

Basic Training

Pre-feasibility study for groundwater desalination and resource recovery in Uzbekistan

Ryu, YoungBok (KITECH)

18 June 2026

CTCN TA project





O'ZBEKISTON RESPUBLIKASI
EKOLOGIYA, ATROF-MUHITNI MUHOFAZA QILISH
VA IQLIM O'ZGARISHI VAZIRLIGI HUZURIDAGI
GIDROMETEOROLOGIYA XIZMATI AGENTLIGI
O'ZGIDROMET



Introduction of CTCN TA Project

Background / Regional Context & Water Challenges

Arid Climate Characteristics

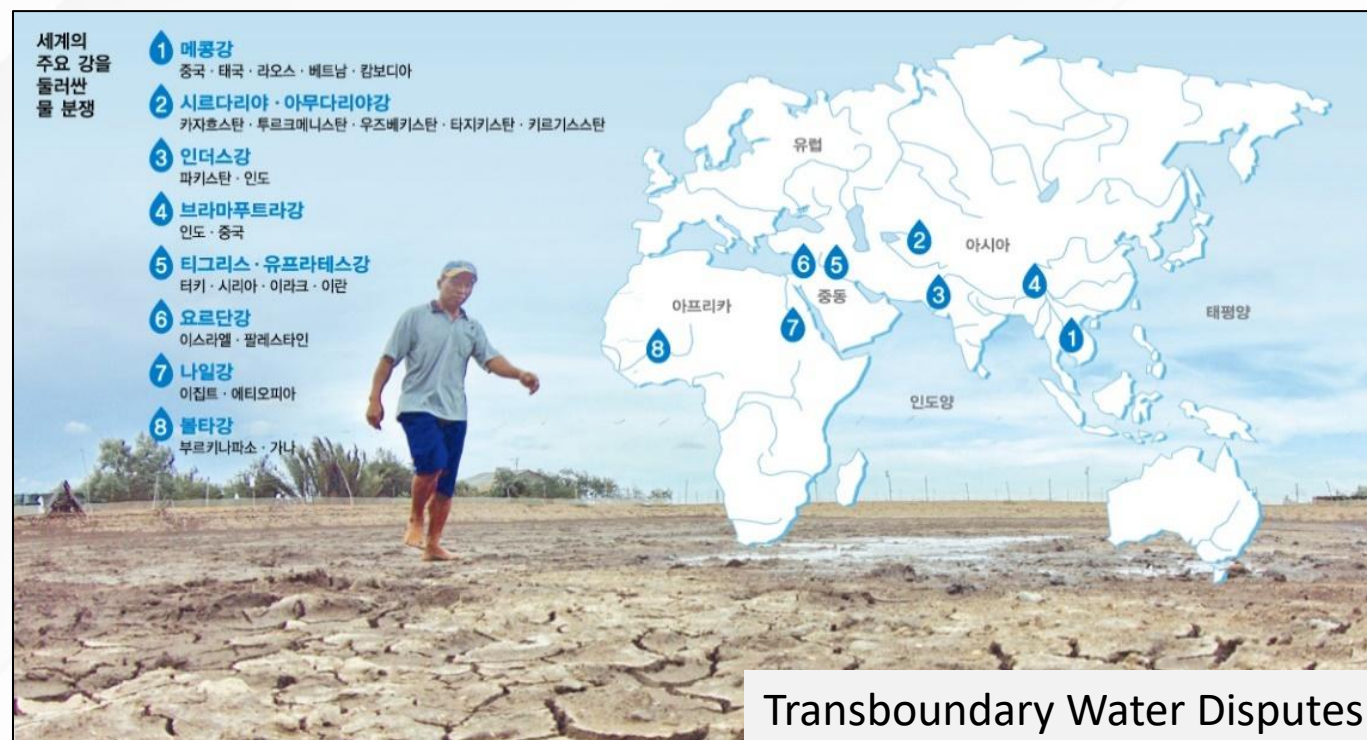
- Uzbekistan is a **doubly landlocked country** in Central Asia.
- Average annual precipitation is approx. 150 mm, exhibiting **arid desert climate** features.

Water Source Limitations

- Major Freshwater Sources: Amu Darya and Syr Darya rivers.
- Shared with neighboring countries (**ongoing water disputes**) → Difficult to secure independent water resources.

Groundwater Dependency

- **80% of total national water demand** is dependent on groundwater.



Background / Groundwater Utilization Policy & Future Strategies

Government Initiatives

- The government is actively promoting **groundwater utilization** to meet rising demand.

Challenges in Water Quality

- High mineral content due to geological factors.
- **Approx. 40% of groundwater has high salinity**, making it unsuitable for direct use.

Strategic Requirements

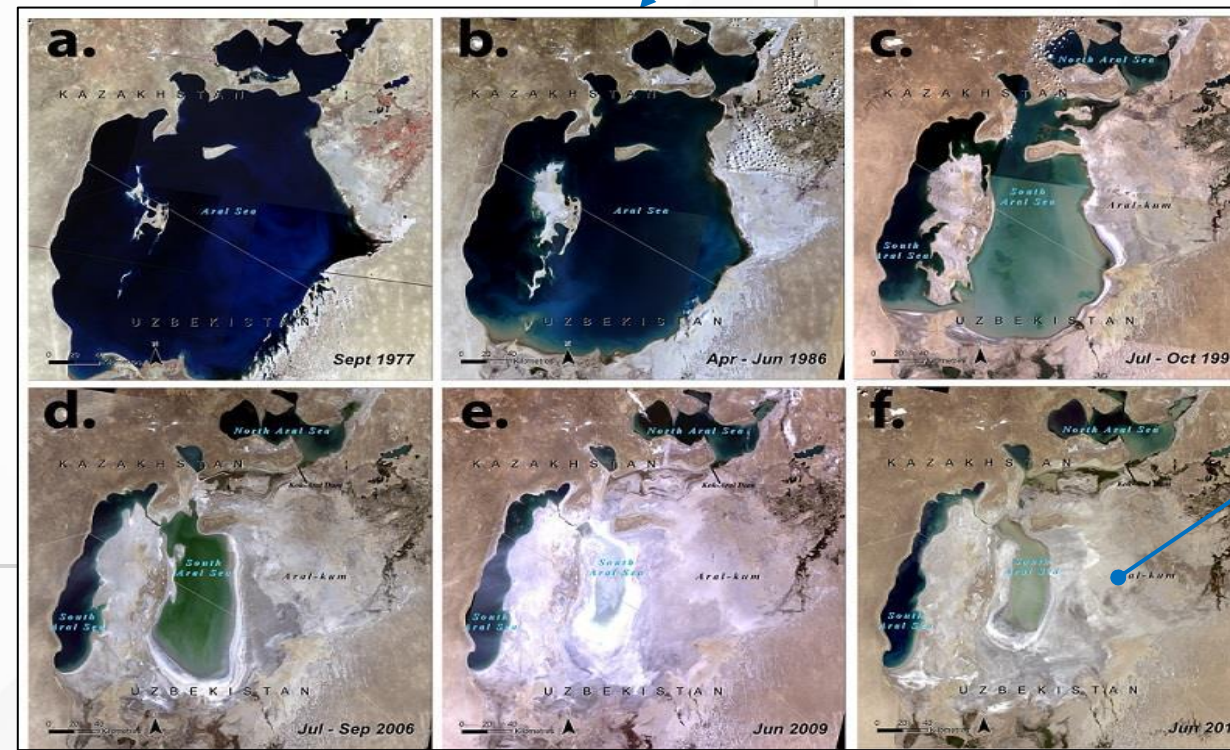
- Securing water resources via groundwater requires **professional talent training** and **technology transfer**.

Agricultural Impact

- Irrigation with saline water has led to **soil salinization** → Reduced farmland and productivity
(Soil restoration is a priority task).

Circular Economy Opportunities

- Potential for **recovering dissolved resources**
(Alkali / Alkaline Earth Metals) from concentrated wastewater.
- Action Plan: Training of resource recovery experts and introduction of advanced technologies.



Background / Groundwater Utilization Policy & Future Strategies

Established Policy Framework (2017-2030)

- **Systematic Roadmaps:** Implementation of Presidential Decrees (PP-3437, PP-6024) to secure and manage water resources.
- **Legal Foundations:** Emergency measures and 2023 legislation focused on groundwater protection and rational use.
- **Strategic Goals:** Reduction of soil salinity and transition to resource-recovery models.

The Critical Challenge: Technical & Institutional Gaps

- **Need for Advanced Technology:** Despite established policy goals, there is a requirement for specialized desalination and resource-recovery technologies tailored to local conditions.
- **Capacity Enhancement:** Importance of strengthening technical expertise and institutional frameworks to implement sustainable systems.
- **International Cooperation:** Identifying, piloting, and scaling appropriate technologies through global partnerships.

Strategic Conclusion

- **From Policy to Action:** Transitioning from a theoretical roadmap to practical implementation through immediate technical intervention and expert training.

Project Overview

- 💧 **Title** : Pre-feasibility study for groundwater desalination and resource recovery in Uzbekistan
- 💧 **Period** : 07/11/2025 ~ 06/09/2026 / **Budget** : 249,914 USD
- 💧 **Proponent** : HYDROENGEO (Uzbekistan) / **Implementor** : KITECH (KOREA)
- 💧 **Location** : Tashkent (Targeting high-salinity wells)
- 💧 **Project Objectives**
 - **Tech Assessment**: Identify feasible desalination and resource-recovery technologies.
 - **Pilot Design**: Design an optimized pilot system for producing potable and industrial water.
 - **Capacity Building**: Strengthen national expertise through technology transfer and professional training.
 - **Strategic Roadmap**: Establish the technical and economic groundwork for future scale-up.



Project Scope & Outputs

Output 1 / Technical Review

- **Technology status and capacity assessment in Uzbekistan**
→ Summary of global technology review and best practices
- **Local survey in Uzbekistan (Groundwater characteristics)**
→ Site visit and raw water sampling report including test results
- **Desalination and resource recovery testing**
→ Technology screening matrix with environmental and economic evaluation
- **Assessment of local applicability based on test results**
→ Final assessment report with technology recommendations and site selection rationals

Output 2 / Pilot System Design

- **System design review based on sample and test results**
→ Pilot process flow configuration summary based on test results
- **Conceptual design of process flow and site-specific layout**
→ Conceptual process flow diagram (PFD) and site-specific layout
- **Pilot scale optimization based on CAPEX and OPEX analysis**
→ Technical memo on CAPEX/OPEX and sizing analysis
- **Preparation of basic engineering documents for pilot construction**
→ Basic engineering design package including specifications and drawings

