Chlorine
Type IX	280<TDS<350	8.0 <pH<9.2
Type X	280<TDS<350	High Chlorine - 1 ppm

2- Sustainability

- Energy recovery devices are common place in the RO industry and operators are spoilt for choices :
  - Turbo Chargers
  - Pelton Wheel
  - Pressure Exchangers etc.
- Low –energy high- surface membranes help too
- However, Power Consumption remains excessive
- Two third of filtered high -salinity water still go back to the sea
- Recovering this “wasted” water and its resources held the key to a novel overall power reduction in addition to other tangible benefits



2.1- Resource Recovery from Brine

- Water, Salt and Bittern can be extracted theoretically from Brine
- Key considerations :
    1. Lower energy consumption per m3 of water recovered from Brine shall reduce the overall average power consumption (Kwhr /m3)
    2. Economical recovery of Salt and Bittern
- The Benefits are quite attractive :
    1. Economically
    2. Environmentally
- Traditional technologies are :
    1. either energy intensive hence untenable
    2. or in need of large space
- The solution lies in a new innovative technology that requires reasonable space and is power-efficient

2.2 Sustainable Green Opportunity !

- SAWACO could not recover water and salt from brine using existing technologies
- SAWACO requested a Japanese technology provider to research recovering water and salt from Brine through Nanomist technology.
- Saudi Arabia demand for salt is expected to increase due to industrial and population growth.
- Ideally , SAWACO would build a 5,000 t/d water and salt recovery plant using Nanomisting. Up to 350-400 t/d salt would be recovered in addition to 3720 m3/d of potable water !

3 –New Innovative Technologies Selected To Achieve our Goals

Three new technologies are considered :

- Nanomisting (Japan)- MOU Signed, Piloting Started
- ESD by Enpar (Canada)-MOU Signed , Pilot Plant in the Assembly Stage
- Gradiant (US)- Negotiations in Advanced Stage

I-Nanomisting

Step 1. A 10 t/d Demo test plant : A 10 t/d demo plant will be built, operated and evaluated

Step 2. Transfer 10 t/d demo plant to SAWACO Plant: The demo plant will be transferred to Jeddah, KSA. The reoperation and reevaluation will be carried out at SAWACO Plant

Step 3. Build a 1,000 t/d BOT plant in KSA.: The JV will build and operate for 10 years a 1,000 t/d plant in SAWACO Plant . Salt, bittern and Potable water will be produced.

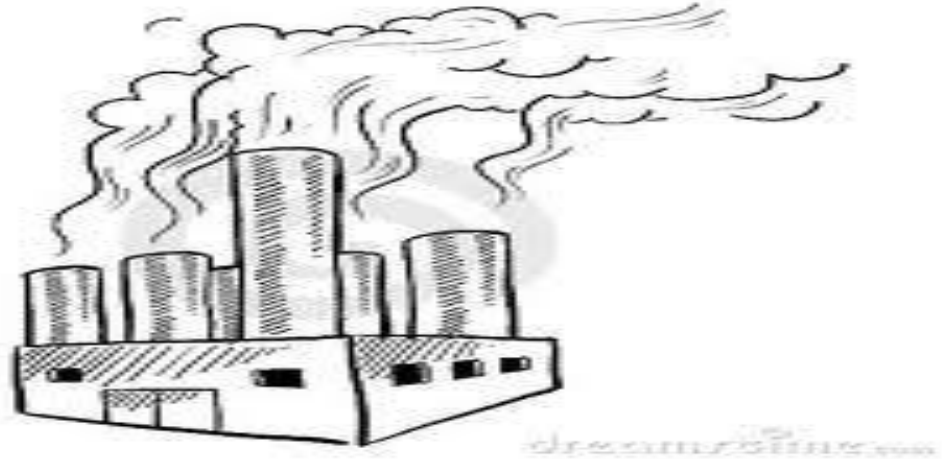
Step. 4. Scale up to 5,000 t/d

The 1,000 t/d plant will be upgraded to 5,000t/d plant at an agreed depending on market conditions

The 1000 t/d Production Stream

1000 t/d Brine Water (7% salt content)

Electricity 0.6 – 3.0 KW/t*



744 t/d
Fresh water

56 t/d
T Salt

14 t/d
bittern**

*Technology Provider will be evaluating the use of Ultrasound (3.0 KW/t)or Electrostatic (**0.6 KW/t**).

