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Crashing the Carbon Footprint of Seawater Desalination

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AGENDA

- Sustainable Desalination
  - LCA intro
  - Hadera SWRO Plant LCA
- Innovative solutions to improve carbon footprint for SWRO plants
- The Sorek B case study
- Way Forward to Net Zero carbon emission

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INTRODUCTION TO LCA

- Measuring and quantifying the environmental impact of SWRO plants is not a common commercial practice
- Life Cycle Assessment (LCA) is an ISO tool used to quantify the environmental impact of any manufacturing process
- IDE is a pioneer in implementing the LCA tool for evaluating SWRO plants
- LCA addresses all **manufacturing stages**, from cradle to grave, enabling an effective evaluation of each step and **comparing alternatives** such as energy and chemical resources, design, technology
- LCA provides the tool to reduce the overall environmental impact and structure the way to **Net Zero desalination** plant
- Creating a reliable emission factor database for one cubic meter of desalinated water, considering also the regional geography.

Green Desalination

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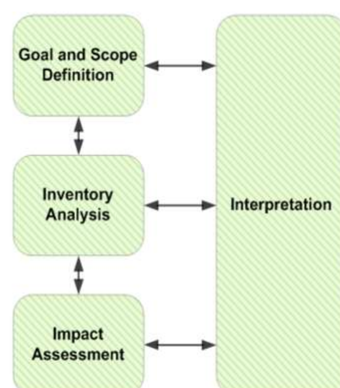
INTRODUCTION TO LCA METHODOLOGY

LCA ISO practice has 4 main general stages:

- **Defining the scope and goals** - the rationale of the study, system boundary, functional unit, assumptions
- **Life Cycle Inventory (LCI)** – quantifying the consumed **resources** (energy, materials) and disposed waste along the manufacturing process – data collecting
- **Life Cycle Impact Assessment (LCIA)** – create a **specific model** for the process, estimating the environmental impact scores of the inventory list in terms of common impact categories, weighting the flows, and comparing alternatives
- **Interpretation** – analyzing the data quality, uncertainty, and sensitivity to determine confidence in the results



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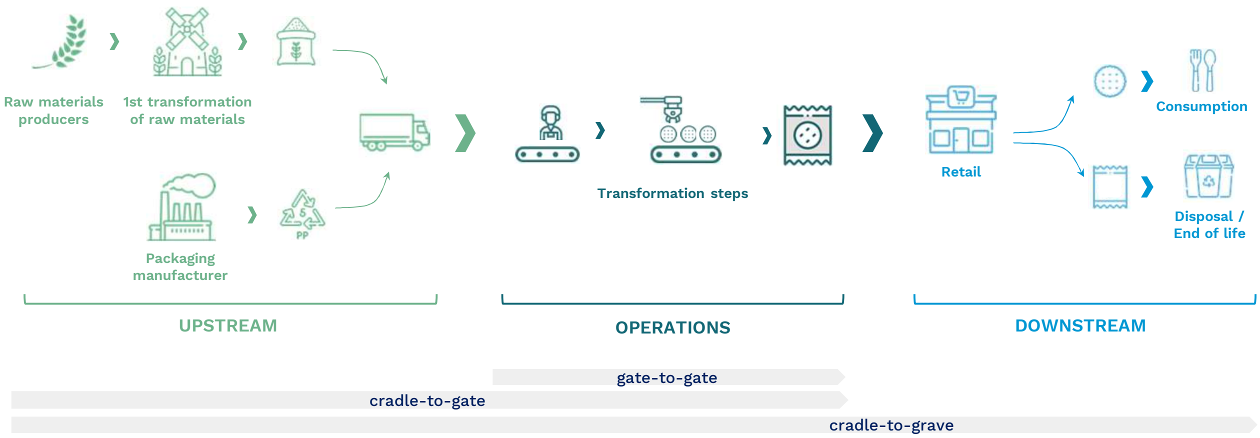
LIFE CYCLE ASSESSMENT (LCA)

LCA is a tool to measure and quantify the possible environmental impacts of a product (desalted water)



