

Under the Patronage of His Excellency **Eng. Abdulrahman bin Abdulmohsen AlFadley**  
Minister of Environment, Water & Agriculture

**منتدى المياه السعودي**  
saudi water forum **SWF 2024**



# CARBON CAPTURE AND BRINE MINING

## CARBON CAPTURE AND UTILIZATION AND MINERALIZATION IN DESALINATION PLANT



29 April – 01 May 2024



Hilton Riyadh Hotel & Residences  
Riyadh, Saudi Arabia

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وزارة البيئة والمياه والزراعة  
Ministry of Environment Water & Agriculture



المؤسسة العامة لتحلية المياه المالحة  
Saline Water Conversion Corporation (SWCC)



شركة المياه الوطنية  
National Water Company



الشركة السعودية لشركات المياه  
Saudi Water Partnership Company



المؤسسة العامة للمياه  
Saudi Water Partnership Company



منظم المياه  
Water Regulator



المركز الوطني لكفاءة وترشيد المياه  
NATIONAL WATER EFFICIENCY AND CONSERVATION CENTER  
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# STATUS – Desalination in KSA

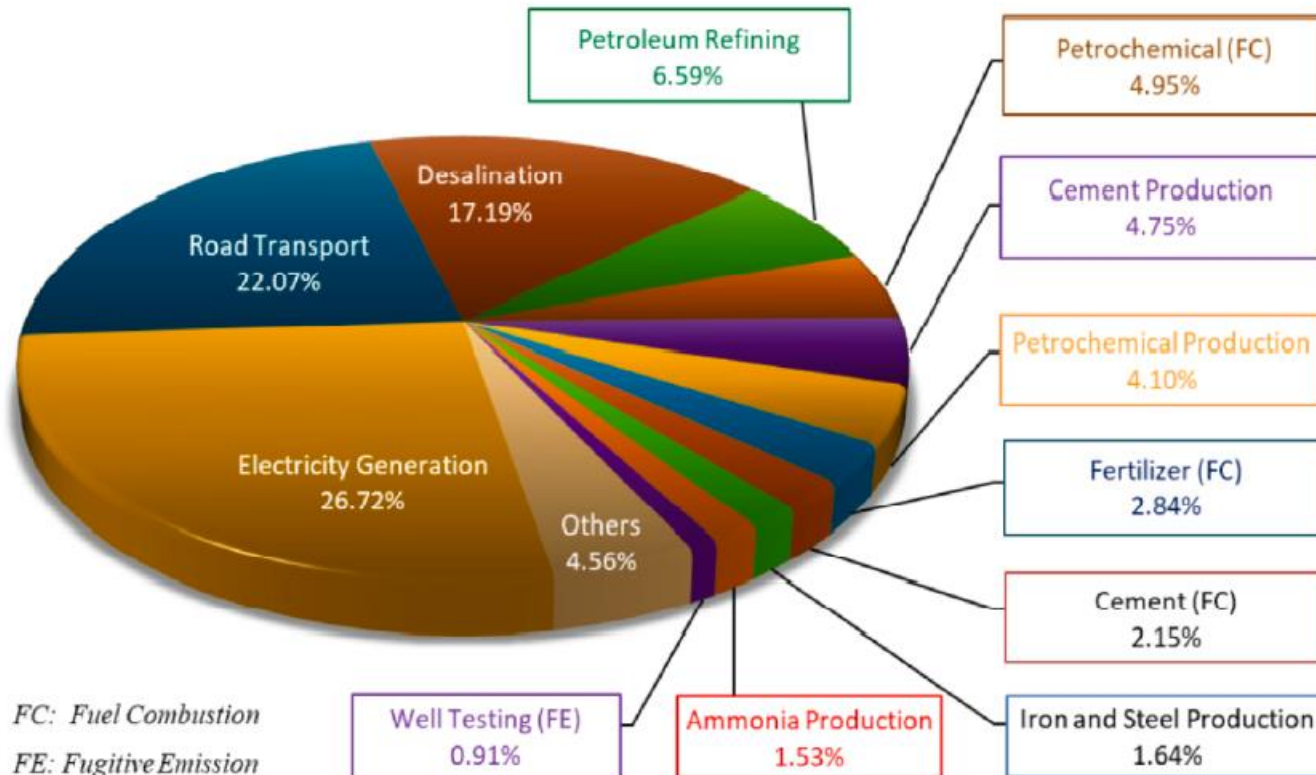


Fig. 2. Saudi DNA reported the relative contributions of major CO<sub>2</sub> emission sources in KSA in 2016 [3].

