"Hybrid desalination systems a solution to environmental challenges"

Presented by

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LEADING EDGE TECHNOLOGIES

Water Reuse and Desalination

Experience and Opportunity

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- *The integration of energy –power and water and environment becomes more important today in coping with the increased costs.*
- *The desalination and power technology has to adapt to the new conditions and find solutions to produce plants with higher efficiency, performance ratios and minimizing the use of materials and eliminate pollution.*

Desalination is an energy and capital intensive process.

All major desalination technologies Multistage Flash (MSF), Multi-effect Distillation (MED and MED TVC), and Mechanical Vapor Compression (MVC) as well as Reverse Osmosis (RO) and Hybrids will be significantly effected.

No more it is practical to built distillation plants with Performance Ratio of 8 in the era of crude trading at

95 $/barrel=15.8$/MMBTU

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- **MSF reliable technology**
- **with Performance Ratio (PR) of PR 8-10.0, power consumption of 3.5 kWhr /ton of water, capital cost $7.50-$9.00 per IGPD. Unit size 16.7-20 MIGD**

- **MED rapidly growing,**
- **with PR-8 to PR-16, internal power consumption of 1.2-1.8 kWhr/ton, capital cost of MED from $7.00-$8.00 per IGPD.**
- **Unit size reached 8MIGD in Sharjah, new design for unit sizes 10-15 MIGD**

Improvements in distillation and membrane processes

- **TOP BRINE TEMPERATURE : The Increase of TBT can Allow Higher Production With Almost Same Desal Trains**
- **HYBRIDIZATION : The Application Of Hybrid Technologies (MSF + RO+NF, or MSF+RO+NF + MED) Can Improve Overall Efficiency**
- **THERMAL IMPROVEMENT : Better HTC , new materials, New MSF+MED Schemes And Ancillary Equipment.**

Potential for MED technology improvements

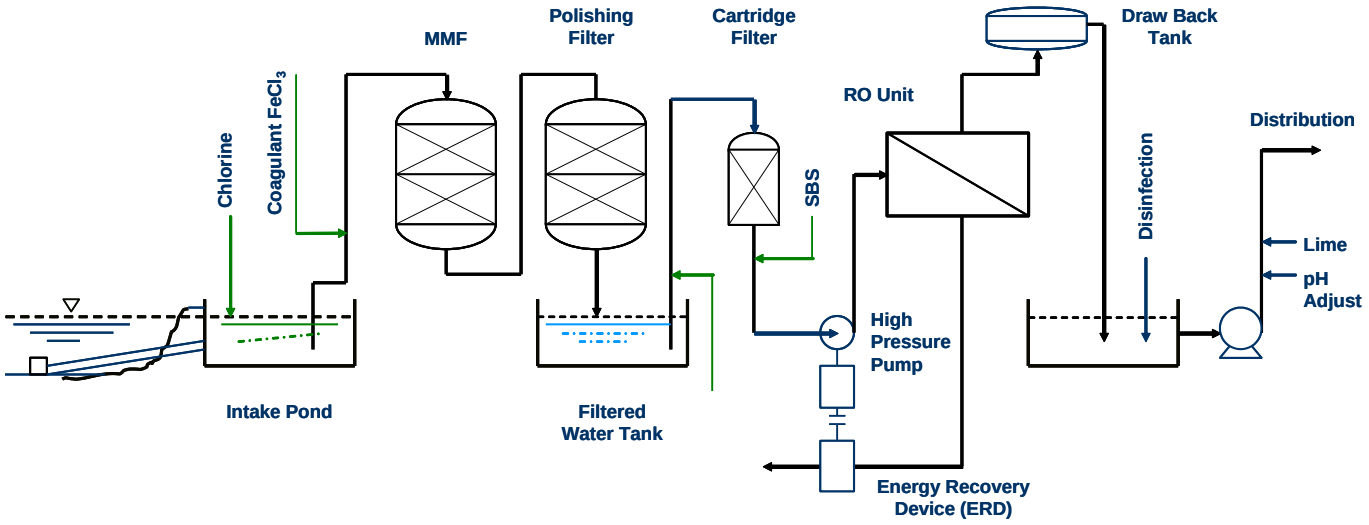
- Increasing TBT from 63° C to 80-100° C with Nanofiltration
- Increase efficiency to PR 12-16 from current 9.
- Increase unit size to 15 MIGD from current 8 MIGD
- Improve HTC by oval and corrugated plates
- Hybridize with MSF-RO-NF

- **Seawater RO is a mature technology with high degree of reliability with challenge on pre-treatment.**

- **Using electric energy recovery devices results in total plant energy requirements below 3.5 kWhr per ton of product.**
- **The capital cost of the RO plant today vary from $6.50-$7.5 per IGPD.**

Potential improvements for Reverse Osmosis.