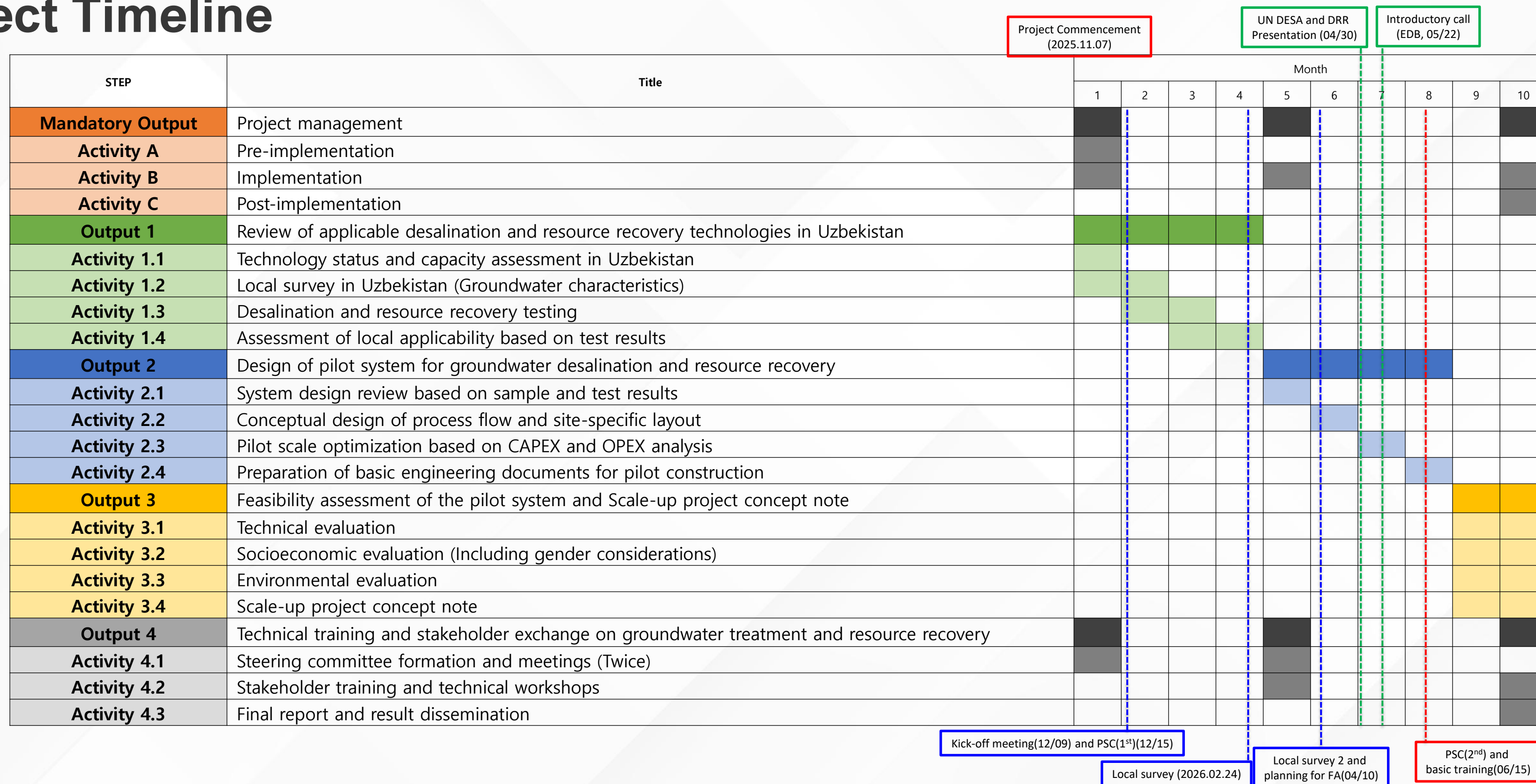
Output 3 / Feasibility Assessment

- **Technical evaluation**
→ Technical Evaluation Materials
- **Socioeconomic & gender analysis**
→ Socioeconomic Evaluation Materials, Gender analysis report
- **Environmental impact assessment**
→ Environmental Evaluation Materials
- **Scale-up project concept note**

Output 4 / Training & Engagement

- **Steering committee formation and meetings**
→ List of committee members, Minutes of the steering committee meeting
- **Stakeholder training and technical workshops**
→ Updated stakeholders list, introductory training materials(Gas hydrate, Mineral carbonation), Technical Training Materials (Practice-Oriented, Based on Pilot Design)
- **Final report and result dissemination**
→ Final Report and Presentation materials

Project Timeline



Major Activities / Kick-off Meeting

Overview

- **Date** : December 9, 2025
- **Venue/Mode** : HYDROENGEO Meeting Room (Hybrid: In-person & Online)
- **Organizer** : KITECH (Korea Institute of Industrial Technology)
- **Participants**: Key stakeholders from HYDROENGEO, KITECH, and National experts

Main Objectives & Achievements

- **Official Launch**: Formally initiated the **UNFCCC CTCN Technical Assistance** project.
- **Scope Alignment**: Finalized and introduced the project scope, objectives, and expected outputs.
- **R&M Definition**: Clarified the specific roles and responsibilities of each stakeholder.
- **Action Plan**: Confirmed the immediate implementation schedule and set priorities for the next steps.



List of Kick-off Meeting Participants
2025.12.09 (Tue) / HYDROENGEO

No	Affiliation	Position	Name	Signature
1	KITECH	Principal Researcher	Y.B. Byn	[Signature]
2	"	"	K.C. Kang	[Signature]
3	"	"	Sangmin Lee	[Signature]
4	NERKON	General Director	Young Jaeng	[Signature]
5	K-GEP	CTO/President	Byungwon Ahn	[Signature]
6	Independent	Communication expert	Whisper Tiliash	[Signature]
7	Hydroengeo	Head of department	Beti Gerasimov	[Signature]
8	Hydroengeo	Chief of Department	Andriyana Stetsko	[Signature]
9	Hydroengeo	Chief of Department	Andriyana Stetsko	[Signature]
10	Hydroengeo	"	Andriyana Stetsko	[Signature]
11	Hydroengeo	Lead specialist	Andriyana Stetsko	[Signature]
12	Hydroengeo	Department head	Kanata Muramatsu	[Signature]
13	Hydroengeo	Director	Gyngy Dzhurayev	[Signature]
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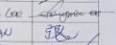
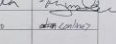
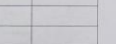
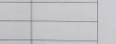
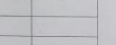


Major Activities / PSC Meeting

Overview

- **Date** : December 15, 2025
- **Venue/Mode** : HYDROENGEO Meeting Room (Hybrid: In-person & Online)
- **Organizer** : CTCN & KITECH
- **Participants**: Steering committee members, including representatives from CTCN, KITECH, and HYDROENGEO

List of PSC Meeting Participants
2025.12.15 (Mon) / HYDROENGEO

No	Affiliation	Position	Name	Signature
1	KITECH	Principal Researcher	Y.B. Ryn	
2	KITECH	Principal Researcher	Sergey Gao	
3	CTCN	Communication Officer	OLEG TYAN	
4	HYDROENGEO	Director	Jurkayon Yashin	
5	Hydrogeo	Director	S. S. S. S.	
6	Hydrogeo	Lead specialist	Michael	
7	Hydrogeo	Head of depart ment	Baris	
8	KITECH	CTO / Director	Georgiy	
9	CTCN	Specialist	Hyung Jo	
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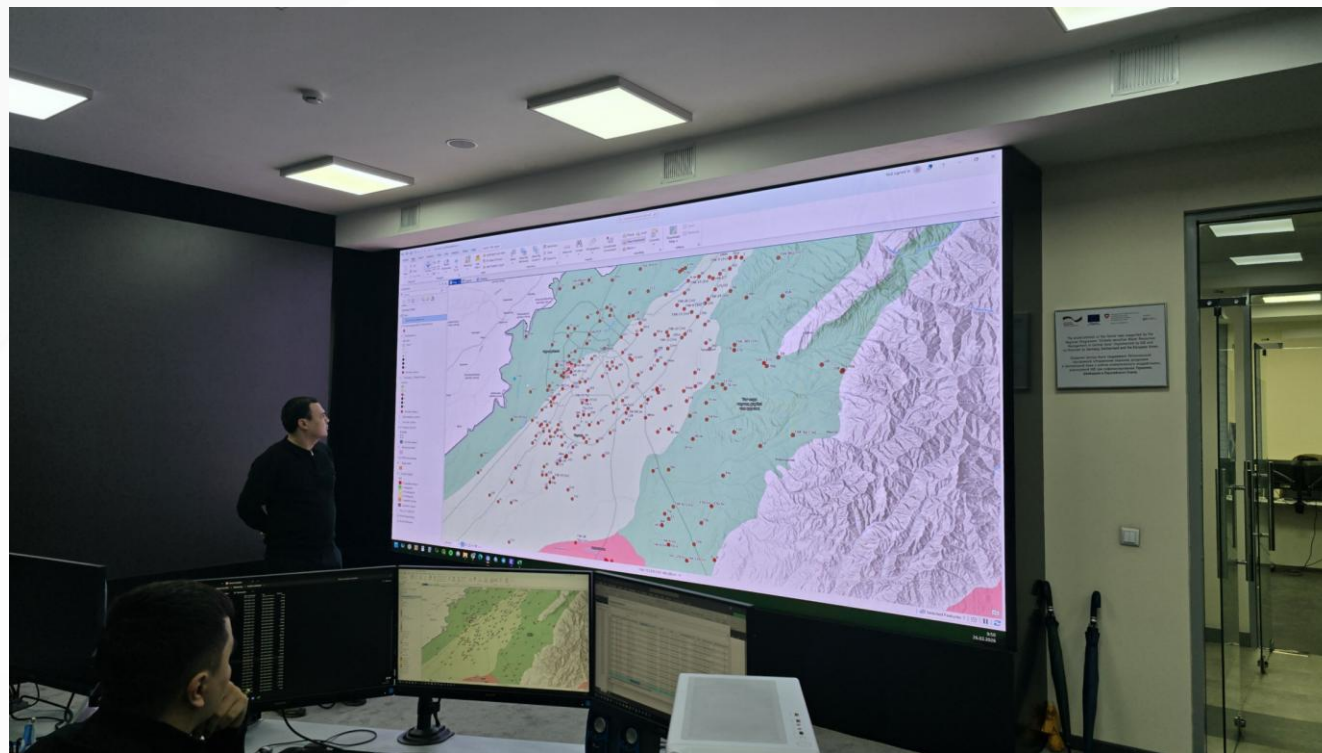
Main Objectives & Achievements

- **Governance Establishment**: Formally established the PSC and confirmed its roles and responsibilities to ensure stable project oversight.
- **Strategy Review**: Conducted a comprehensive review of the project scope, implementation approach, and overall governance structure.
- **Strategic Guidance**: Provided initial strategic direction to align the project with local and international climate technology goals.
- **Consensus Building**: Reached an agreement on the decision-making process for key project milestones.



Major Activities / Local survey

Monitoring System (HYDROENGEО)



- Utilized the **Centralized Monitoring Room** to identify well locations and real-time water quality data.
- Uzbekistan manages approximately **3,000 wells** nationwide, with over **200 wells** located in the Tashkent region.