- ✓ Desalination industry is one of the major industry in Saudi Arabia, uses major stake of energy consumption
- ✓ SWCC has production capacity of 11.5 mil.m<sup>3</sup>/day of desalination
- ✓ In 2022, SWCC has production capacity of 6.6 mil.m<sup>3</sup>/day for seawater desalination, leaves appr. 18 mil.ton/year CO<sub>2</sub> in the atmosphere
- ✓ In combination with power plants to supply thermal and electrical energy to desalination plants, CO<sub>2</sub> emission is estimated more than 75 mil.ton in 2022, second largest after Electricity sector

## STATUS – Desalination in KSA

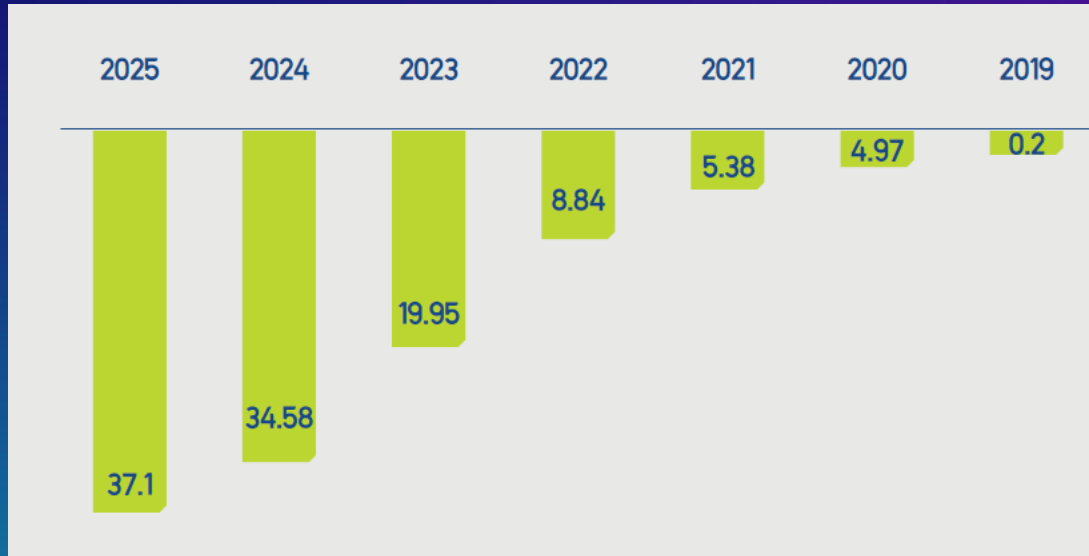
Configuration	STEC*	SEEC*	SEC	CO <sub>2</sub> Emission	Carbon Emission of Desalinated Water
OFPP-MSF	12.72 kWh/m <sup>3</sup>	4.0 kWh/m <sup>3</sup>	16.72 kWh/m <sup>3</sup>	0.766 kg/kWh	12.808 kgCO <sub>2</sub> /m <sup>3</sup>
OFPP-MED	12.72 kWh/m <sup>3</sup>	2.0 kWh/m <sup>3</sup>	14.72 kWh/m <sup>3</sup>	0.766 kg/kWh	11.276 kgCO <sub>2</sub> /m <sup>3</sup>
CCPP-MSF	10.80 kWh/m <sup>3</sup>	4.0 kWh/m <sup>3</sup>	14.80 kWh/m <sup>3</sup>	0.389 kg/kWh	5.757 kgCO <sub>2</sub> /m <sup>3</sup>
CCPP-MED	10.80 kWh/m <sup>3</sup>	2.0 kWh/m <sup>3</sup>	12.80 kWh/m <sup>3</sup>	0.389 kg/kWh	4.979 kgCO <sub>2</sub> /m <sup>3</sup>
OFPP-SWRO	N/A	3.0 kWh/m <sup>3</sup>	3.0 kWh/m <sup>3</sup>	0.690 kg/kWh	2.070 kgCO <sub>2</sub> /m <sup>3</sup>
CCPP-SWRO	N/A	3.0 kWh/m <sup>3</sup>	3.0 kWh/m <sup>3</sup>	0.355 kg/kWh	1.065 kgCO <sub>2</sub> /m <sup>3</sup>
<b>SWRO</b>	<b>N/A</b>	<b>3.0 kWh/m<sup>3</sup></b>	<b>3.0 kWh/m<sup>3</sup></b>	<b>0.569 kg/kWh</b>	<b>1.707 kgCO<sub>2</sub>/m<sup>3</sup></b>