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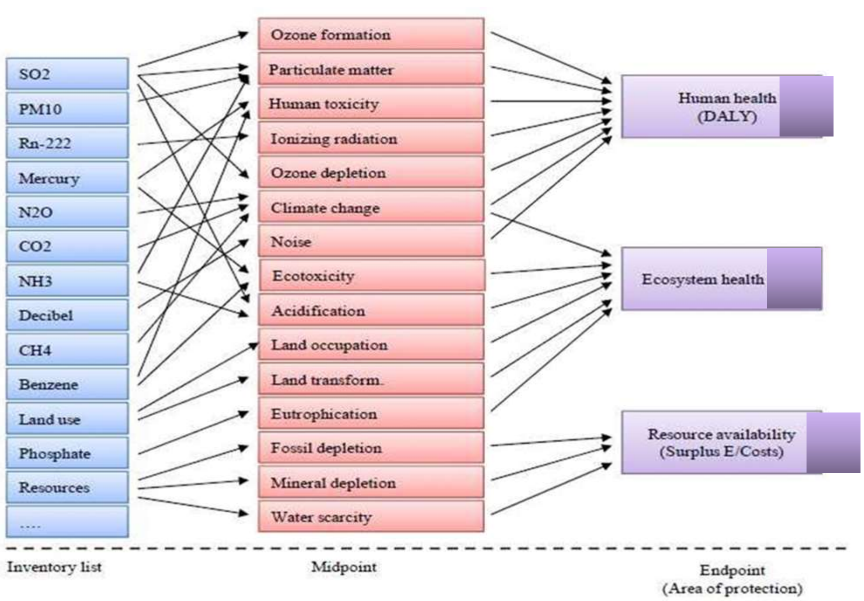
POSSIBLE ENVIRONMENTAL IMPACTS



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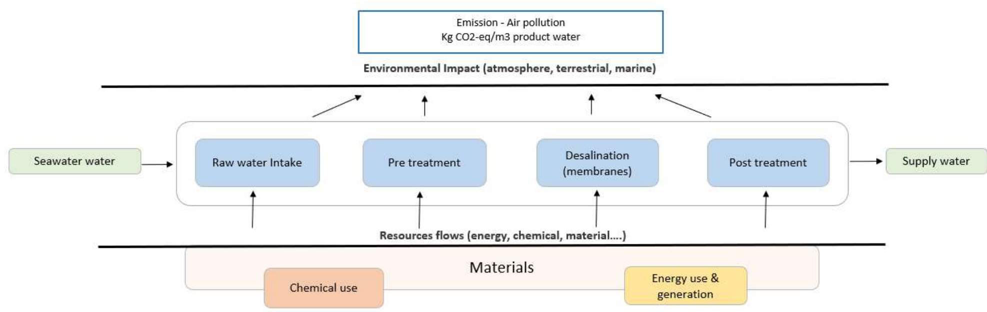
PRACTICE IN DESALINATION

Desalination impacts the marine, terrestrial, and carbon footprint. Implementing solutions such as **reducing power and chemical consumption**, increasing reverse osmosis **membrane lifespan**, and **utilizing greener energy** will improve a desalination plant's sustainability level. There is a need for **a clear tool to quantify** each improvement and its impact on the sustainability level.



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HADERA SEAWATER DESALINATION FACILITY

One of the world's largest SWRO desalination plants

- **Capacity**
  137,000,000 m³/year
- **Max Potential**
  160,000,000 m³/year
- **Technology**
  RO (Reverse Osmosis)
- **Project Type**
  25 Year BOT
  (Build-Operate-Transfer)
- **Shareholders**
  IDE Technologies (50%)
  + H&C (50%)
- **Location**
  Orot Rabin Power Station,
  Hadera, Israel
- **Commissioned**
  2009
- **Operation**
  January 2010

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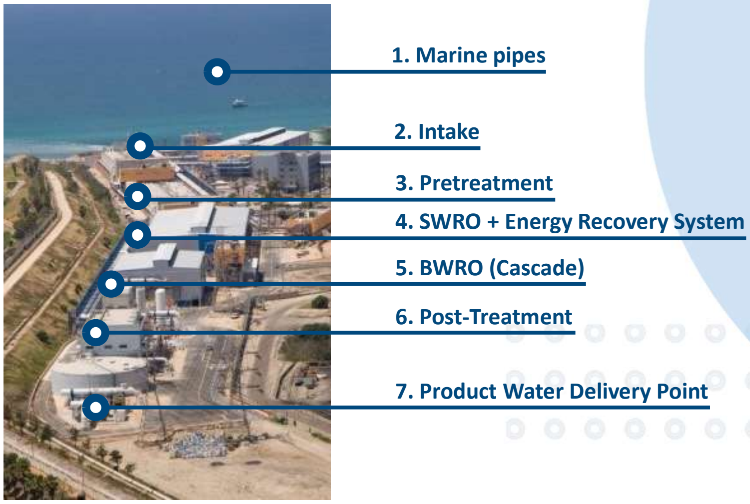
HADERA SWRO – AERIAL VIEW