On-going Activities to Reduce Costs



Beach Well	MF/UF	High Efficiency ERD	Boron Resin
Infiltration Intake	Submerged MF/UF	High Flow or Thicker Spacer RO Elements	
Intermittent Chlorination	DAF	High Recovery RO System (Single Stage or BCS)	
Co-location Power Station	Bio-filter	Large Diameter RO Elements	
Mix BW with SW		NF - NF or NF - RO Hybrid	

ERD: Energy Recovery Devices DAF: Dissolved Air Flotation BCS: Brine Conversion System

Integrated hybrid

- **Blending distillate and membrane permeate will reduce requirements on Boron removal by RO.**

- **The RO and NF membrane life can be extended. (12 years)**

Integrated hybrid environmental benefits

- Cool RO Reject and Feed to be used as a cooling source for heat reject section of distillation plants.
- The blend of reject stream from RO with warm seawater and blowdown from distillation or power plants reduces heavy density plume of RO outfall.
- Blend of RO permeate reduces temperature of distillate.
- A common, smaller seawater intake & outfall.

THE SEWA LET INTEGRATED UPGRADING

- DESIGN TO INCREASE 44% THE CAPACITY OF EXISTING MSF FROM 5 MIGD to 7.2 MIGD, ACHIEVED 50 % to 7.5 MIGD
- MIMIMUM FOOT PRINT, NO ROOM FOR NEW DESALINATION PLANTS
- REDUCE OPERATING COST
- NO CHANGES TO INTAKE STRUCTURE
- NO INCREASE IN POWER FACILITIES
- CUTTING MSF CAPITAL COST FOR ADDITIONAL CAPACITY BY 40%

Benefits of Nanofiltration

- **PREFERENTIALLY REMOVES SCALING (DIVALENT) IONS**
- **ALLOWS HIGHER TOP BRINE TEMPERATURE FOR MSF (121 vs. 110 °C AND FOR MED (100 vs. 63-75 °C)**
  - **Higher Flash Range Increases Production and Efficiency**
  - **Reduced Capital Costs**
  - **Reduced Operating Costs**

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MSF 5MIGD Layyah Plant subject of Integrated Upgrading

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Layyah Integrated Upgrading the NF System