(\* STEC and SEEC are specific thermal energy consumption and specific electrical energy consumption respectively)

### Portfolio of desalination technology matters

SWCC is gradually phasing out thermal desalination technologies and moving forward for SWRO  
 SWCC is pursuing further reduction of energy consumption in SWRO technology (2.27 kWh/m<sup>3</sup>)

## STATUS – SWCC Journey for Carbon Reduction



- ✓ In recent years, desalination capacity has been increased by 50%, but average CO2 footprint of desalinated water has been reduced by 70%
- ✓ Phasing out thermal desalination leads to decommission thermal power plants associated to it
- ✓ In overall, SWCC estimates to reduce CO2 emission by 37 mil.ton in 2025

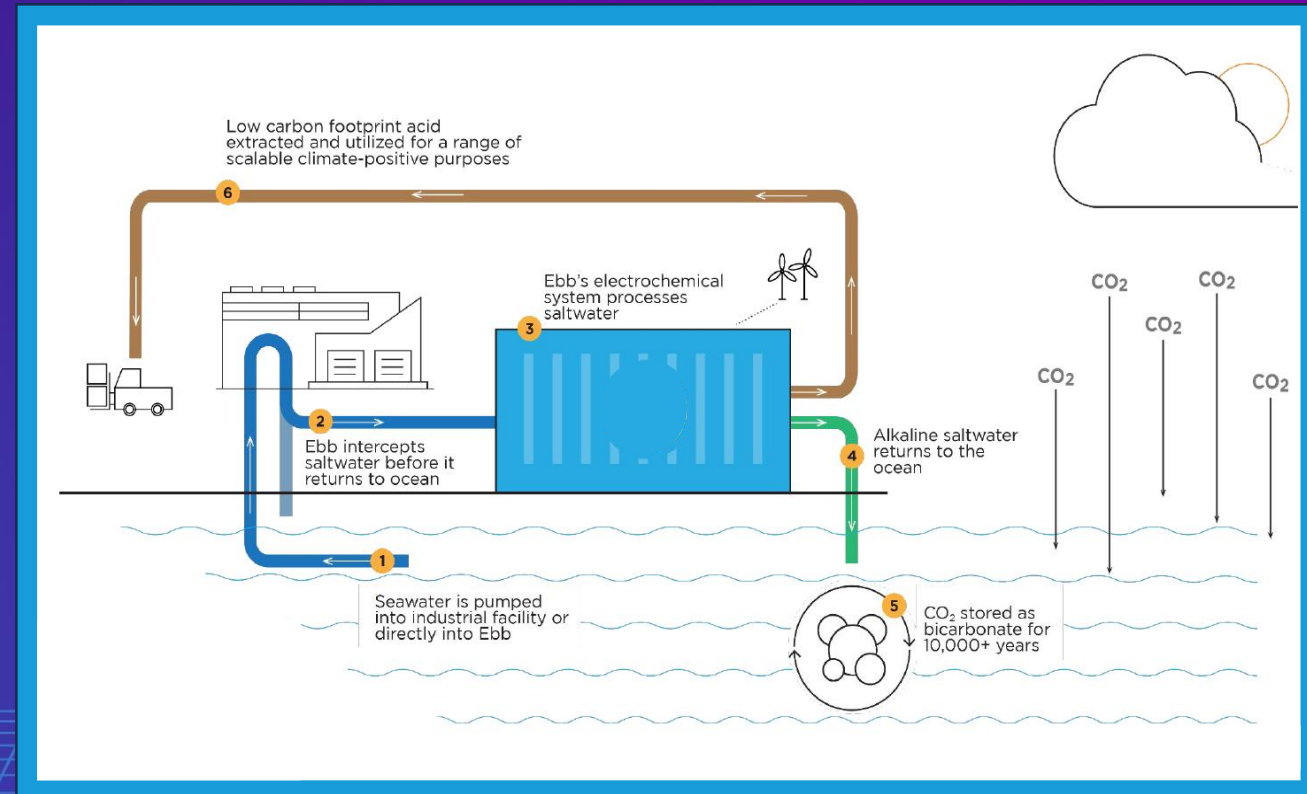
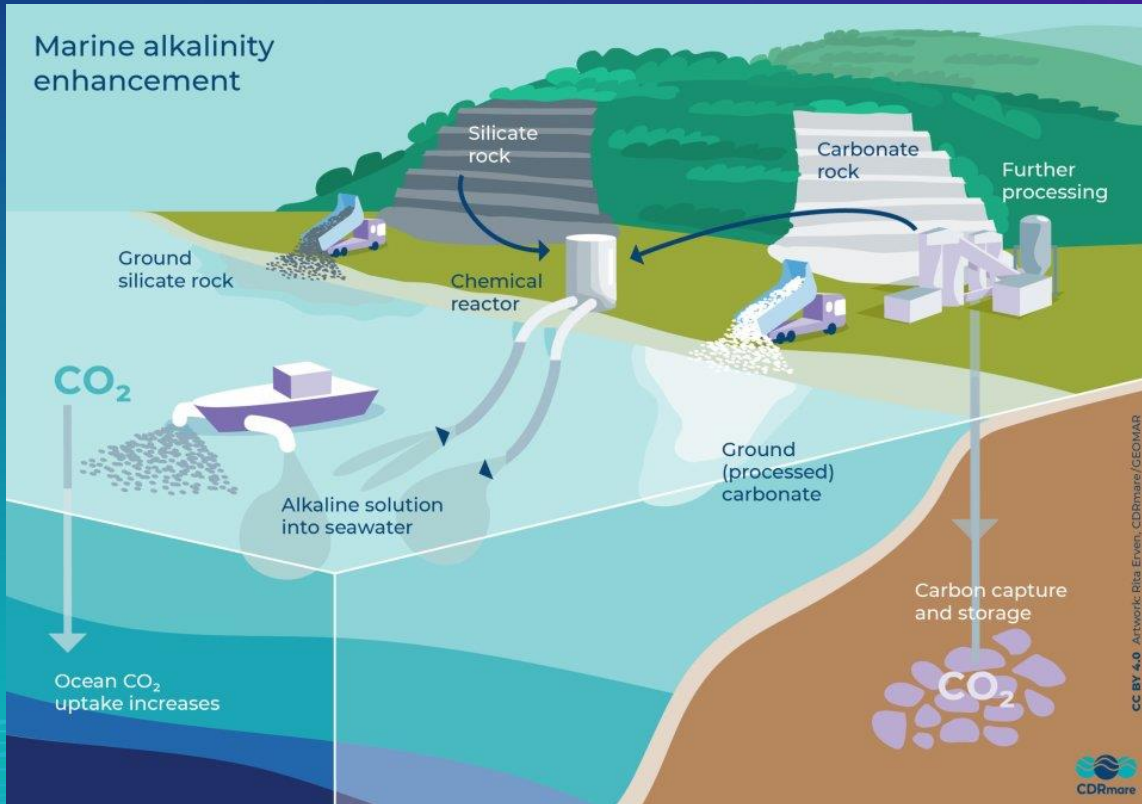
	Total Production Capacity	Production from Thermal	Production from SWRO	Avg. CO2 Footprint	CO2 equiv.
Year 2018	5,000,000 m3/day	3,910,000 m3/day (78.2%)	1,090,000 m3/day (21.8%)	9.4 kgCO2/m3	17.1 M.ton/y
Year 2022	6,600,000 m3/day	3,910,000 m3/day (59.2%)	2,690,000 m3/day (40.8%)	7.5 kgCO2/m3	18.1 M.ton/y
Year 2025	7,700,000 m3/day (+54%)	1,310,000 m3/day (17.0%)	6,390,000 m3/day (83.0%)	2.7 kgCO2/m3	7.6 M.ton/y (-55.6%)