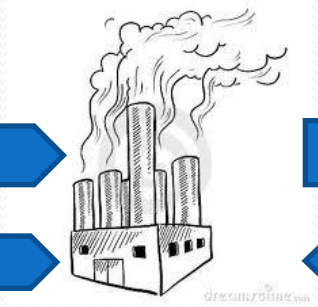
** Magnesium Chloride

The 1000 t/d BOT Mechanics (Step 3)

SAWACO

Brine water 1,000 t/d (free)

Electricity (Free)



Bittern Salt 14 t/d

Manager

Offtaker

Fresh Water 736 t/d

Table Salt 56 t/d

Bittern production to be exported to Asia

- The BOT period is x years.
- After x years, plant Title/Management/Operation will be transferred to SAWACO

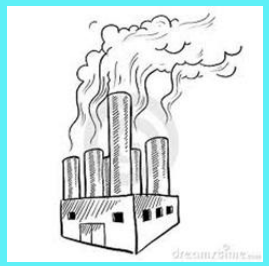
The 5,000 t/d Opportunity

Current
SAWACO

5,000 t/d Brine water into Red Sea

OR

Future
SAWACO + TECH PROVIDER



+ Electricity 0.6-3.0 KW/t

5,000 t/d Salt & Water recovery plant

3720 t/d Fresh water $x/t

280 t/d Salt $y/t

70 t/d bittern $z/t

=

$α Million/ year

Resource Recovery : Green + $

- There is a technological solution to treat brine water, and produce valuable commodities.
- The economics reflect profitable returns due to: 1- zero value based feedstock, 2- high market pricing for production line, and 3- technological edge.
- Pursuing this opportunity by a desalination plant tremendously improves its returns, and competitiveness.

II- Electro-Static Deionization

The Removal of Total Dissolved Solids with High Water Recoveries and High Ion Removal Efficiency

Enpar Technologies Inc.

SAWACO

ESD vs Membrane (RO)

(Comparison is for drinking water quality)

ESD	Membrane (RO)
Up to 95% water recovery (WR)	70 -75% WR 1st stage 85% WR 2nd stage
$0.06 per m^3	$0.08 – 0.16 per m^3
No water softening required	Water softening required
Low maintenance	High maintenance
Total ion removal OR selective to monovalent ions	Total ion removal

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Heart of the ESD System – CDI Cell

Carbon Electrode

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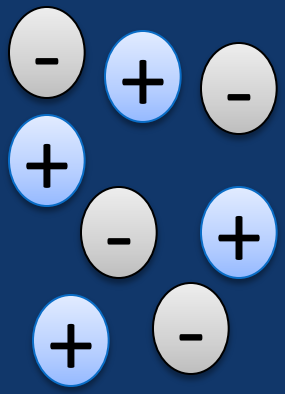
Operation - Purification