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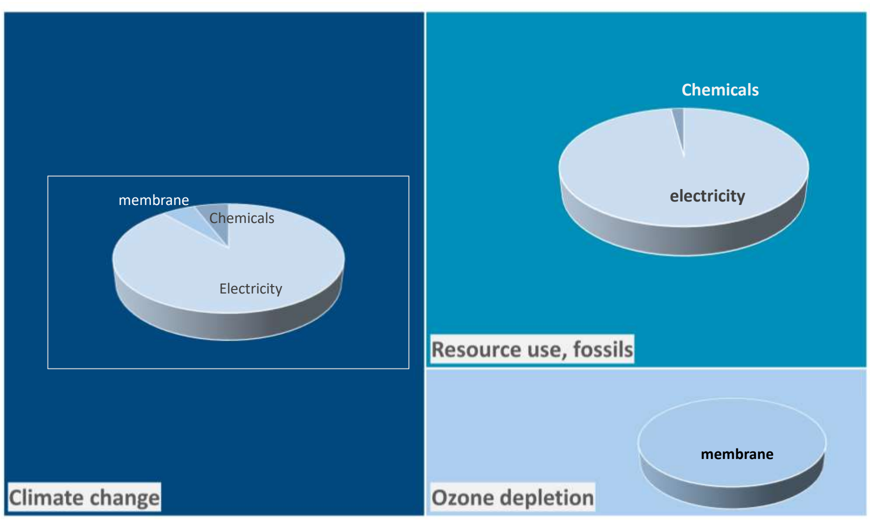
MAIN CONTRIBUTORS FOR HADERA ENVIRONMENTAL FOOTPRINT



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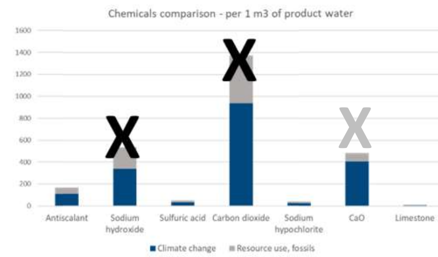
REDUCING CARBON FOOTPRINT WITH LCA

Since the CO_2 emission, which relates to power consumption, cannot be eliminated completely, **the way to Net-Zero Desalination** is by addressing other factors, such as chemicals and membranes, and implementing **Carbon-Negative** solutions

In order to minimize the impact of membranes on the LCA we need:

- Maximize the membranes lifespan by O&M excellence.
- Utilize high performance membranes



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POWERING DESALINATION WITH RENEWABLE ENERGY

85%-90% of a desalination plant's carbon footprint originates from its energy consumption.

Using **renewable energy** to operate the plant diminishes this issue.

Utilizing renewable energy can be achieved by onsite power generation or by Power-Purchase-Agreement (PPA)

In the Western Galilee SWRO desalination plant – **70% of its required energy** will be supplied from a renewable sources.

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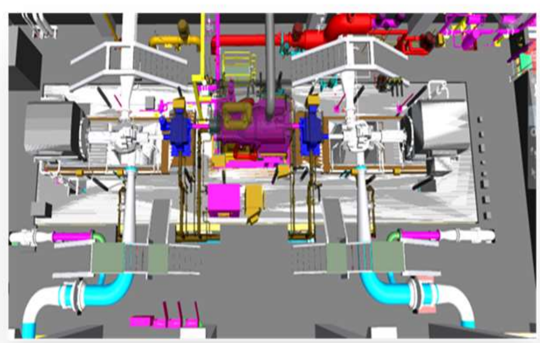
THE NEXT STEP – HPP DIRECT-DRIVE

IDE has developed a **solution** for operating the HP pumps using steam with a direct connection to a steam turbine

The turbines can be fed from standard steam sources such as NG Boilers or Gas Turbine HRSG, but also by 'Green-Steam' generated by Biomass

The direct drive concept also **eliminates** inherent generator, motor, VFD, and transmission-related inefficiencies

When implemented and operated with a 'Green-Steam' source, the direct drive approach can reduce the SWRO carbon footprint by 60%-70%!