# CARBON CAPTURE – CARBON CAPTURE TAXONOMY

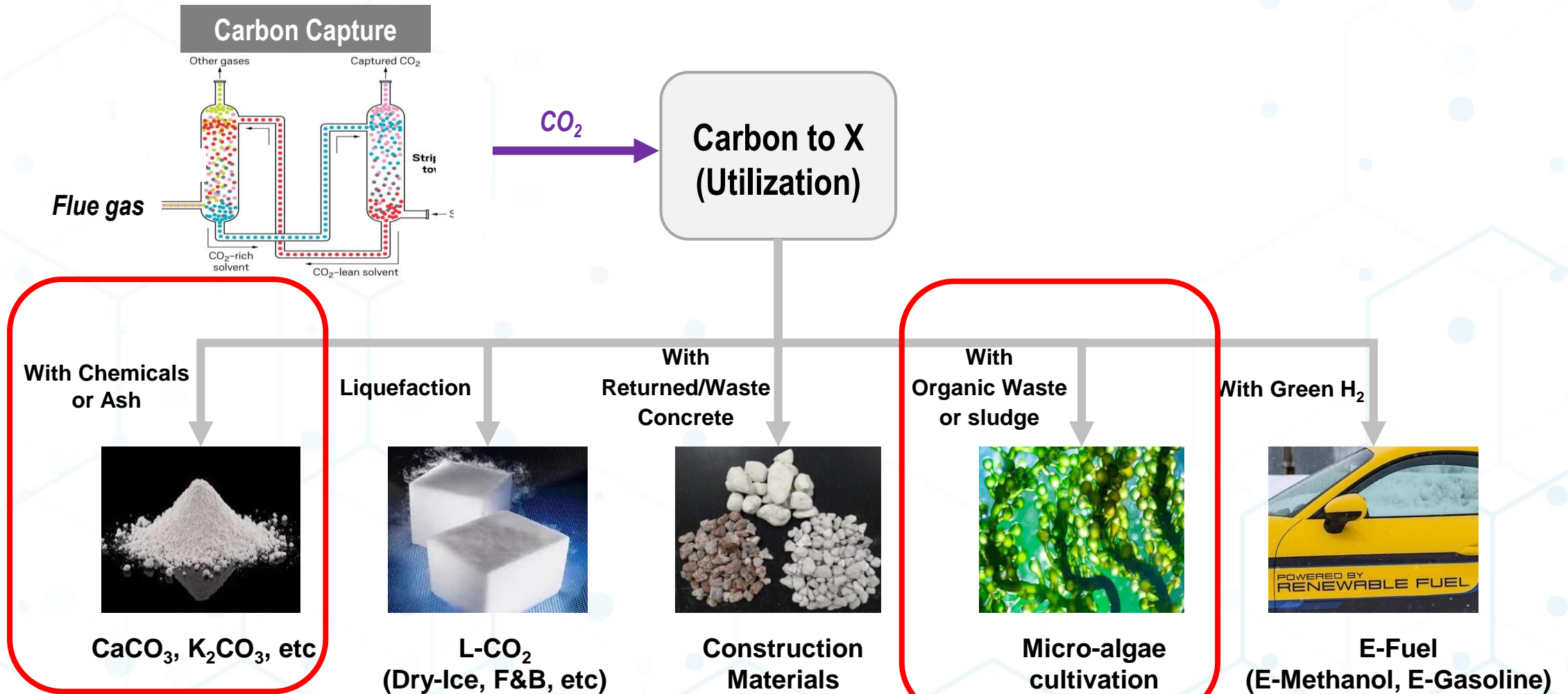
Removal/Reduction	Type of Technology	Technology in Brief	Technology Trend	Carbon Credit	Players
Point Source Carbon Capture (Carbon Reduction)	Pre-Combustion Carbon Capture	Related to Chemical Process CO2 concentration is high Blue Hydrogen related (Fossil fuel cracking + Carbon Capture)	Simple CO2 compression and liquefaction, or simple CO2 purification (moisture removal, O2 removal, etc.)	Industry related, RE100, Compliance Market	Linde, Carbonco, Mitsubishi, Shell
	Post-Combustion Carbon Capture	Carbon capture from Fossil fuel burning process Power plant, Coal coking, Cement industry	Selective CO2 dissolution using special solvent Developing solvent with less energy consumption for regeneration		Linde, Carbonco, Mitsubishi, Shell
Direct Capture (Carbon Removal)	Direct Air Capture	Solid solvent	Developing more effective solid solvent	CDR from volunteer companies, or government S, Voluntary Market	Many start-up companies, CarbonCapture
		Liquid solvent	Using base chemical (NaOH), Desalination plant can be used as a platform		Capture6
	Direct Ocean Capture	Making seawater capable to dissolve CO2 more (Ocean Alkalinity Enhancement Program)	Getting environmental permit to discharge basic seawater to the ocean – Desalination plant can be used as a platform		Ebb Carbon, Banyu Carbon

# CARBON CAPTURE – Ocean Alkalinity Enhancement

- ✓ Potential methods of marine (ocean) alkalinity enhancement, including some associated land-based activities are being suggested
- ✓ Potential of Marine alkalinity enhancement program from desalination plant