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NF SOFTENING SYSTEM

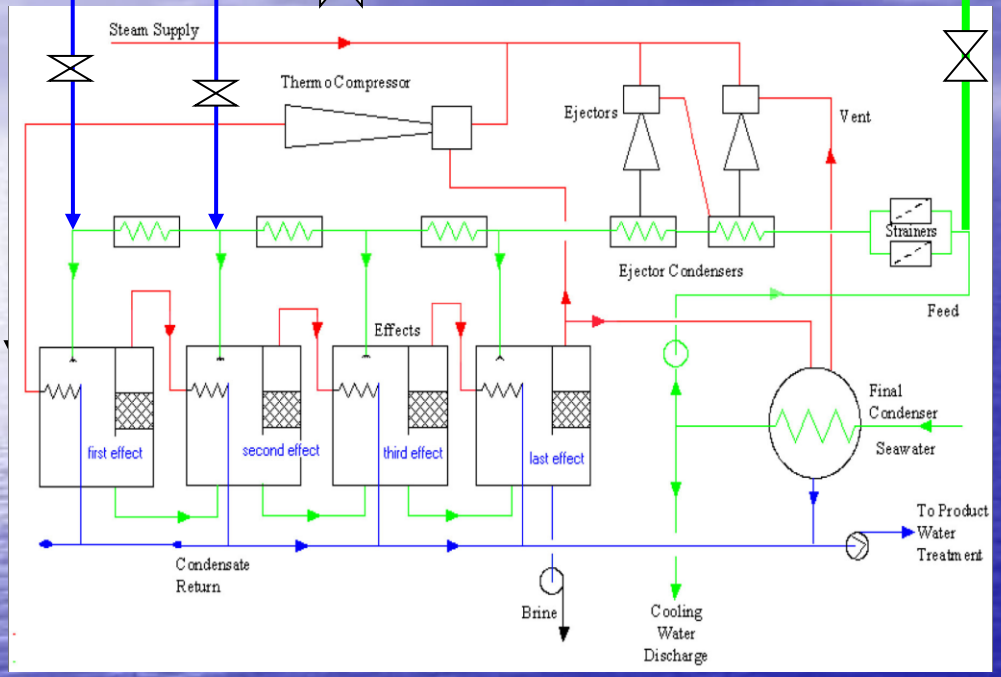
Reject from softening to outfall

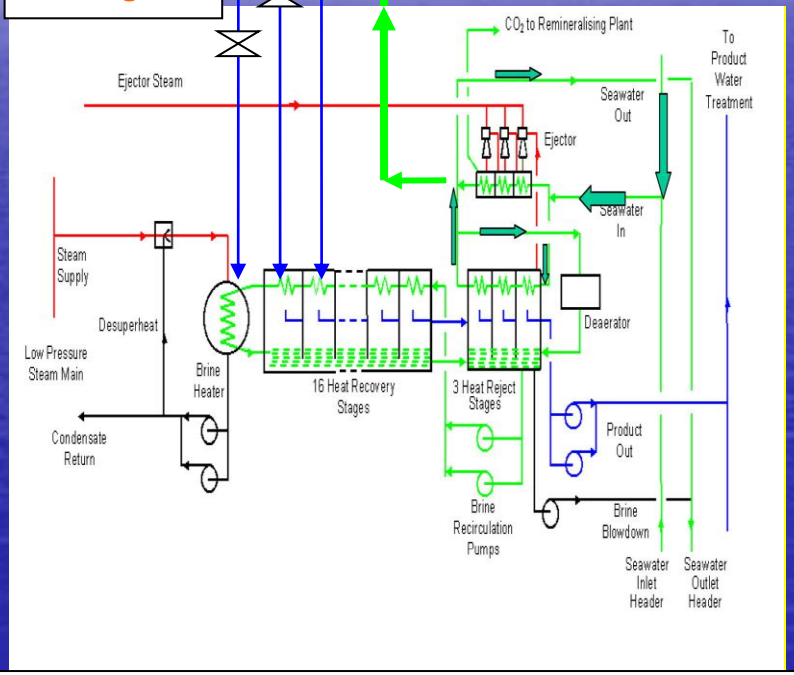
Softened feed to high temp. MED effects

Seawater to softening

Softened feed to high temp MSF Stages

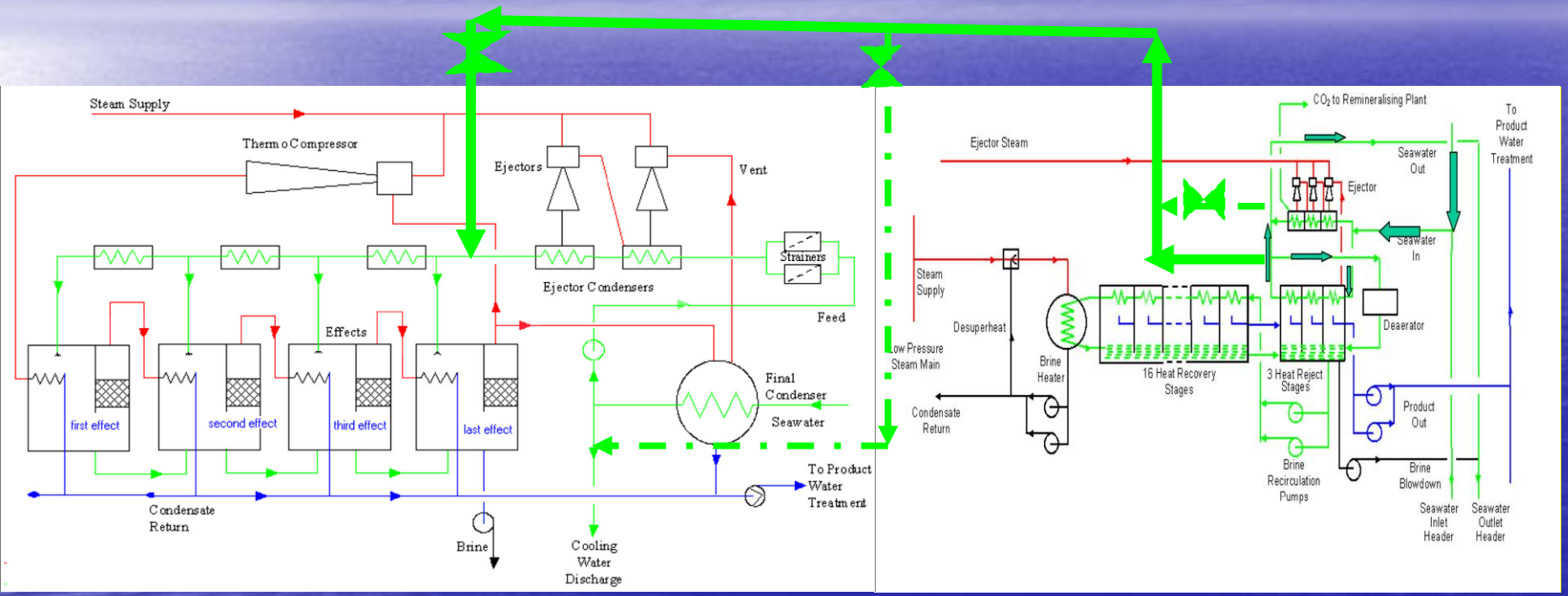
Seawater to softening