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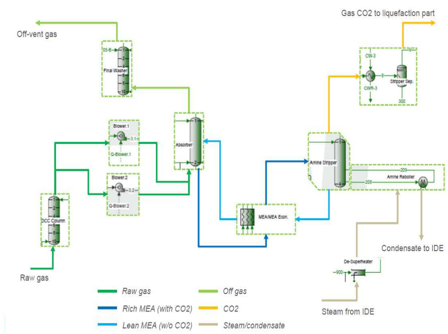
CARBON CAPTURE FOR PP TO POST-TREATMENT

The Sorek B plant implements **a carbon capture system** from the IPP flue Gases. The system provides:

- Carbon footprint **reduction**
- **Self-generation** of the CO2 on-site
- Cutting CO2 costs also **reduces the overall OPEX**



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HYPOCHLORITE FROM SALINE WATER

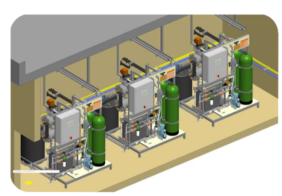
The Sorek B plant also implements an **electro-chlorination system** for the generation of Hypochlorite.

The system provides:

- **Reduced carbon footprint** of the desalination process (no need to transport the chemical to the site)
- **Increased sustainability** by self-generation of the Hypochlorite
- Reduction in Hypochlorite cost, thus **reducing overall OPEX**
- Increased **plant safety** by avoiding storage of high quantities of Hypochlorite

$$NaCl + H_2O + 2e^- \longrightarrow NaOCl_{(aq)} + H_2$$

Salt | Water | Electricity | Sodium hypochlorite | Hydrogen



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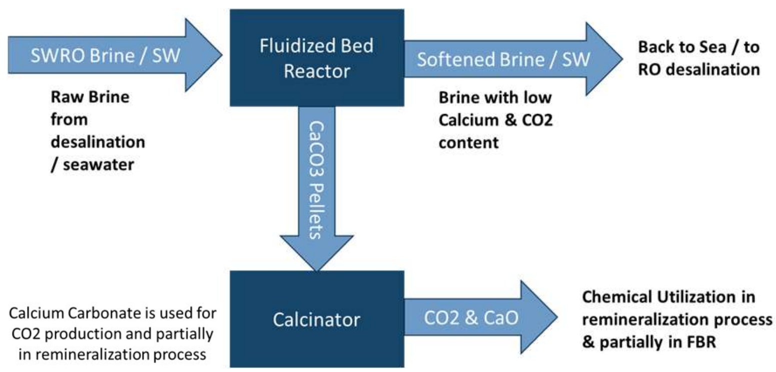
THE NEXT STEP - GREEN CHEMICALS

Inhouse chemicals production for the post-treatment process (CaO, CO_2)

- **Simplifying** the post-treatment.
- The techno-economical evaluation shows a **clear saving** in chemical expenses.

- Implementation in SWRO as pretreatment provides **additional process benefits** by reducing organic load and increasing boron rejection capabilities in the RO.



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THE ECONOMICAL INCENTIVE

- Chemical generation by implementing SDP adds up **0.1-0.2 kWh/m3** to the plant's specific energy.
- The actual cost saving related to chemical use depends on the alternative cost of chemicals and the electric tariff of each specific site.
- An additional perk is the absolute assurance of chemicals' costs and availability.

Country	Savings in percentage
Chile	54%
USA	11%
India	10%

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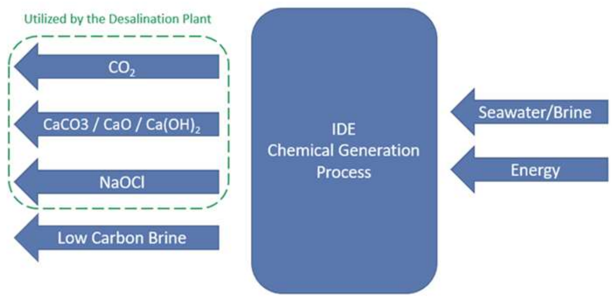
SELF-PRODUCTION OF GREEN CHEMICALS