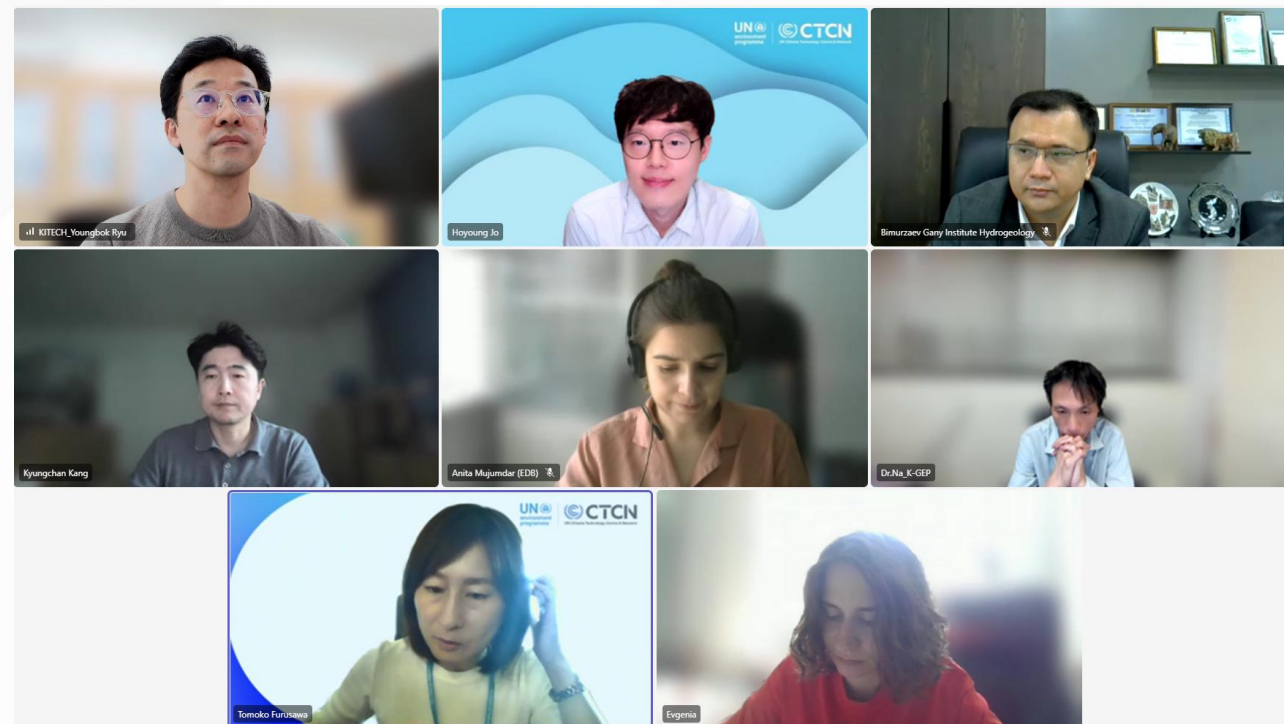
Field Survey: Chirchik-Keles Aquifer



- Selected and inspected high-hardness wells based on monitoring data.
- Location / Infrastructure:** Evaluated surrounding infrastructure and potential CO₂ sources for resource recovery.
- On-site Testing & Sampling:** Collected raw water samples for precise lab analysis and desalination testing.

Major Activities / Introductory call with EDB

Meeting Overview



- **Date** : 22 May(Fri), 2026
- **Format** : Online meeting (MS Teams meeting)
- **Organizer** : UNEP CTCN
- **Participants** : CTCN, EDB, HYDROENGEO and KITECH
- **Purpose** : To introduce the Uzbekistan Technical Assistance (TA) Project and share the progress achieved to date.

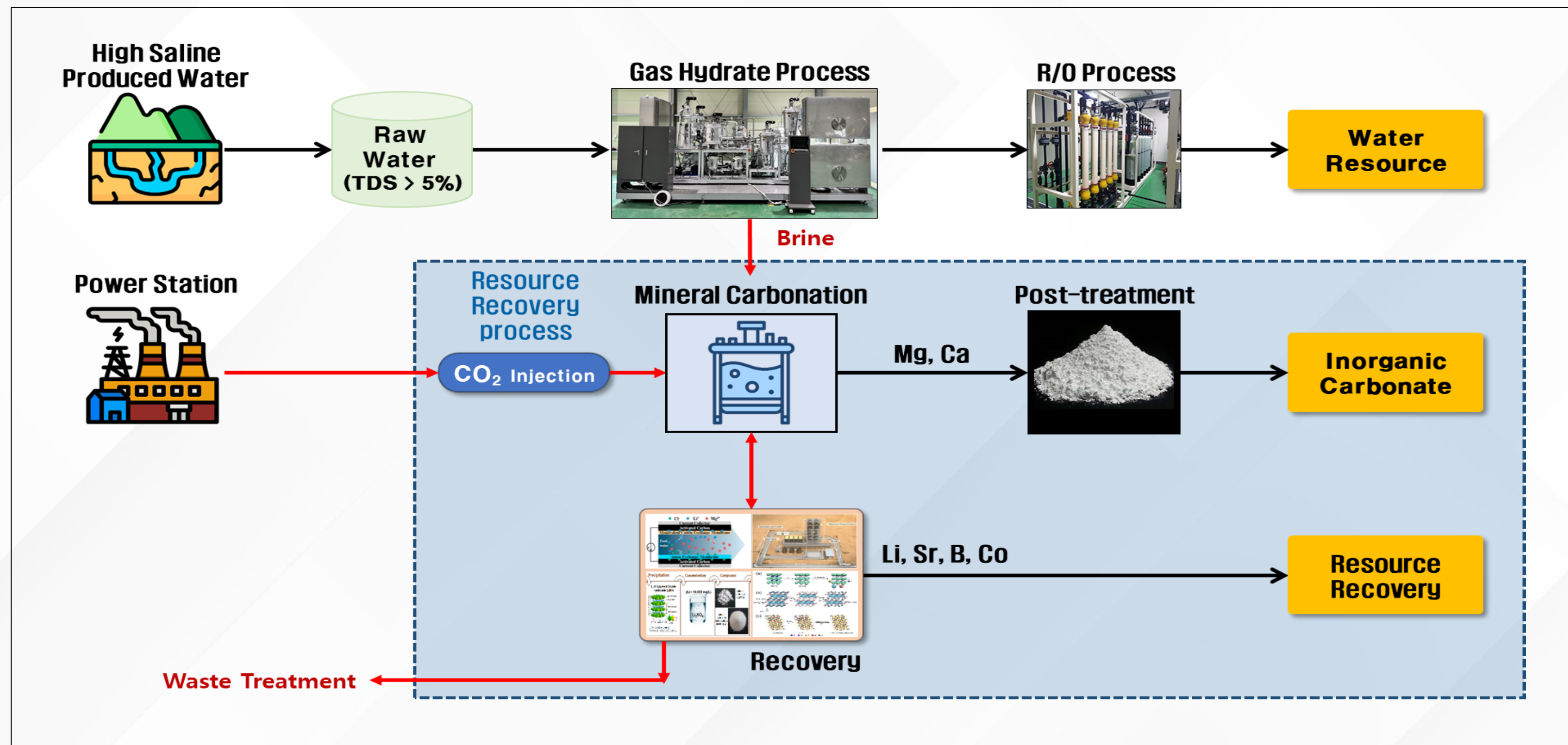
Meeting Summary

- Introduced the objectives, scope, and implementation status of the TA Project.
- Shared the progress and key activities completed during the project implementation.
- Exchanged views on the project background, implementation needs, and future development opportunities.
- Discussed the potential for continued communication and information sharing among the participating organizations.

Outcomes

- Established a common understanding of the current status of the TA Project.
- Agreed to maintain communication and share updates on project progress as appropriate.

Technology Concept



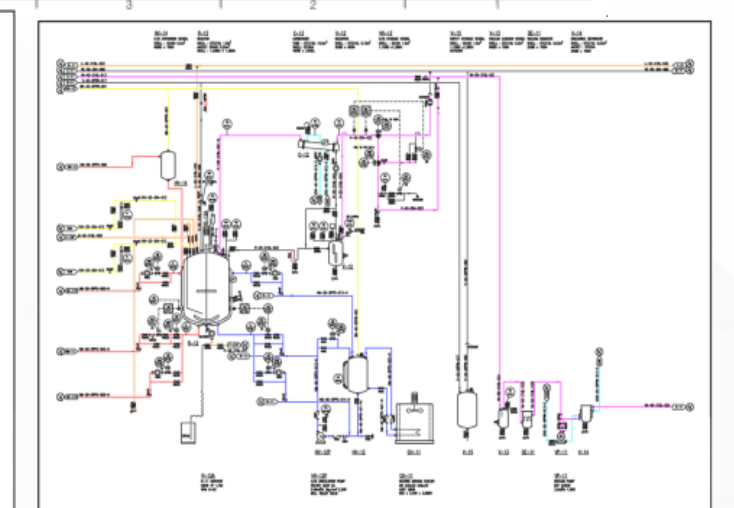
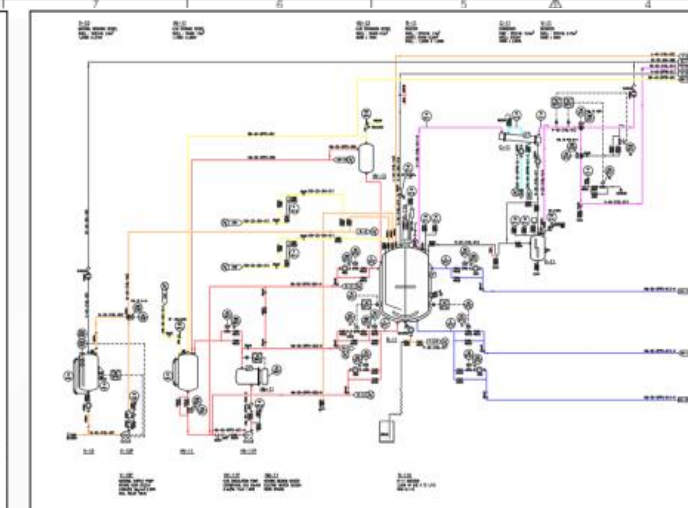
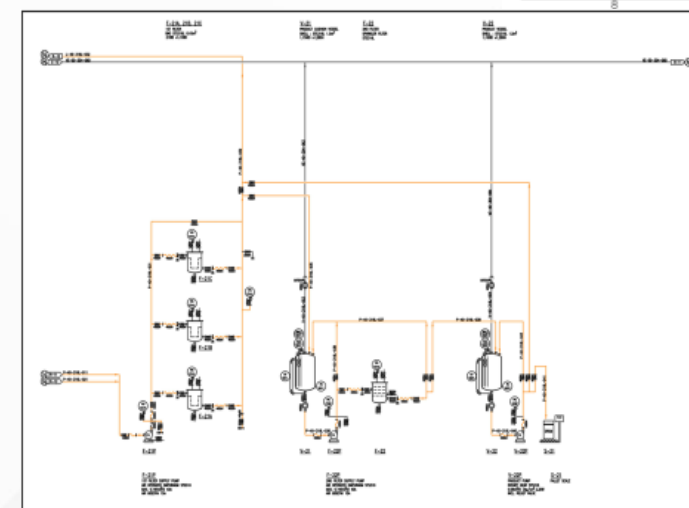
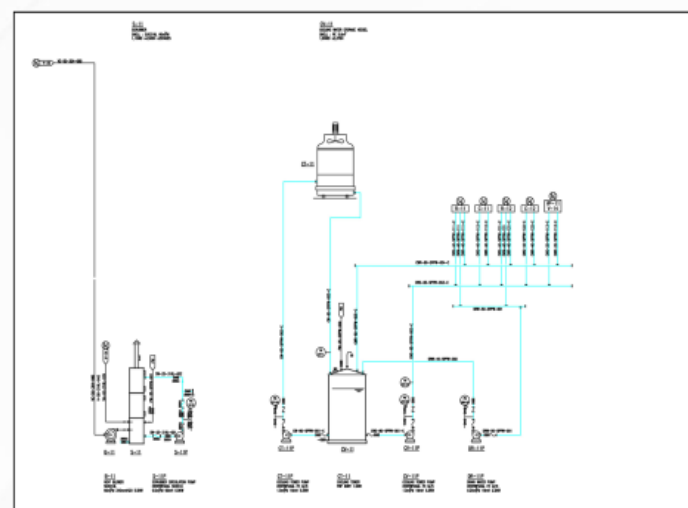
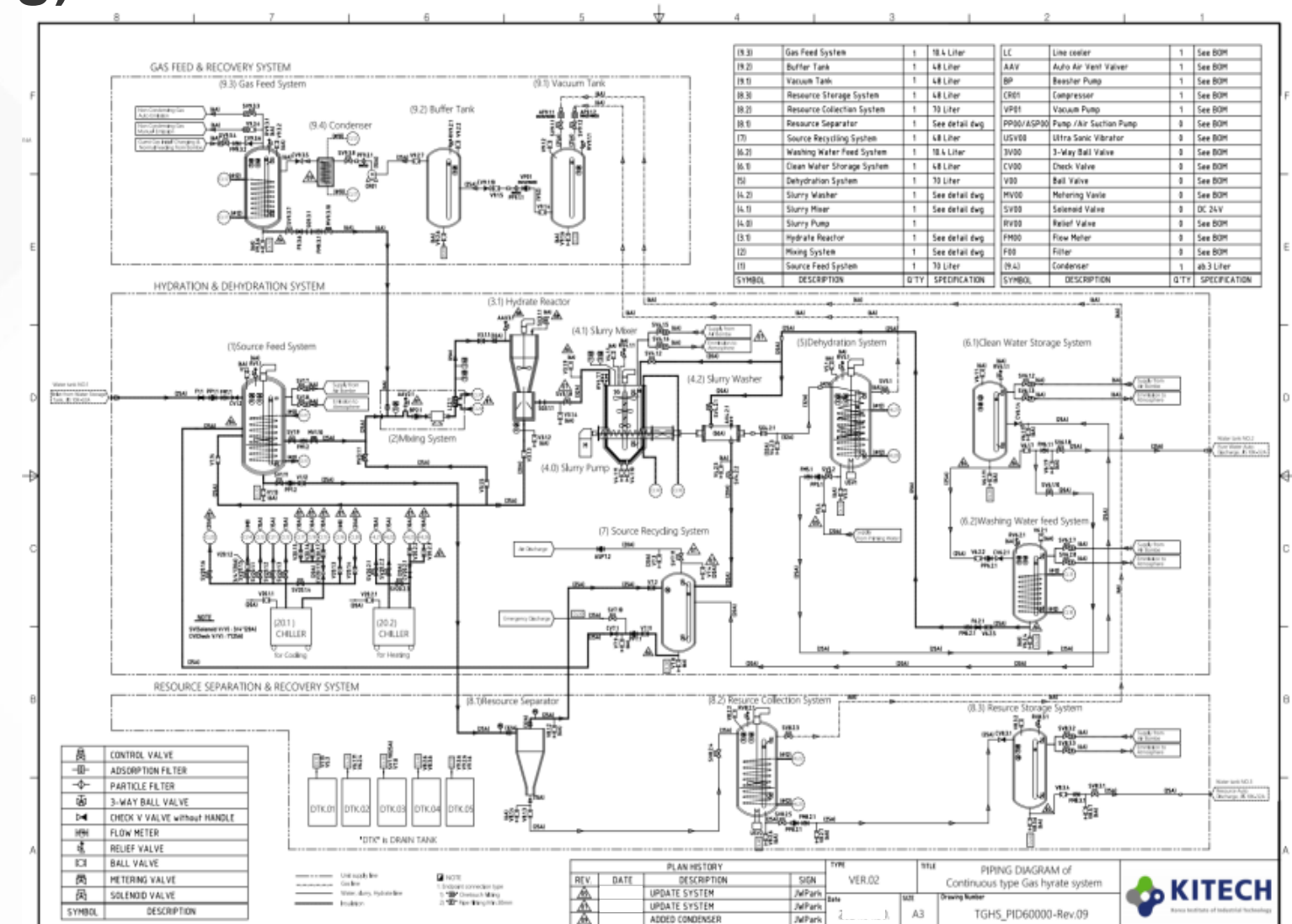
Major Activities / Design of Pilot System (on going)