Process and apparatus for partial blending of softened feed to high temperature effects of MED and/or high temperature stages of MSF, in order to increase TBT and Flow of Recycle or Feed

Warm Seawater HYBRID
Discharge from MSF as source of Heat and Feed to MED process.



Flow diagram of heat and seawater utilization from seawater of MSF Reject section to feed MED-TVC

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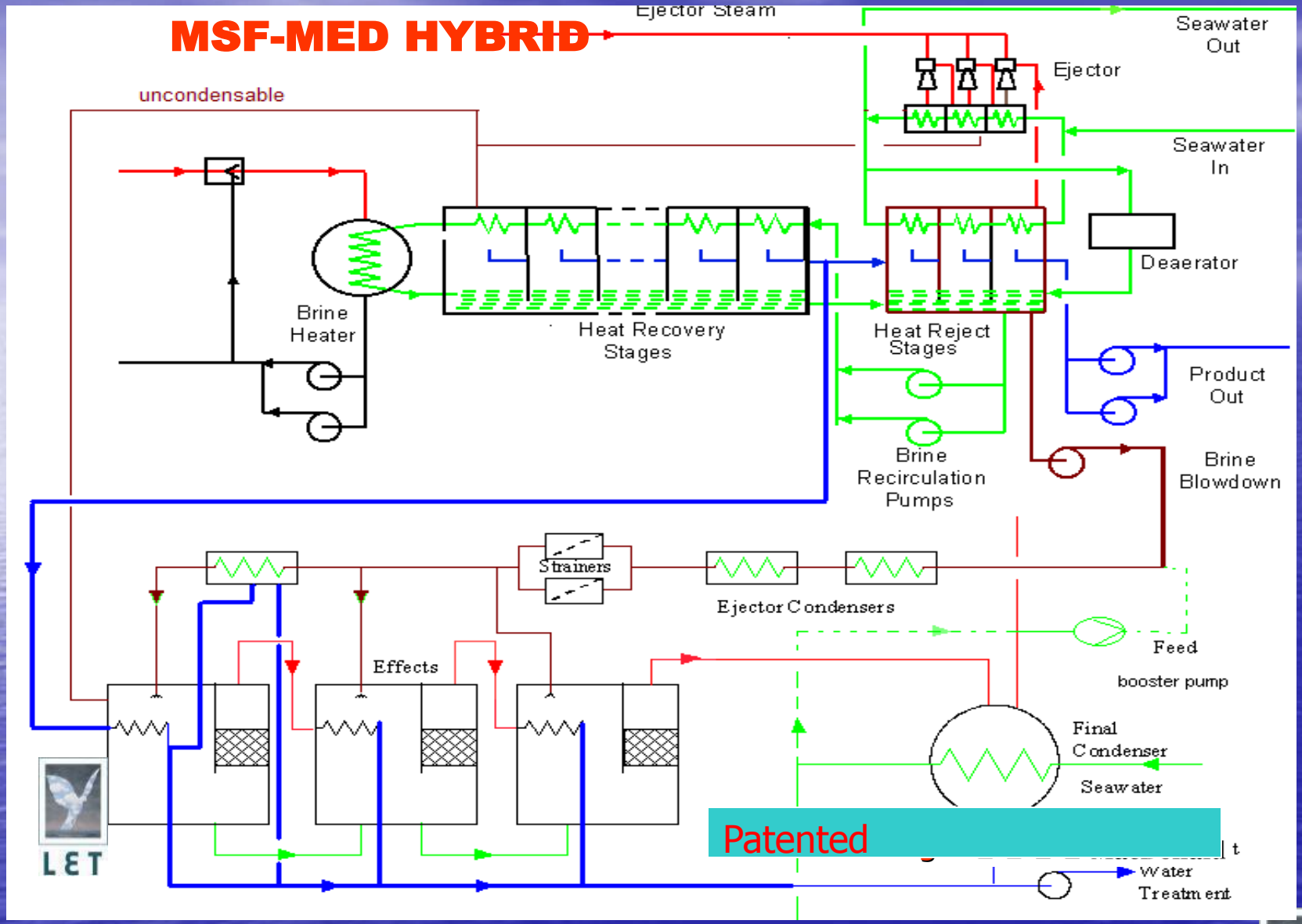
MSF-MED HYBRID