Sustainable solution – maximizing the Carbon Capture potential



This solution not only increases plants' sustainability but also delivers an **additional revenue stream**

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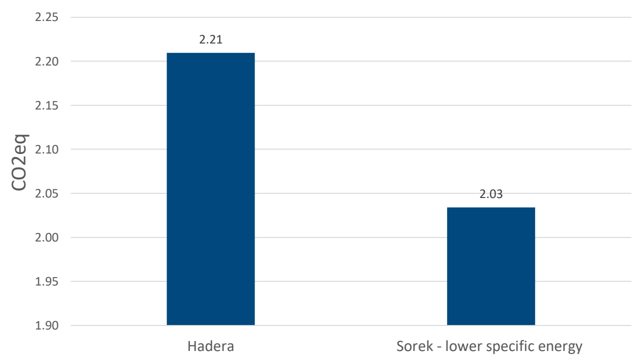
TECHNOLOGIES IN THE SERVICE OF THE ENVIRONMENT

Reducing Carbon footprint - Improving the Specific Energy (~8.5% Compared to Hadera)



- High-pressure pumps – bigger size, higher efficiency
- Membrane – New configuration with higher flux and better performance
- Improved plant hydraulic design

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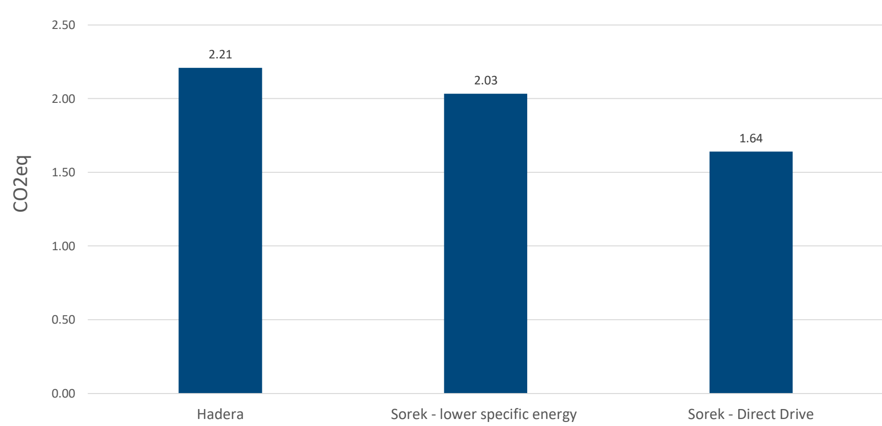
TECHNOLOGIES IN THE SERVICE OF THE ENVIRONMENT

Next step – Utilizing Direct-Drive Concept



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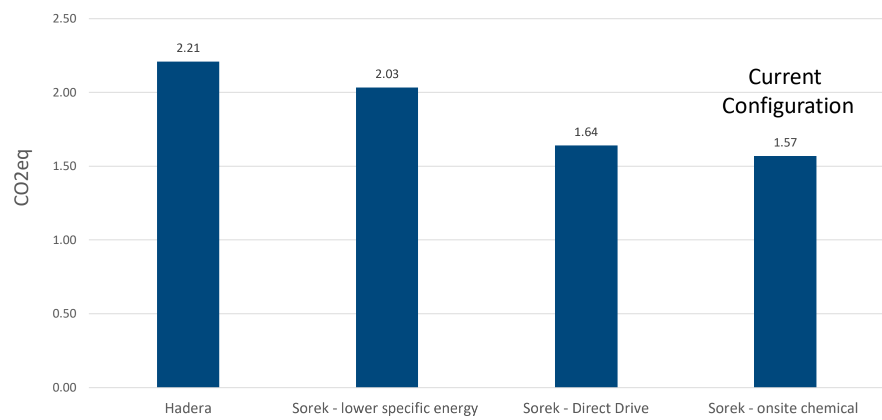
TECHNOLOGIES IN THE SERVICE OF THE ENVIRONMENT