# CARBON UTILIZATION – CCU in Desalination Process

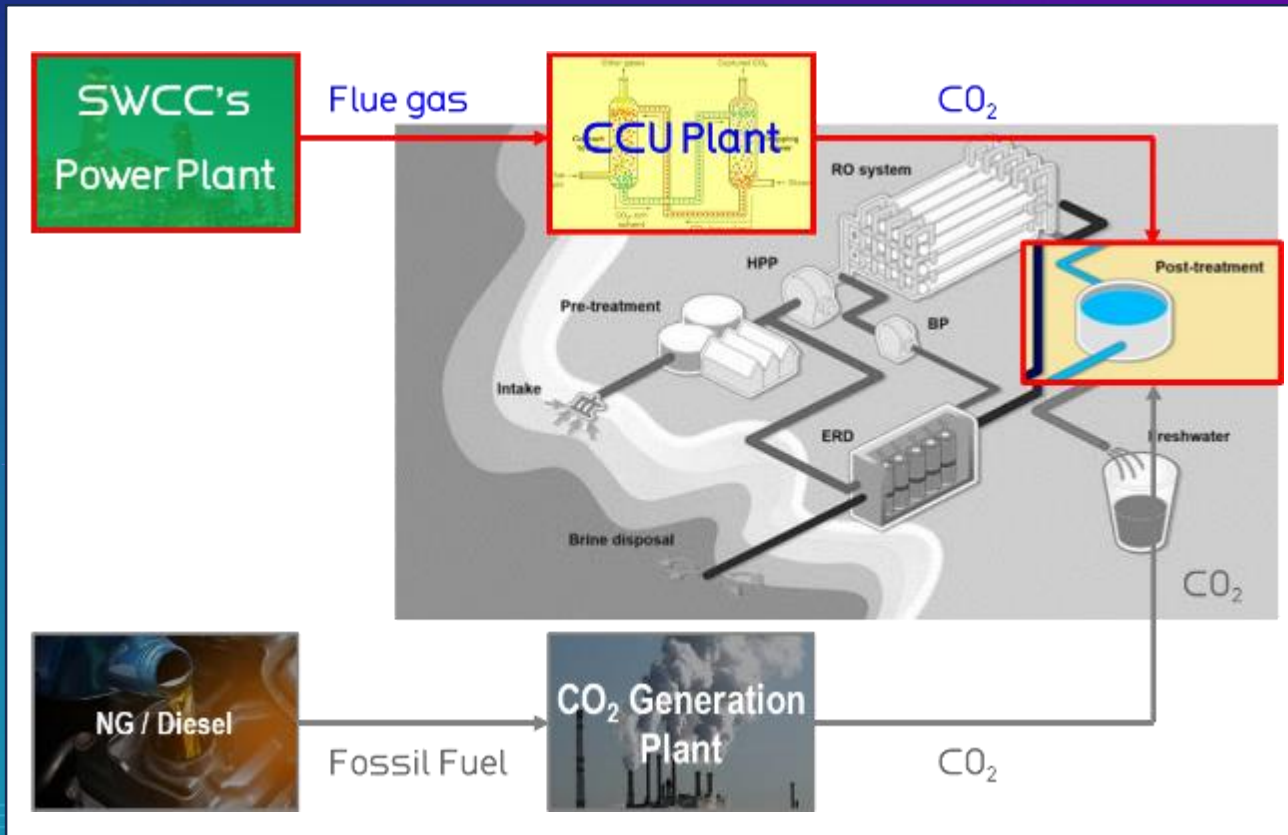




# CARBON UTILIZATION in Desalination Process

Captured CO<sub>2</sub> from the power plant can be injected post-treatment system