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DESALINATION and WASTE WATER AQUIFER STORAGE AND RECOVERY (DASR) and (WASR)

- The concept has critical importance to strategic storage of water for security
- It has clear economic benefits taking advantage of idle power
- Has an impact on cost of pipeline transmission from coast to Riyadh in saving power during peak demand as well as security

HYBRID SYSTEMS AND DESALINATION AQUIFER STORAGE AND RECOVERY (DASR)

DASR - Creating the Additional Water

- Electricity demand drops to 30-40% of peak during the winter months
- As a result, over 50% of power generation capacity of power-desalination plants is idle
- This idle power can be used to produce low-cost water (above normal demand) using nano-filtration and other membrane desalination technologies

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Schlumberger

Environmental Challenges in Power Desalination Projects

With Kuwait use of crude or residual oil for majority of power -desalination projects the main environmental aspect will require consideration of carbon tax or credit imposed by Global Climate treaty.

1. Stack emissions- seawater scrubbing
2. Efficiency of the power-desalination
3. Seawater thermal and effluents pollution

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Use of seawater in flue gas desulfurization

- In most cases, the natural alkalinity of seawater is relied on in a single-pass system. The use of seawater alone requires a very large flow to remove a high percentage of the sulfur dioxide.
- Flakt process comprising adding to the seawater calcium based alkali subsequent to the absorption, and then introducing into a decarbonation/oxidation reactor to which an oxygen-containing gas is supplied in order to oxidize sulfur oxides in the seawater and to strip carbon dioxide from the seawater.
- When the seawater has been removed from the decarbonation reactor, calcium based alkali is again added to the seawater in order to increase its pH.