- For feedwater with **TDS ≥ 5%:**
Primary concentration using **Gas Hydrate Technology**
- For feedwater with **TDS < 5%:**
Apply **Reverse Osmosis (RO)** or **Mechanical Vapor Recompression (MVR)**

- Increase the concentration ratio to enhance resource recovery from the concentrate
(Apply **Gas Hydrate Technology** if necessary)

- Evaluation of **CO₂ conversion** and **product purity**

- Continuous **Bench-Scale Validation** for Water Treatment & Mineral Carbonation to
Develop the Optimal Pilot Plant P&ID (**10 ~ 100 ton/day**)



Major Activities / Design of Pilot System (on going)

Groundwater composition analysis results for the Bukhara–Karshi region

Sample No.	pH	TOC (mg/L)	T-N (mg/L)	T-P (mg/L)	TDS (mg/L)	Mg (mg/L)	Ca (mg/L)
N4	6.86	43.5	13.3	0.56	89,139	1,654	4,811
N6	5.59	557.6	11.81	1.33	77,352	1,649	4,819
N7	7.97	15.2	8.69	0.05	65,227	1,570	3,316
N9	7.41	21.9	12.91	0.05	91,610	3,111	9,411
N10	7.65	55.5	17.64	0.02	81,832	1,761	5,204
N14	7.56	33.1	9.31	0.03	91,301	2,634	4,816
N15	7.67	46.9	16.56	0.05	87,016	1,688	4,966
N17	7.65	35.2	7.42	0.03	137,089	3,579	2,204
N18	5.61	134.4	10.37	0.07	75,929	1,581	4,894

Treatment efficiency using synthetic raw water (gas hydrate method)

항목	Na ⁺	Mg ²⁺	Ca ²⁺	K ⁺	Cl ⁻	SO ₄ ²⁻	TDS
Raw conc.(mg/L)	16,120	1,591	432	682	33,900	4,100	56,825
Final conc.(mg/L)	2,461	240	78	112	4,600	500	7,991
Brine conc.(mg/L)	23,380	2,149	653	971	47,800	5,600	80,553
Removal efficiency (%)	84.73	84.92	81.94	83.58	86.43	87.80	85.94

Resource recovery results synthetic Brine (mineral carbonation)

	Na	Ca	Mg	K	B	Remarks
Brine	17,117.1	571.54	2,137.04	821.02	4.97	Unit : mg/L
Mg carbonates	2.27	12.59	230.7	N.D	N.D	
Ca carbonates	10.05	372.23	1.44	0.02	N.D	
Wastes	25,538.94	8.03	7.53	485.83	3.01	

Future Work Plan

- Design of a pilot plant suitable for the demonstration site
- Completion of the technical, socio-economic, and environmental assessments, along with the scale-up project concept note
- Preparation of the final report and presentation of the final project results
- Implementation of stakeholder training through an invitation program in the Republic of Korea



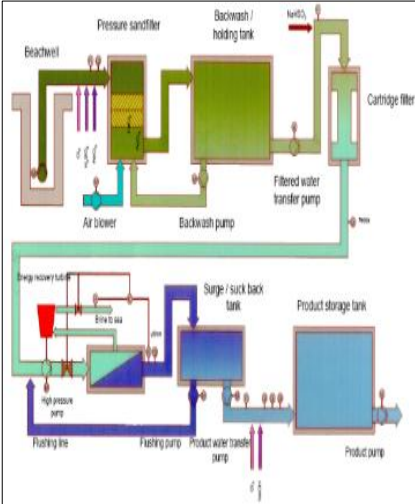
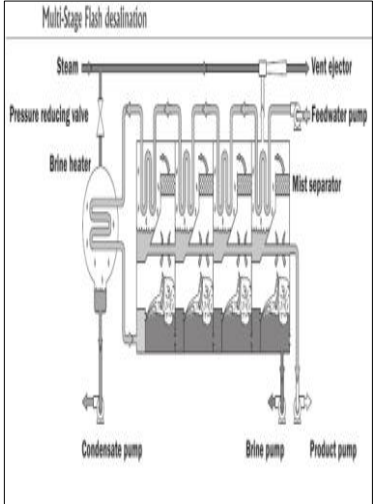
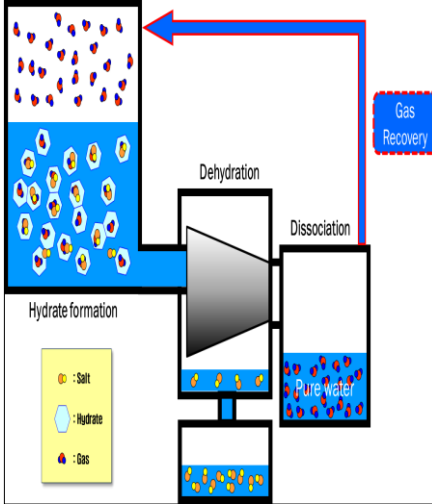
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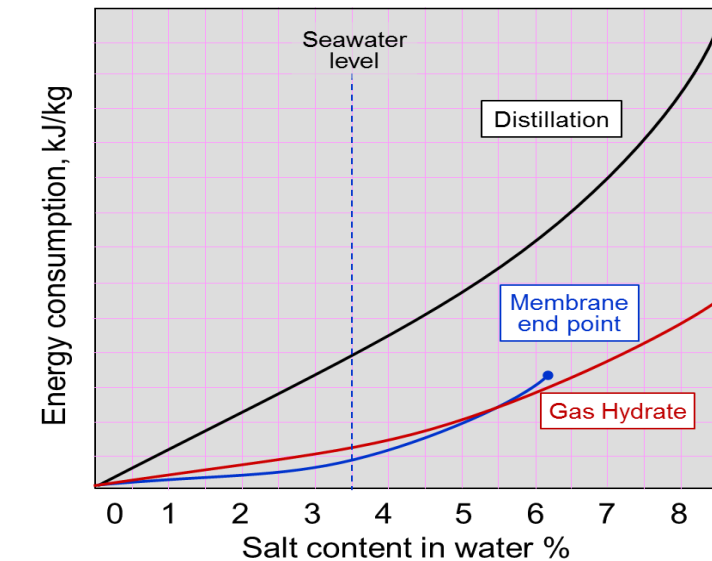


KITECH
Korea Institute of Industrial Technology

Basic Technical Capacity Building Training (Desalination)