Next step – Implementing Carbon-Capture and Onsite NaOCl Production



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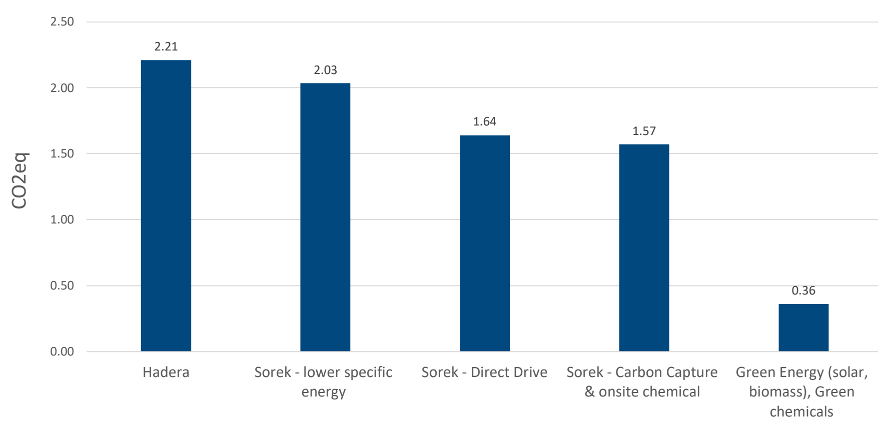
THE WAY TO NET ZERO

The Next Step - Green Energy (Biomass & Solar) & Green Chemical



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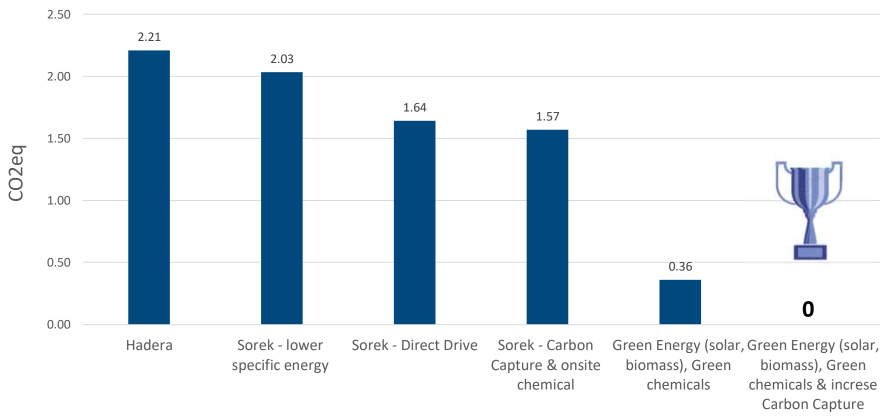
THE WAY TO NET ZERO

Net-Zero Configuration

Green Energy (Biomass & Solar) & Green Chemical and increased Carbon-Capture



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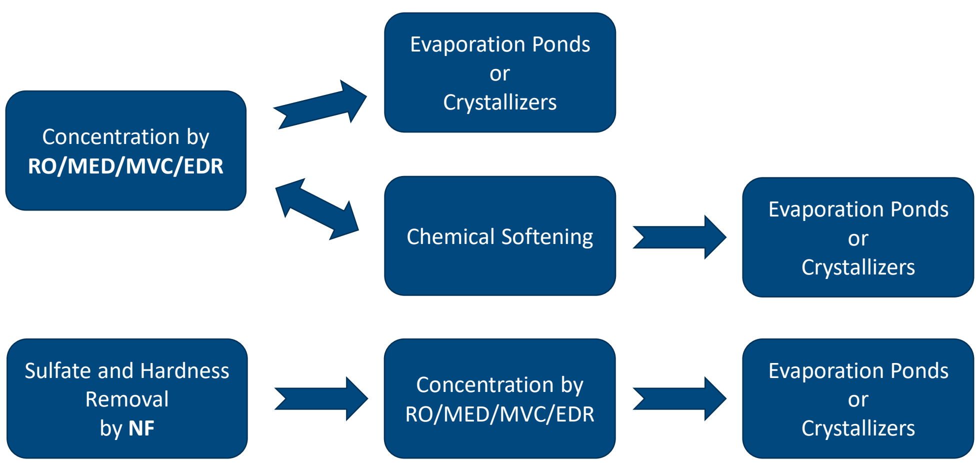
High Levels Ways to Extract NaCl* from Seawater



* NaCl as dry crystals

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Popular Applications for NaCl from Seawater Brine

- Industrial grade salt for use as “dry” NaCl
- Source for Chloride for Cl_2 , HCL & $CaCl_2$ generation (and others)
- Source for Sodium for NaOH and Na_2CO3 generation (and others)