Newly proposed method for CO<sub>2</sub> Supplying

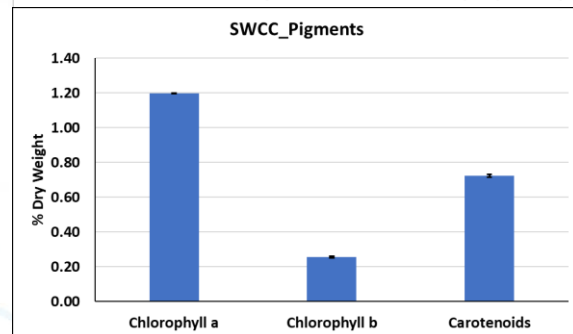
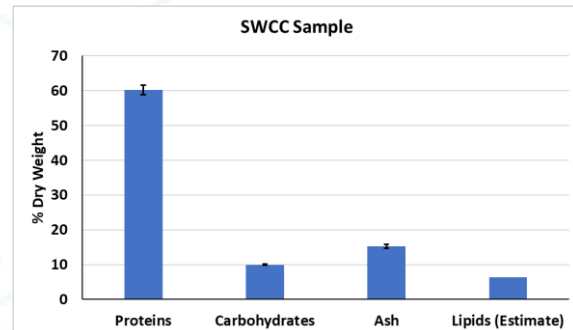
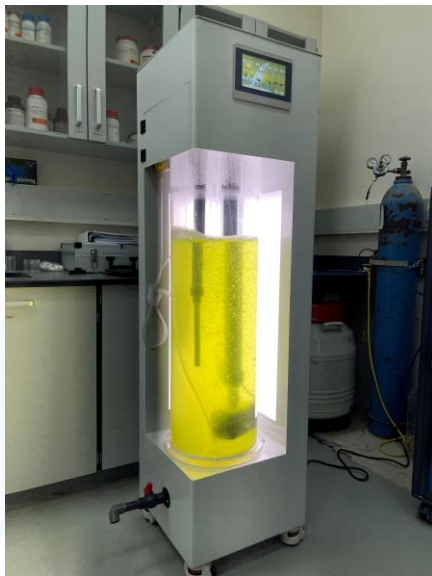
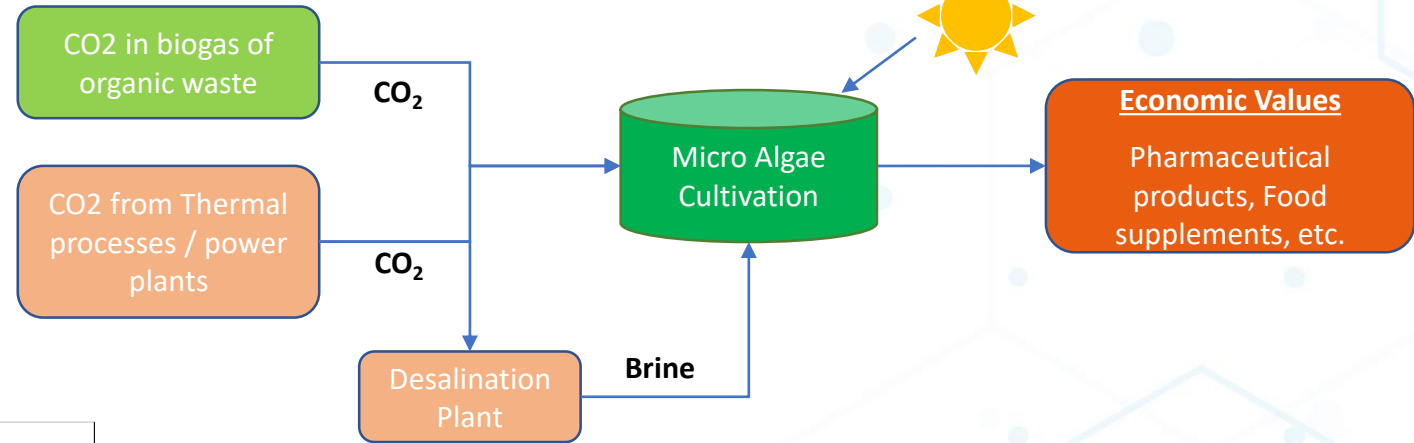


Conventional method for CO<sub>2</sub> Supplying

- For 4.0 mil.m<sup>3</sup>/day SWRO capacity,
- 200 t/day of liquid CO<sub>2</sub> is required to recarbonate desalinated water in post-treatment system
- By utilizing captured CO<sub>2</sub> in the post-treatment system, daily 87,000 liters of diesel can be saved
- Annual savings more than 23 mil.SAR