Desalination

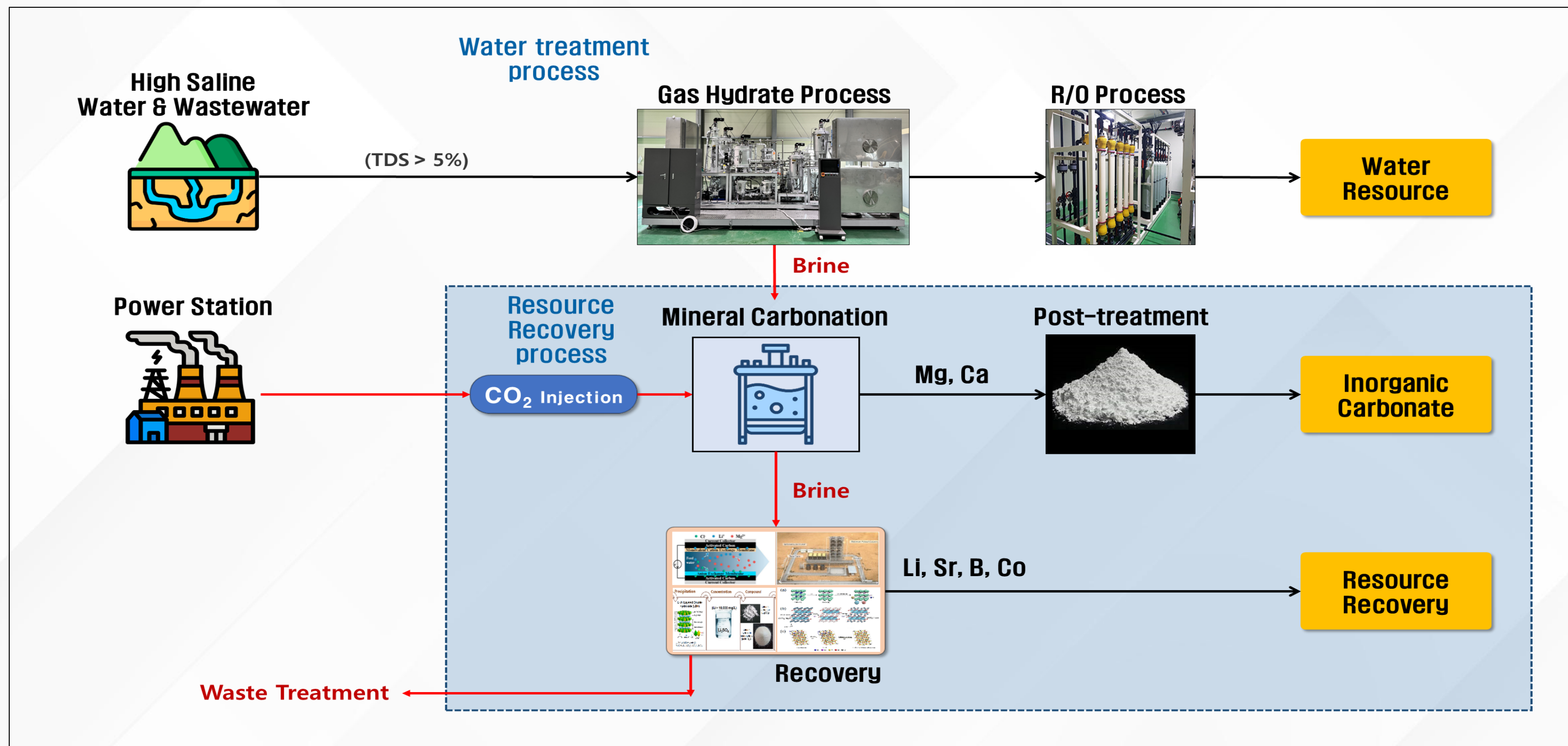
Methods	Reverse Osmosis (RO)	Distillation (MSF)	Gas hydrate (HBD)
	 	 	 
Strengths	✓ The most widely used commercialized process ✓ The facility scale is small compared to the processing capacity. It is easy to expand. ✓ Well optimized, resulting in low energy consumption ✓ Recovery rate of produced water : High (40 ~ 50%)	✓ The method is straightforward to implement. ✓ Capable of large-scale processing ✓ The process yields higher purity water than RO.	✓ Handling salinity concentrations greater than 5% TDS. ✓ No additional chemical additives and simultaneous resource enrichment is achievable ✓ Ensures stable treatment regardless of various impurities in the feed water ✓ The method requires about 4.7 times less energy (8.59kJ/mol) compared to the distillation method, with a recovery rate of over 30%.
Weaknesses	✓ Significant pretreatment is required. ✓ The process requires large amounts of chemicals. ✓ Frequent membrane replacement is necessary. ✓ Unable to process salinity levels exceeding 5%.	✓ High latent heat of vaporization (40.77 kJ/mol) results in excessive energy consumption ✓ Recovery rate of produced water : Low (around 15 ~ 18%) ✓ Pre-treatment to prevent scaling in the evaporator (Less than reverse osmosis)	✓ Higher energy consumption compared to RO methods ✓ Investment is required for initial facility construction. ✓ Large-scale facility construction requires significant investment, making it more suitable for small to medium-sized treatment plants.



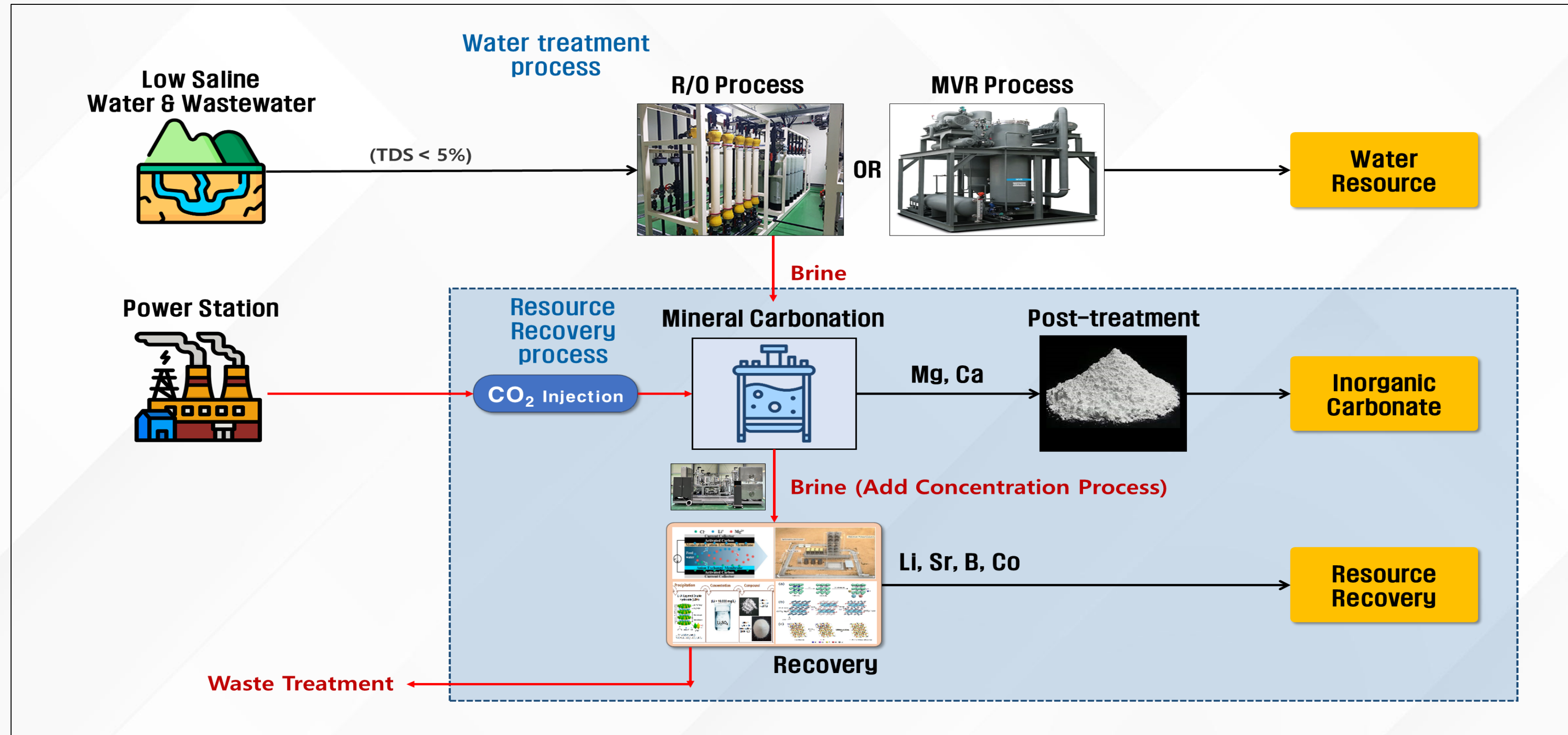
HBD Technology

- ✦ No fouling
- ✦ Operating over high TDS (salts, over 5%)
- ✦ Recovery rate is lower than that of the membrane method(50%), but the energy is reduced by about 4 times compared to the evaporation method.
- ✦ Under the conditions of produced water (8 ~ 20% TDS) from oil & gas fields, Gas hydrate method is the best option.

Technology Concept Case 1 (High Salinity, TDS > 5%)



Technology Concept Case 2 (Low Salinity, TDS < 5%)

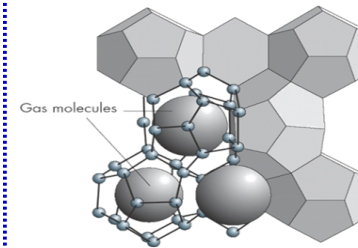


Gas Hydrate-Based Desalination

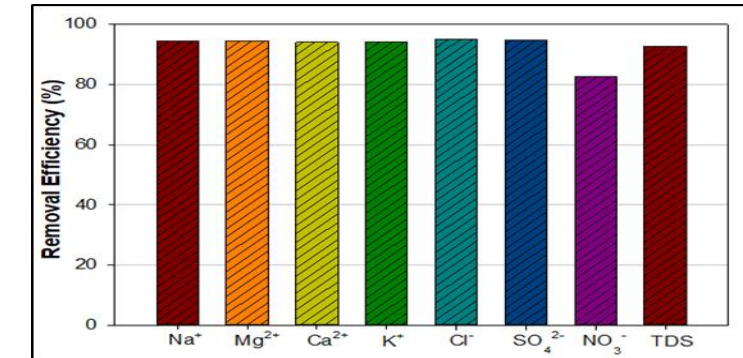
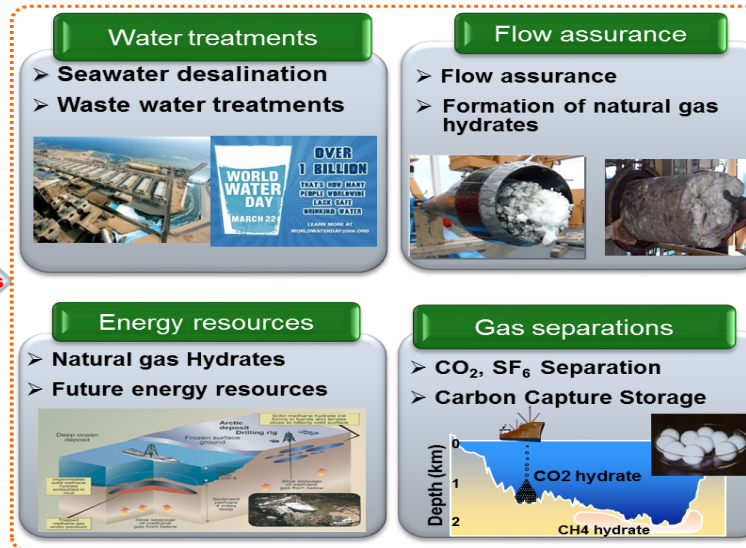
- Produced water(wastewater) in Oil and gas fields contains a large amount of TDS.
- Secure TDS and water resources with low-energy, eco-friendly technology.
- Concentration technology is needed to increase the content of useful resources.