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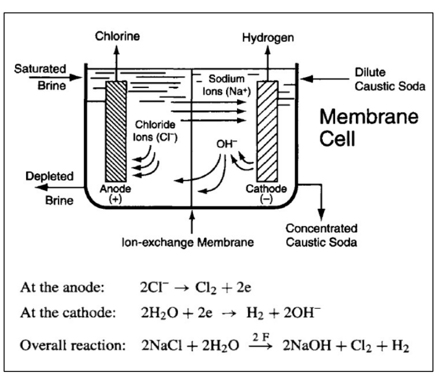
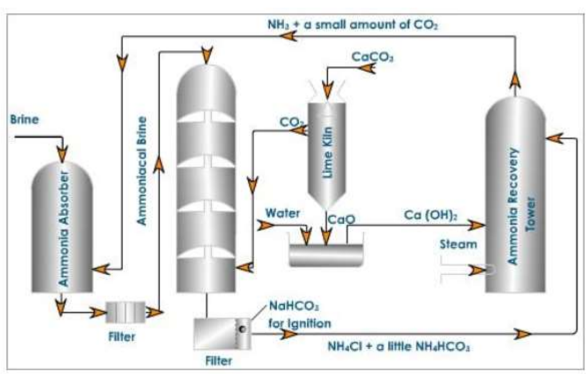
NaCl Production for Applications Requiring High Purity

- Most industrial applications uses NaCl as feedstock require high-purity NaCl, including the following:
  - Chlore-Alkali Process – for generationn of Chlorine (Cl_2) and caustic soda (NaOH)
  - Solvay Process – for Generation of Soda-Ash (Na_2CO_3)



Chlore-Alkali Process



Solvay Process

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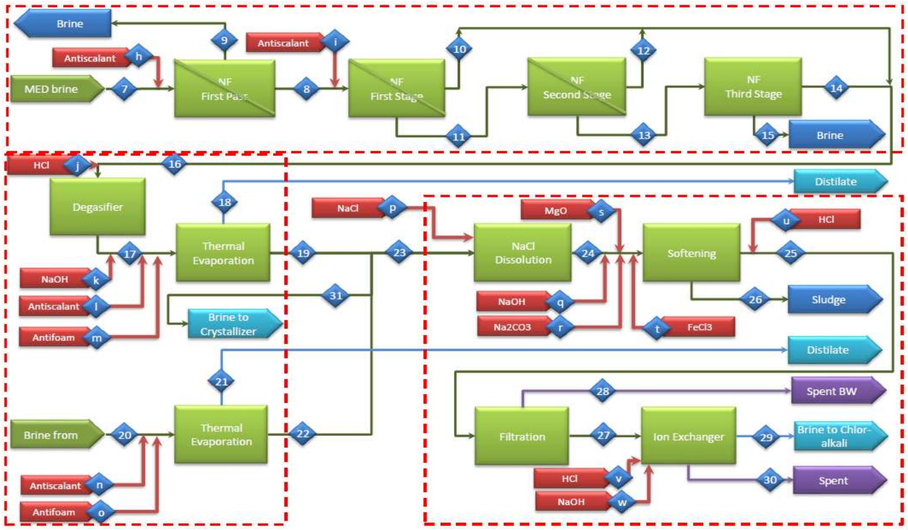
Seawater Desalination & Pure NaCl Brine

- This approach includes combination NF, RO, MED, Softening & IX:



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The Tianjin SDIC MED Case

- **China is the world largest salt producer – with annual production of ~ 60 – 70 million tons**
- Tianjin is one of China's major sea-salt production centers
- The salt in Tianjin is produced using evaporation ponds in "Salt-Farms"
- However, pre-concentration of seawater is required in order to facilitate an increase in the "Salt Farms" production

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CONCLUSION AND KEY TAKEAWAYS

- The key to improving the carbon footprint of desalination is implementing a clear and measurable parameter, such as **kgCO2/m3** – and including it in new projects' evaluation criteria.
- There are innovative technological solutions that effectively mitigate carbon footprint reduction challenges:
  - Direct-Drive of the SWRO HPP using '**Green-Steam**'
  - On-site generation of chemicals by the SDP approach
  - Utilization of renewable energy for electricity and generation of '**Green-Chemicals**'
  - Implementation of 'Carbon-Negative' solutions such as Carbon-Capture and SDP
- '**Net-Zero-Desalination**' is not a myth – and can definitely be achieved

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