Contaminants

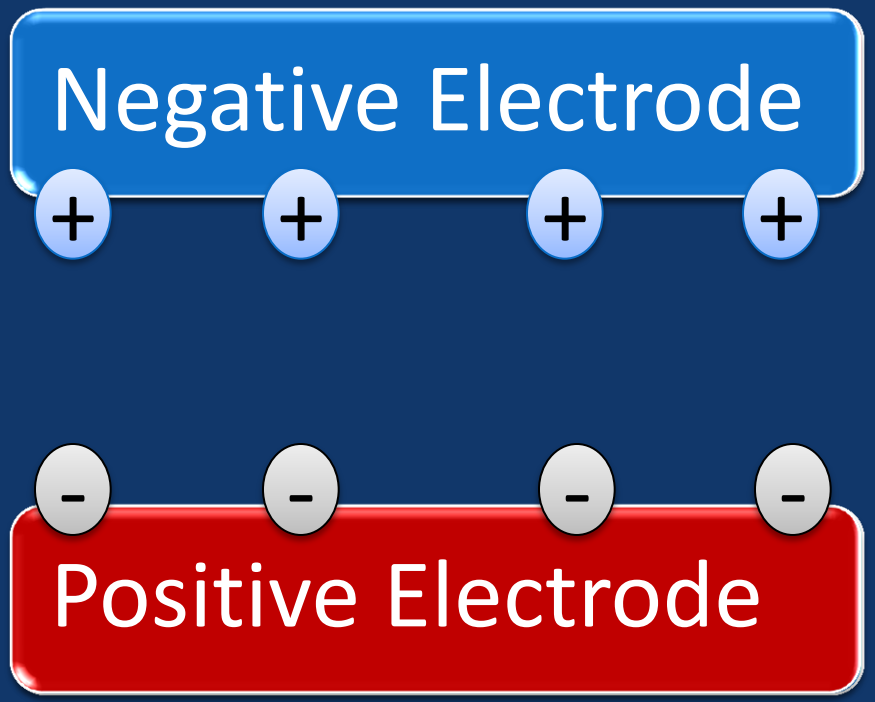
Negative Electrode

Positive Electrode

- U = 1.2 V

Operation - Regeneration

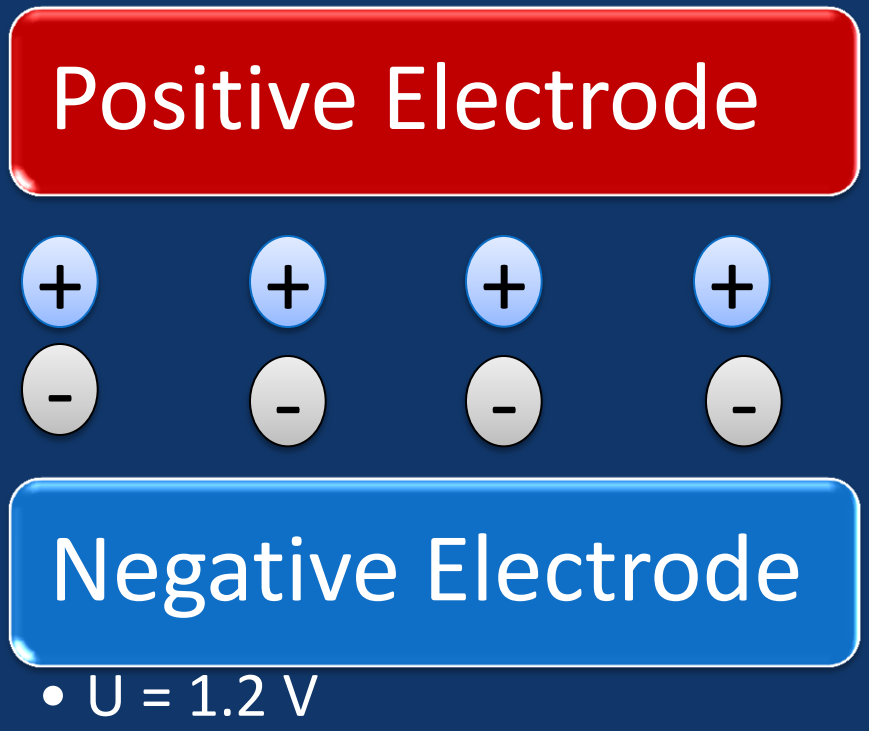
- The polarity is reversed.
- Ions move away from the electrodes.



- U = 1.2 V

Operation - Purge

- During the purge the ions are removed as a small volume of concentrate.



Full Scale ESD 112K Module (Korea)

Module contains 36 cells

Capacity: 112 – 150 m^3 per day

enpar Technologies Inc.

SAWACO

Full Scale ESD 100K Module

City of Guelph

Module contains 36 monovalent cells

Capacity: 100 – 140 m^3 per day

Enpar Technologies Inc.

SAWACO

III - Gradiant Corp HDH CGE

-High TDS ZLD: What is the ideal technological solution?

Technology	Max. system TDS	Recovery @ 120k TDS	Feasible System size	Cost	vs. Gradiant
Reverse Osmosis	70,000	N/A	Flexible	**N/A**	Very low TDS
Forward Osmosis	220,000	30-40%	Flexible	**Medium**	Low recovery, high Opex
Membrane Distillation	250,000	40-50%	>2000 bbl/d	**Medium**	Low recovery, high pre-treatment
MVR	250,000	40-50%	>2000 bbl/d	**High**	Low recovery, High Capex, Large size
Vacuum distillation	250,000	40-50%	>4000 bbl/d	**High**	Low recovery, High Capex, Large size
Crystallizer	270,000+	>80%	>2000 bbl/d	**Very High**	Very high cost, large size
Carrier gas extraction	270,000+	>80%	Flexible	**Low**	High TDS, high recovery, no membranes or complex machinery