Properties of Gas Hydrates

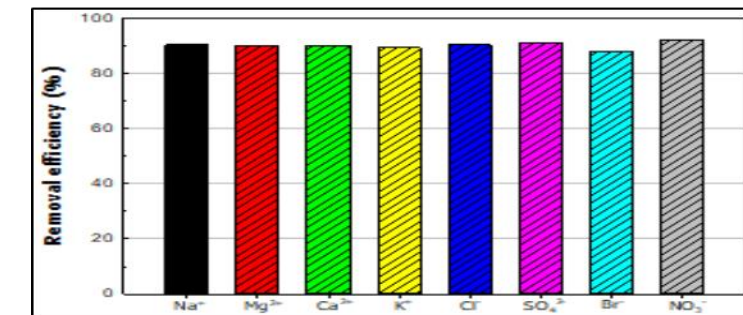
- Non-stoichiometric crystalline compounds, which consist of water and suitable guest molecules



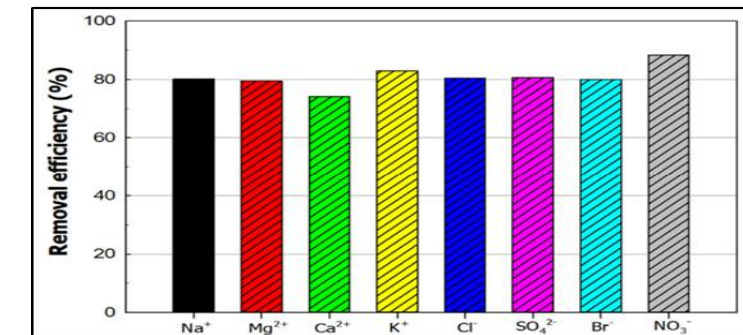
Applications



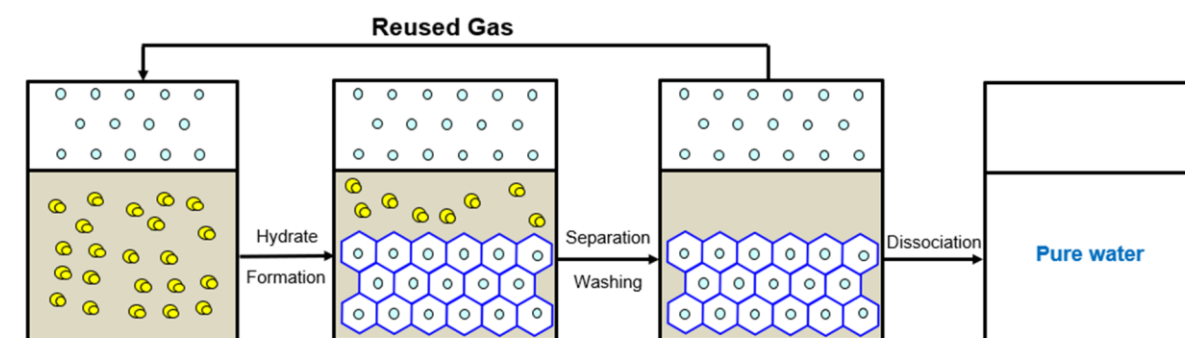
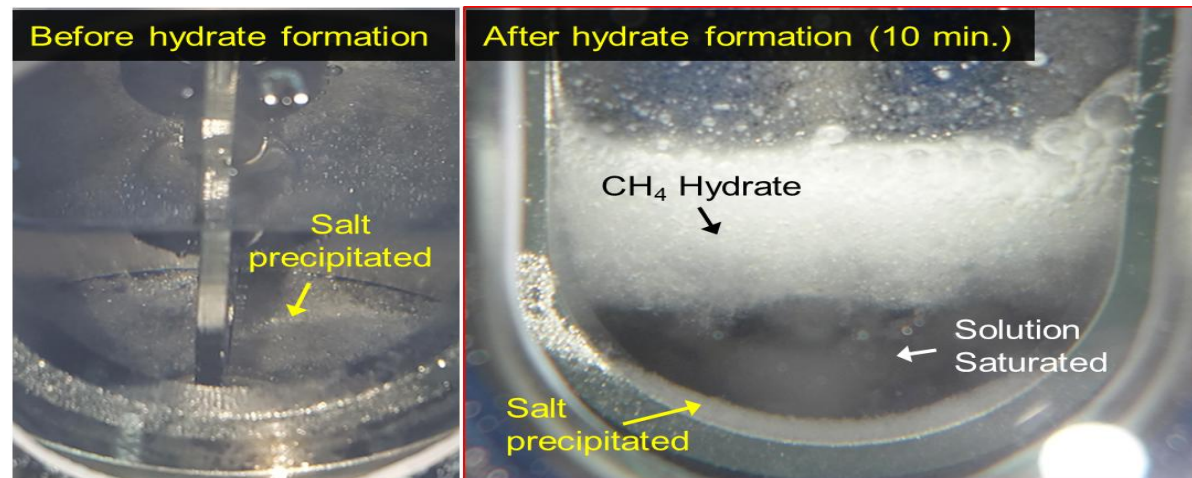
< TDS 50,000 ppm >



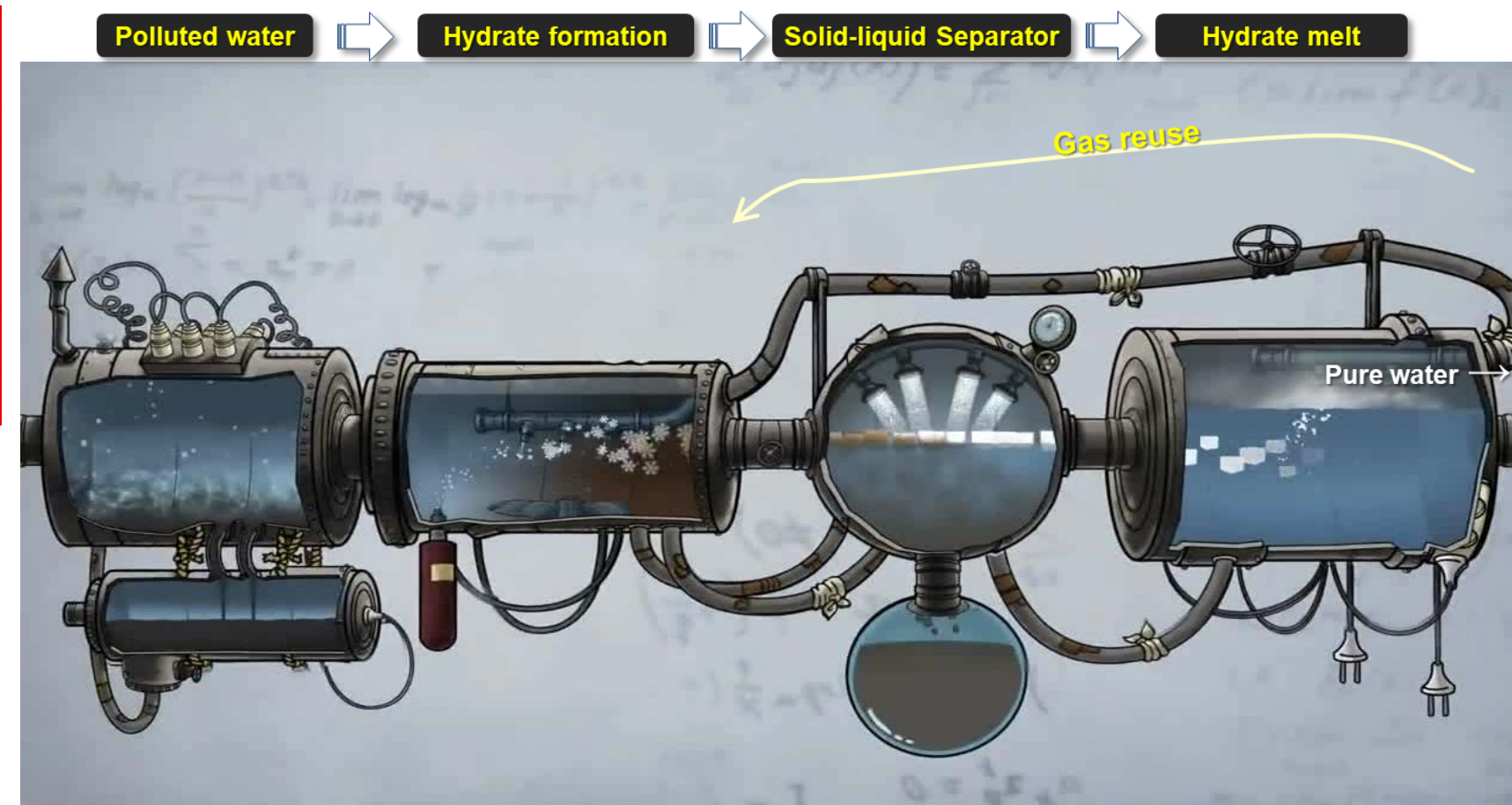
< TDS 100,000 ppm >



< TDS 150,000 ppm >



< Gas hydrate based desalination >



Previous Projects (Gas Hydrate-Based Purification)

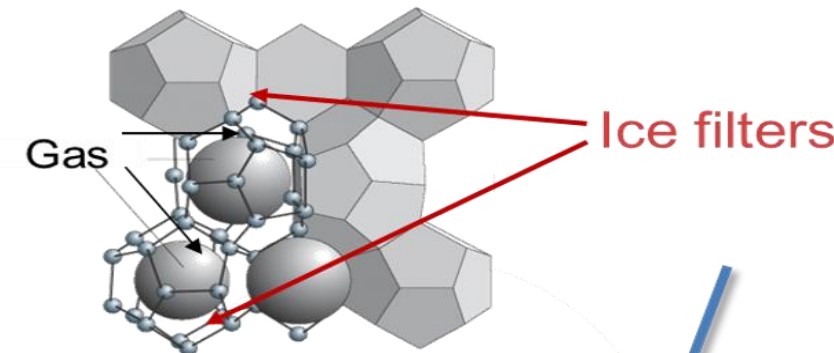
Radioactive Liquid Waste with Salts



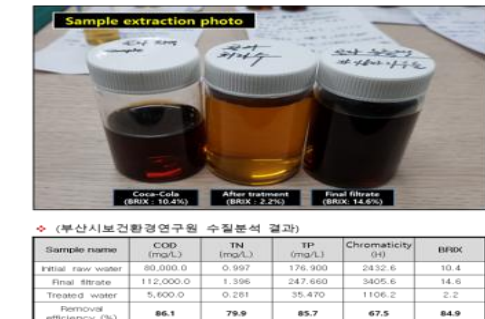
- Facility Capacity: 5 m³/day
- Target Radionuclides: Sr²⁺, Co²⁺, Cs⁺, I⁻
- Simultaneous Treatment of Radionuclides Possible
- Capable of Treating Brine with Radionuclides waste
- Eco-Friendly Process Without Filtration

Gas Hydrate

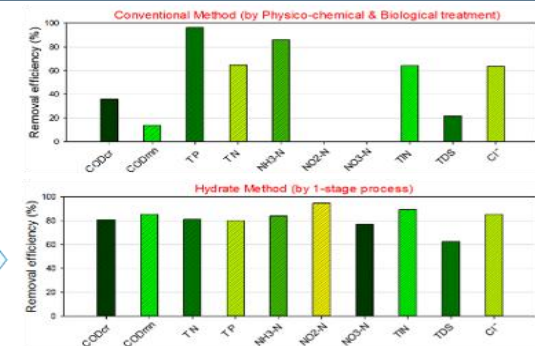
- Pure water and gas crystal
- Contaminants are excluded because of the crystals own **ice filters**