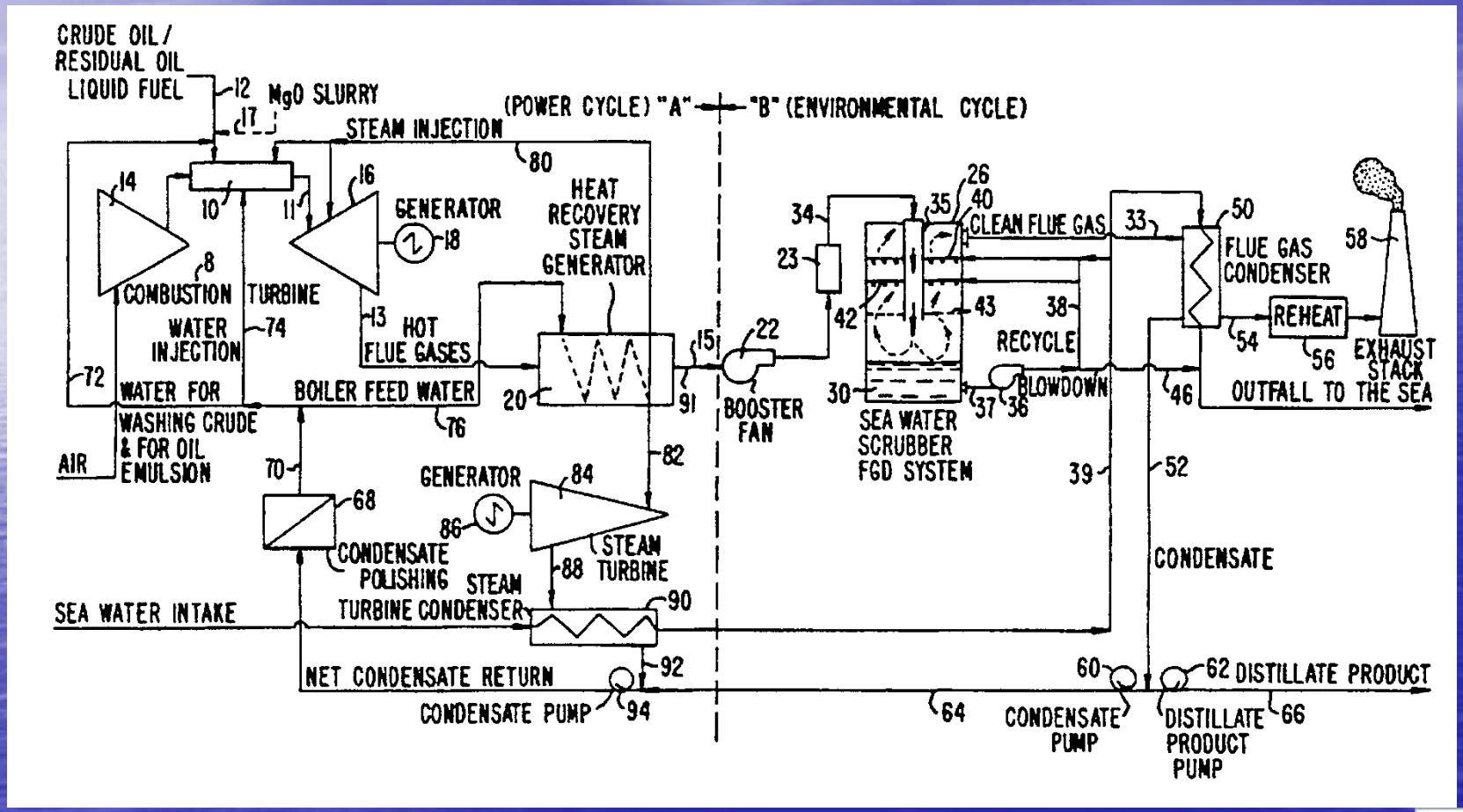
Original Flakt Process by Arne Ellestad et al US Patent 4,337230 June 1982

Integrated use of seawater in flue gas desulfurization

- Efficient removal of SO_2 from a flue gas is achieved in a scrubber using a recirculating aqueous stream with magnesium hydroxide and magnesium sulfite act as absorbents
- They are product of a reaction between soluble magnesium from the seawater and calcium hydroxide added to the scrubbing system.
- After oxidation magnesium sulfate is converted back to magnesium hydroxide by reaction with additional calcium hydroxide, with gypsum as a by-product.
- Gypsum is soluble in large amounts of seawater and may be returned to the ocean without adverse environmental impact.

J. Abrams , L. Awerbuch United States Patent 4,804,523

Combined Power Environmental Cycle



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Combined Power Environmental Cycle

- The Awerbuch et al PCT Application WO 94/16992 invention discloses a combined power environmental cycle utilizing crude or residual fuel oil for gas turbine where and compares to utilities using inefficient steam cycle to produce power and desalinated water.
- The invention provides seawater scrubber to clean the flue gas exhausted from the gas turbine and concurrently producing high quality condensate.
- The scrubbing is currently further improved by use of enriched natural chemicals contained in seawater.