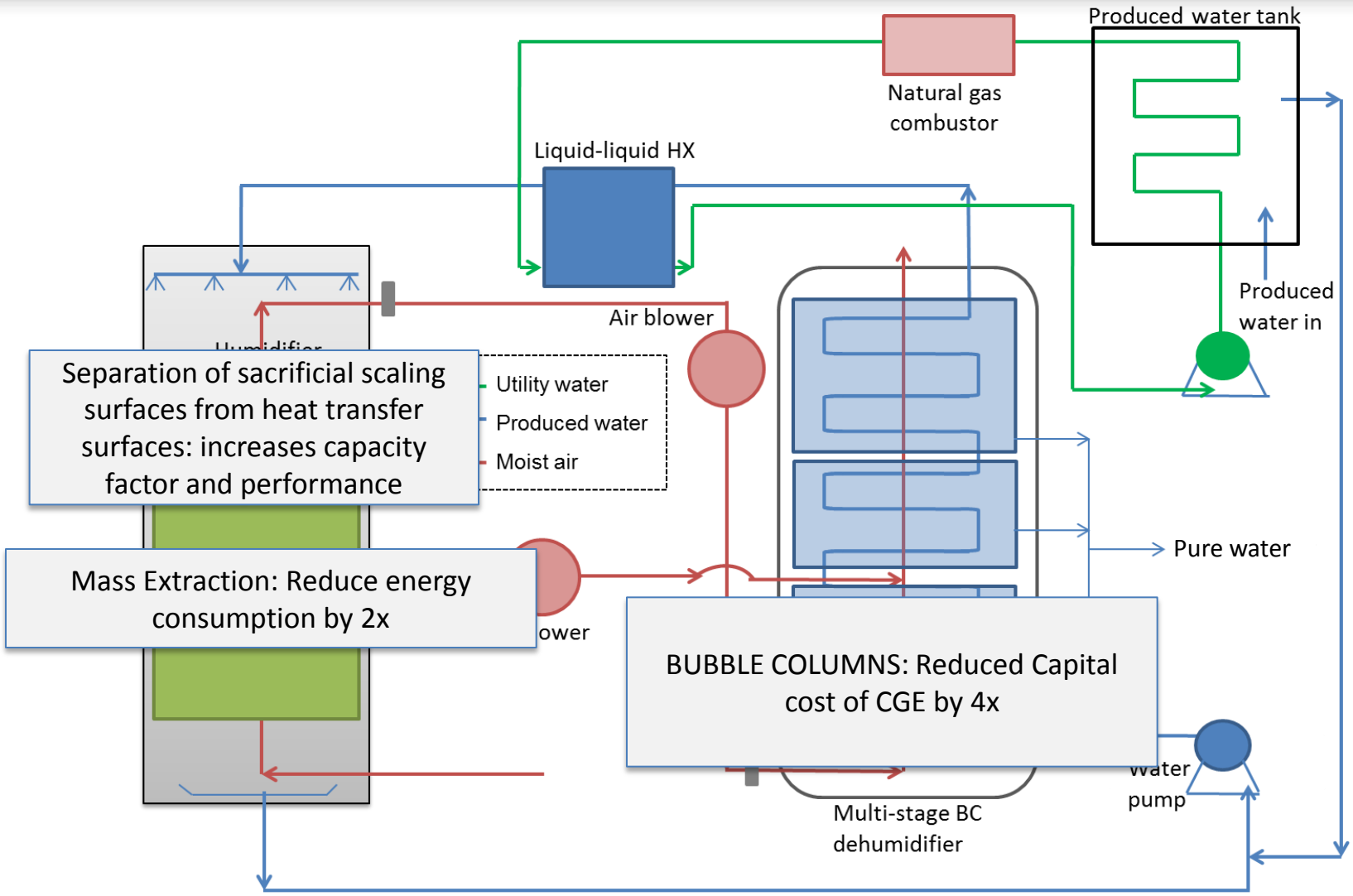
Inability to do high recovery and higher TDS