Livestock Waste with COD ≥ 80,000 ppm

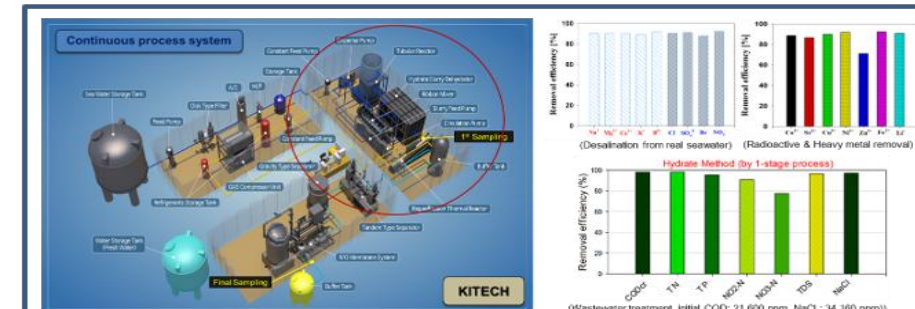
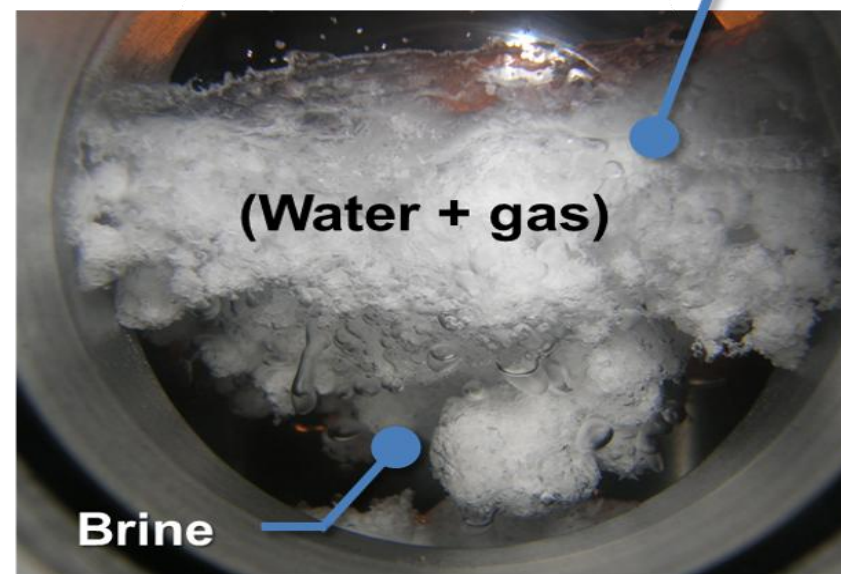


- Removal Efficiency of COD : 86.4%
- Treatment Results for Wastewater with COD ≥ 300 Times Higher than Existing Sewage Treatment Plant
- Significantly Superior to Existing Leachate Treatment Method (MLE)



- Wastewater contains nutrients (TN and TP), non-biodegradable organics, and COD
- Any contaminants and nutrients were effectively removed by hydrate method (≈ 80%)
- Tested wastewater from landfill leachate in Korea

Wastewater from Landfill Leachate with COD ≥ 50,000 ppm

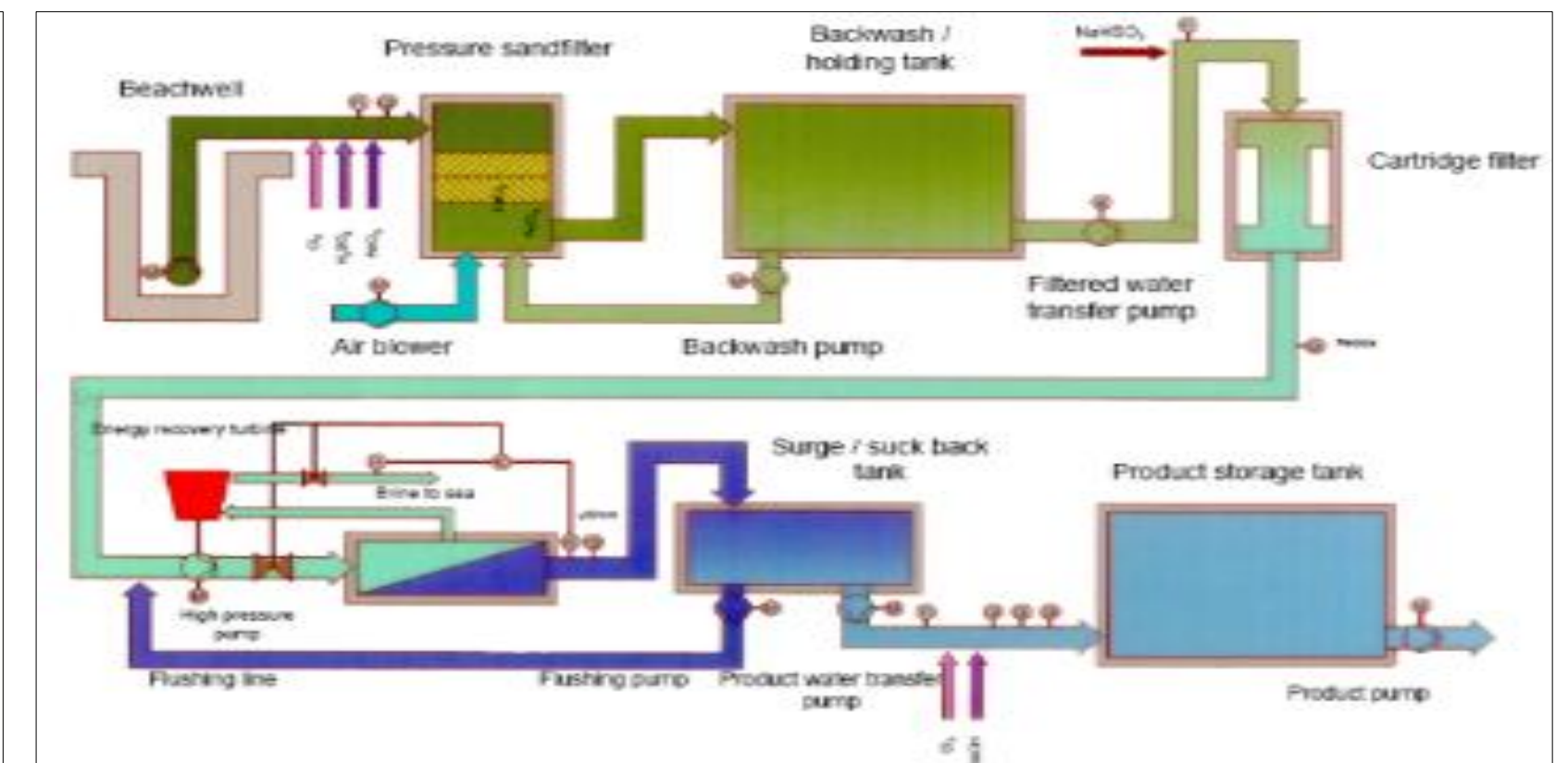
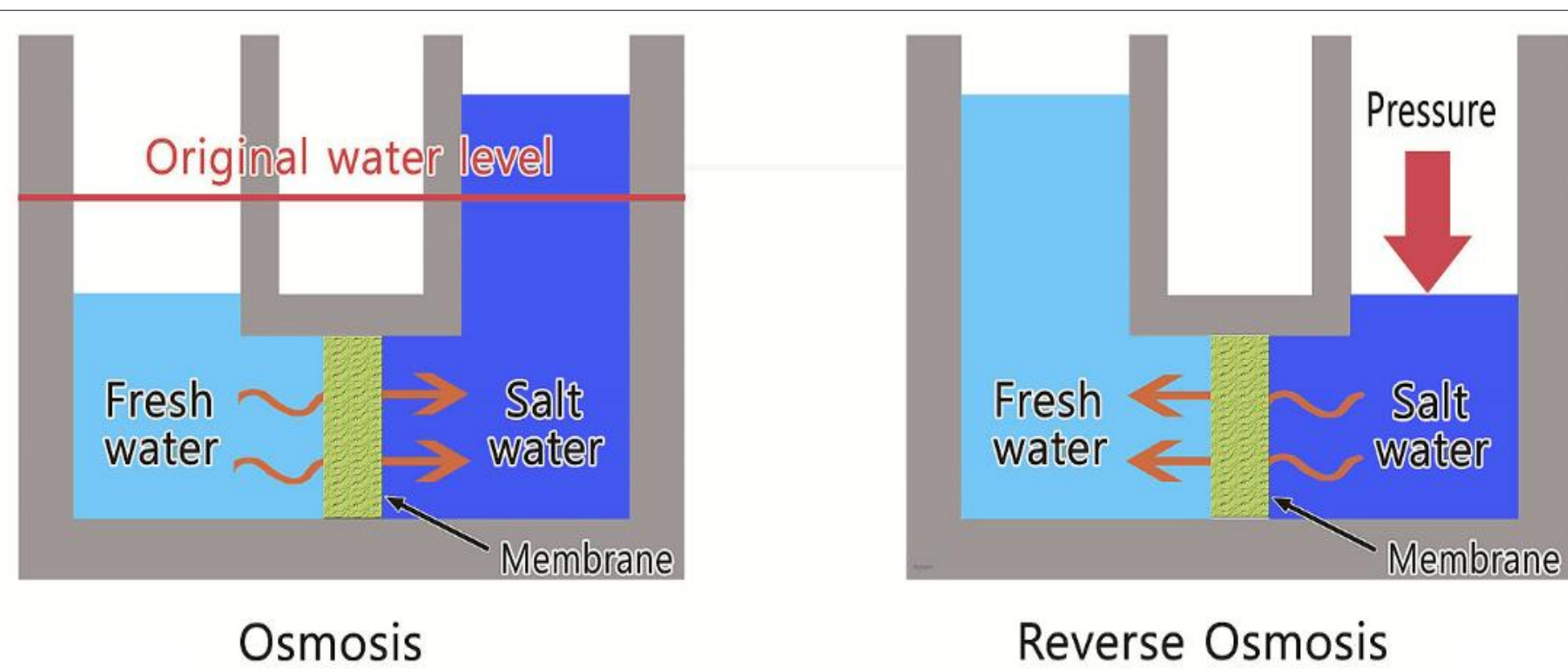
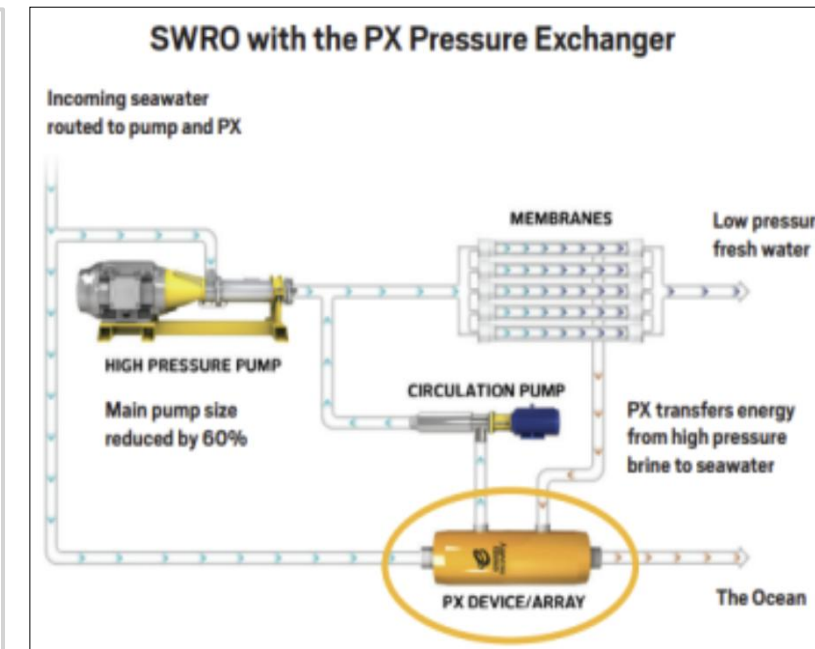