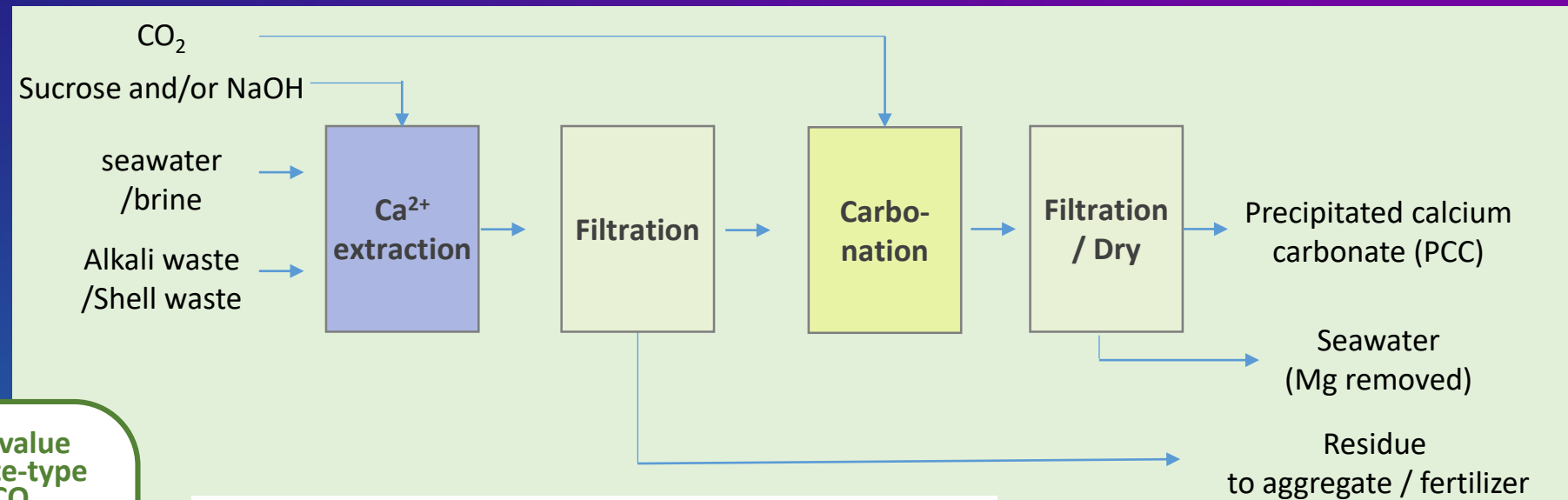
# CARBON UTILIZATION for Microalgae Cultivation

- ✓ Identify local microalgae species which can grow in SWRO brine and generate protein, polysaccharides and lipids
- ✓ Optimize the growth conditions for large scale cultivation and harvesting



# CARBON MINERALIZATION – Vaterite type CaCO<sub>3</sub>

Vaterite type CaCO<sub>3</sub> recovery process by using Cement Kiln Dust, CO<sub>2</sub>, and SWRO brine

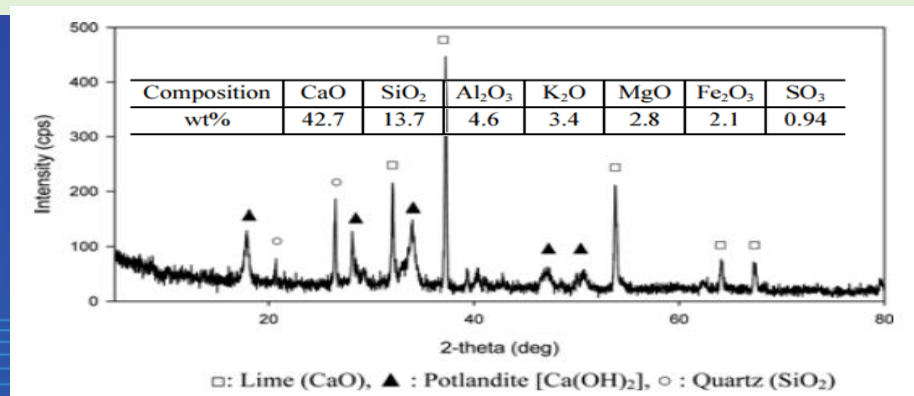


Seawater Desal. Brine

CO<sub>2</sub> gas

Alkali Industry By-product

High-value Vaterite-type CaCO<sub>3</sub>



Analysis of Saudi CKD sample confirmed the good quality to produce vaterite-type CaCO<sub>3</sub>.

## CONCLUSION - Implication

- ✓ SWCC drives energy reduction initiatives in desalination industry by shifting technical domains, and contribute to CO2 reduction in the industry
- ✓ Carbon Capture technology is still capital intensive, but adding utilization part in post-treatment in desalination process, it can add value to the industry
- ✓ Desalination plant can be a platform to apply various enhanced ocean alkalinity technologies, and CDR credit can monetize water production cost
- ✓ Captured CO2 can be utilized to grow microalgae together with desalination waste stream, and create added value by monetizing microalgae
- ✓ Captured CO2 can be utilized to produce high value vaterite type CaCO3 together with Cement Kiln Dust and desalination waste stream

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# THANK YOU!



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