Very high cost, centralized systems

High recovery at high TDS, low cost, scalable

* TDS in parts per million

CGE technology is simple, membrane-less, and robust under high TDS water



Gradiant has 5 issued and 10 pending patents on CGE

** Produced water refers to saline brine*

GRADIANT CORPORATION

Commercial scale pilots demonstrated

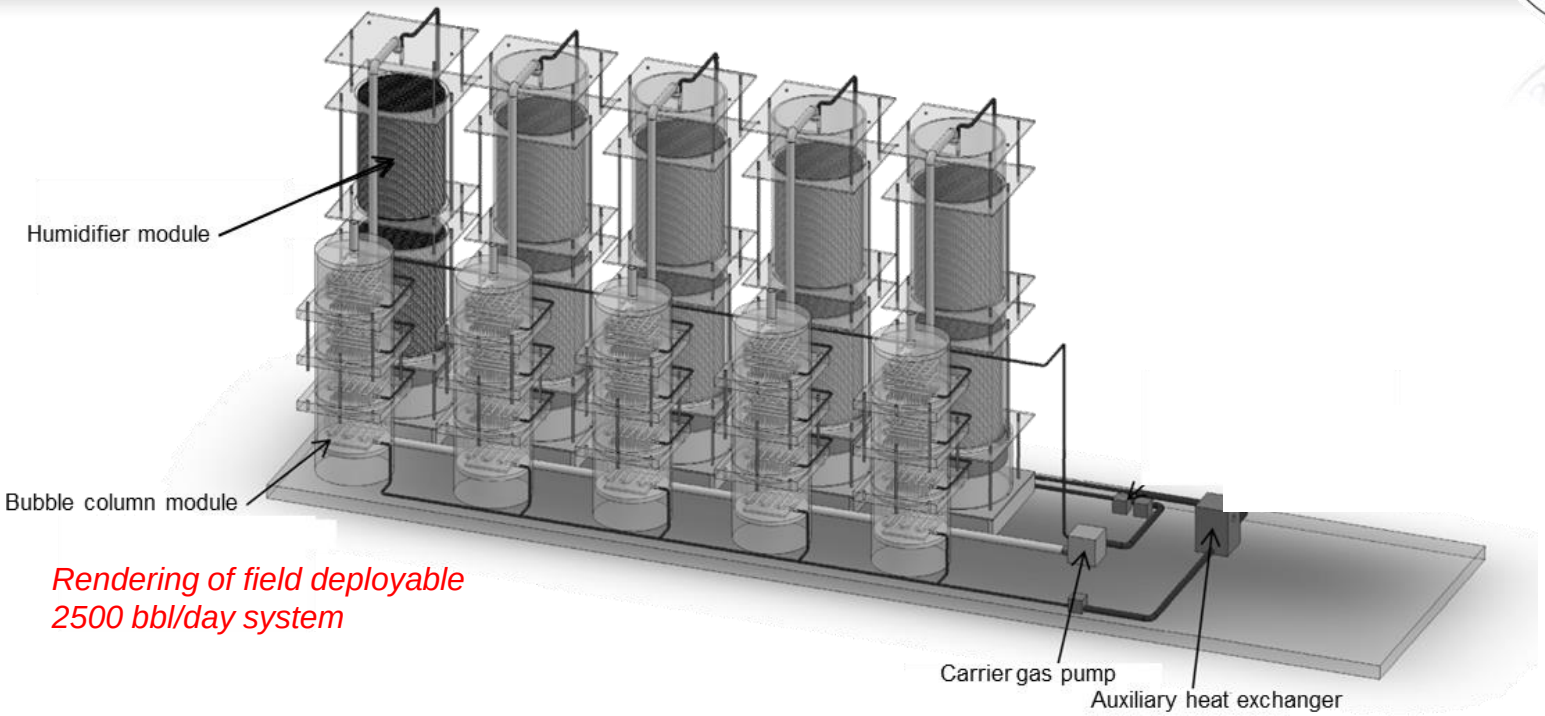
Photo: 10 BPD zero liquid discharge CGE™ lab system*

- **Extensive testing program**: 10 and 50 BPD pilots tested over 18 months
- Successfully treated varying water qualities of very high TDS water from different shale oil and gas play in the US (**Permian, Barnett, Eagle Ford**, Horton Bluff, Haynesville, Bakken, Marcellus, Lost Hills, Mississippian Lime, Niobrara)

Photo: 50 BPD industrial CGE™ system

* 6.29 BPD = 1 m^3 per day

Field deployable CGE™ pilot unit constructed



Rendering of field deployable 2500 bbl/day system

- To be tested by end-2013
- Skid mounted, **modular, scalable system** for varying water production rates
- 4000 bpd facility with 500 bpd modules
- Process can use **any source of heat at above 70°C**

The Future ….

- SAWACO will integrate these technologies into its core processes
- Focus on Feed and Brine Opportunities
- New-tech will transform SAWACO Plants into near ZLD
- Brine will be an important factor in our sustainability drive : recovery of water , minerals while reducing environmental impact and increasing revenues!!!
- New Operating Parameters will be added to SAWACO Log Books
- Enhancing the Water Designer Concept

Thank you

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