Can the desalination and power industry find the appropriate solution to adjust to the new market conditions?

The answer is yes with innovation and integration which provides better energy efficiency both for thermal and membrane processes, hybridization better match power and water requirements, storage and security with DASR and WASR. Innovations to get carbon credits and use of existing assets. New solutions for environment integrating seawater scrubbing, chemicals and mineral recovery.

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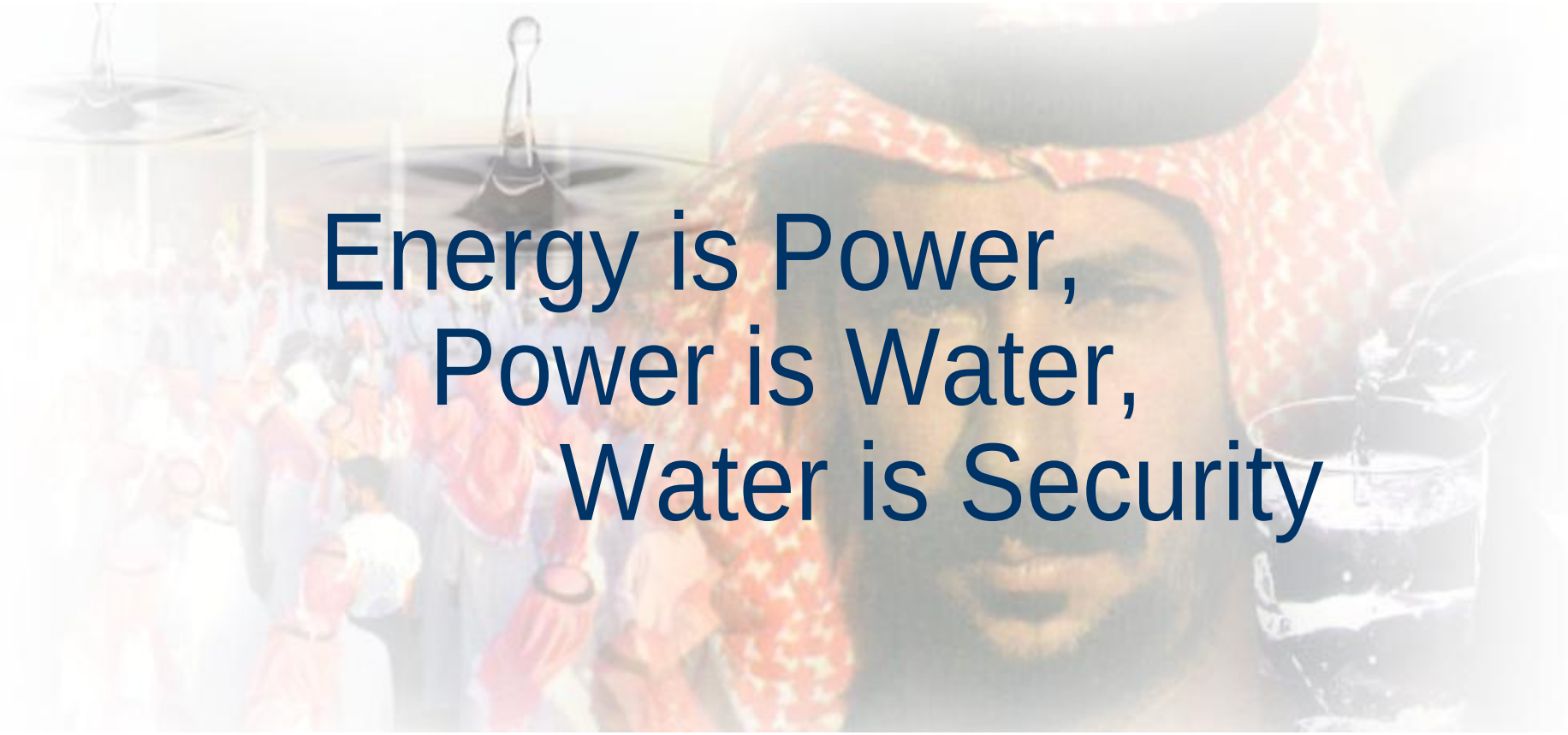
Energy is Power,
Power is Water,
Water is Security