- Removal efficiency from 1 stage of hydrate formation/dissociation process
- Removal efficiency from 1 stage at 3 bar, 278 K
- High saline water : 85~90 %, Radioactive : 80~90 %
- Application for water purifying or element recovery under high salt (> 20%, > 200,000 mg/L) condition

High saline water with TDS 50,000 ~ 150,000 ppm

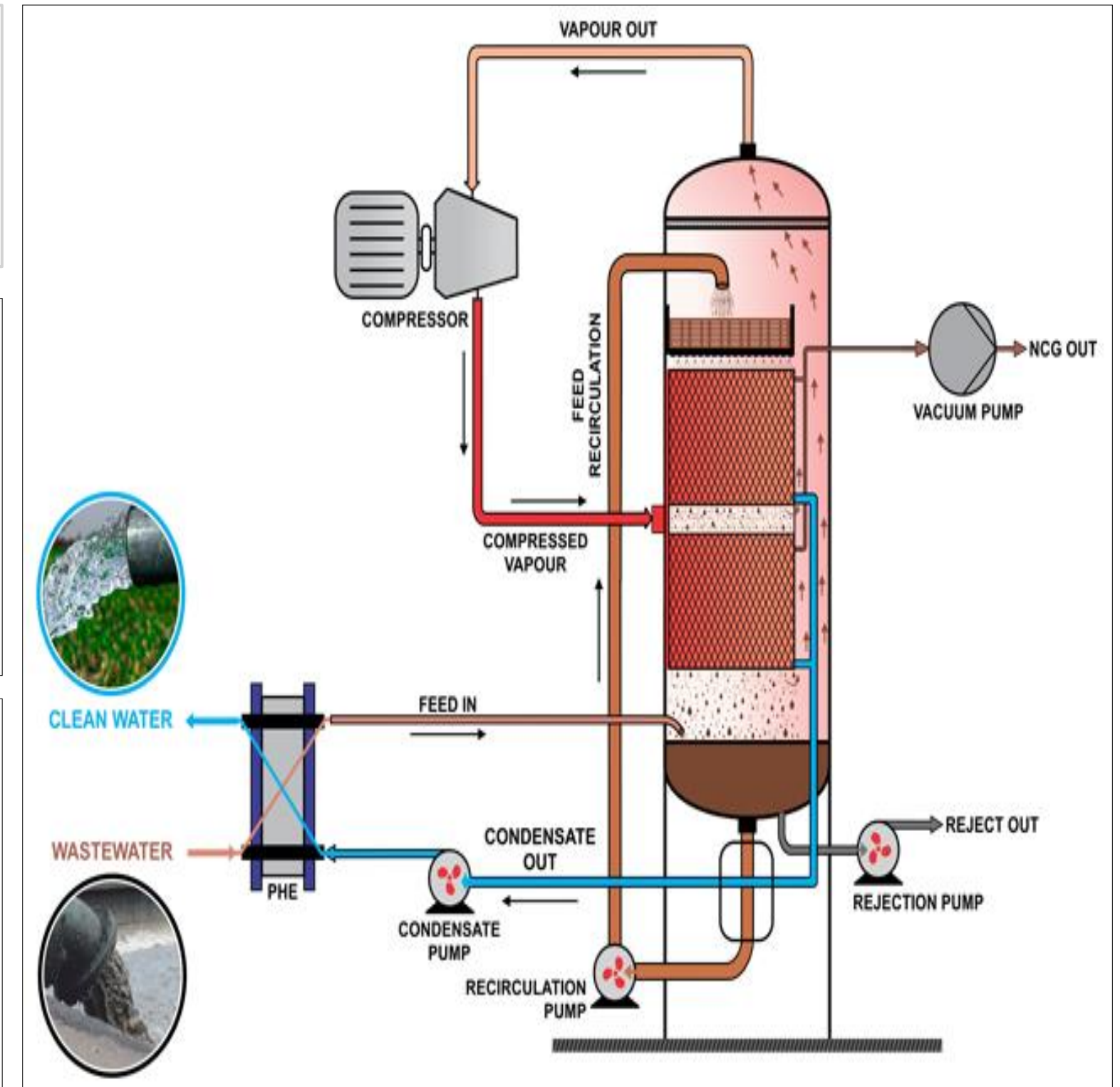
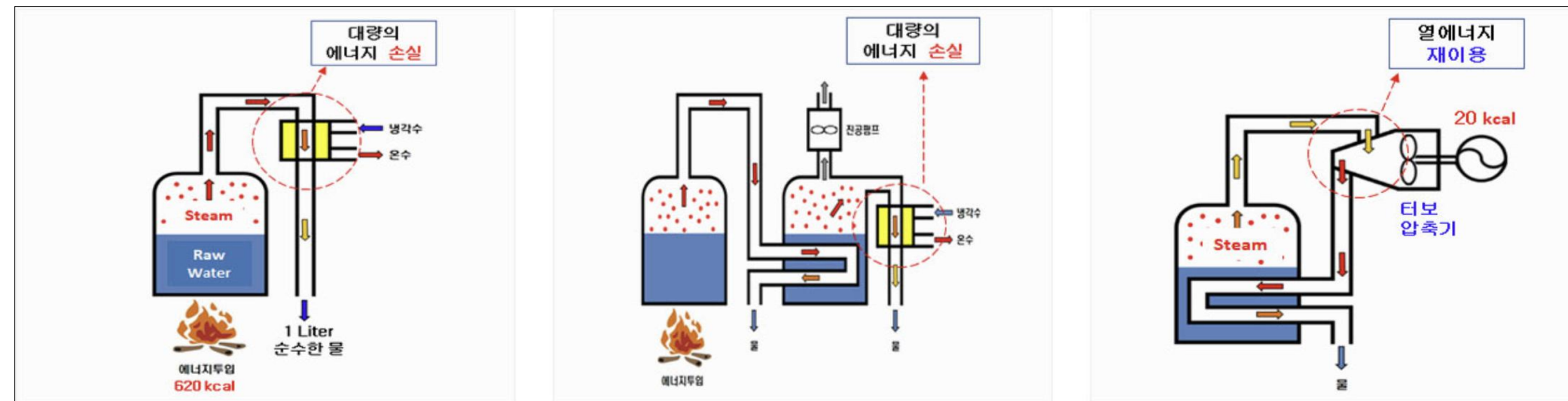
Reverse Osmosis

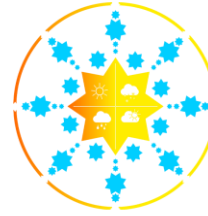
- Water purification method that removes salt and impurities from seawater by using high pressure to force water molecules through a semi-permeable membrane
- Pure water molecules pass through a membrane, while salts and impurities are left behind
- Recovers the immense pressure from the discharged brine to significantly reduce the energy costs and power consumption



Mechanical Vapor Recompression

- 💧 MVR systems use the vapor generated for heat instead of relying on other external heat sources
- 💧 This method ensures higher energy saving, lower environmental impact and lower overall operational costs
- 💧 MVR evaporation process needs no extra steam input



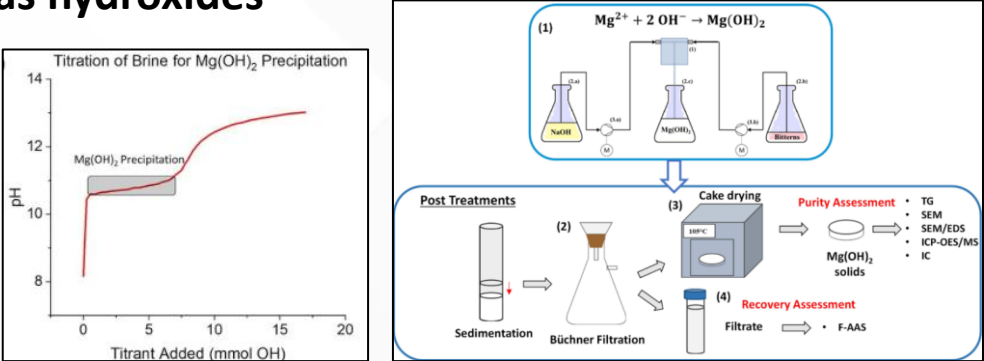
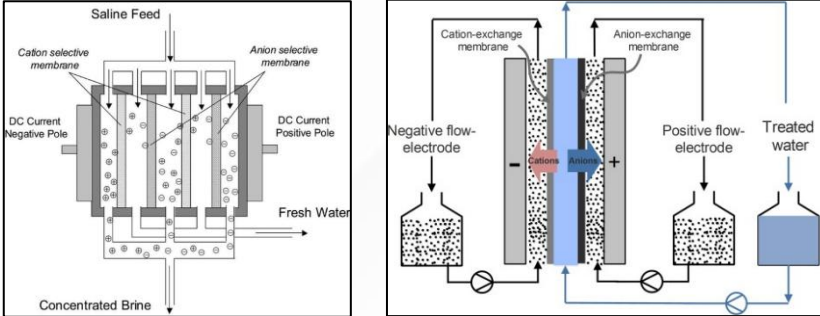


O'ZBEKISTON RESPUBLIKASI
EKOLOGIYA, ATROF-MUHITNI MUHOFAZA QILISH
VA IQLIM O'ZGARISHI VAZIRLIGI HUZURIDAGI
GIDROMETEOROLOGIYA XIZMATI AGENTLIGI
O'ZGIDROMET



Technical Capacity Building Training (Resource Recovery)

Resource Recovery

	Hydroxide Precipitation	Mineral Carbonation	Electrochemical Recovery (ED/FCDI)
Fundamental Principle	Raises pH to precipitate Mg^{2+} and Ca^{2+} as hydroxides 	Reacts Ca^{2+} and Mg^{2+} with CO_2 (CO_3^{2-}) to form solid carbonates 	Uses electric field, membranes, or electrodes for selective ion separation 
Technology Readiness Level	High (commercialized)	Medium (pilot to demonstration stage)	ED: High / FCDI: Medium
CO₂ Utilization	None	Direct CO₂ mineralization (core function)	None
Main Products	$Mg(OH)_2$, $Ca(OH)_2$	$CaCO_3$, $MgCO_3$ (value-added carbonates)	Concentrated salts, Li^+ , specific ion streams
Selectivity	Low	Medium	High
Process Complexity	Low	Medium	High
Energy Demand	Low	Medium	Medium to High
Operational Stability	High	Medium	Medium
Scalability	Very high	High	Medium
Solid Waste / Byproducts	Large sludge generation	Solid, stable carbonate products	Brine concentrate and membrane fouling issues
CCUS Integration Potential	None	Very high	Low
Economic Feasibility	High	Medium to high (product-dependent)	Uncertain
Technology Positioning	Basic and robust recovery route	Core CCUS -linked resource conversion technology	Advanced selective recovery technology

Technology / Mineral Carbonation

- What is Carbonation Technology?
 - Carbonation technology is a process in which ionic metals (M^+ , M^{2+}) react with carbon dioxide (CO_2) to form stable carbonates (MCO_3 , M_2CO_3).
 - This technology leverages the principles of **low Gibbs free energy (ΔG)** and **exothermic reactions**, enabling energy-efficient and eco-friendly recovery of valuable metals.
- Key Advantages of Carbonation Technology
 - ① **Low Gibbs Free Energy (ΔG) and Exothermic Reaction**
 - The formation of carbonates (MCO_3) occurs spontaneously due to low ΔG and is an exothermic reaction, allowing the process to continue without additional energy input.
 - This characteristic facilitates carbon-neutral resource recovery, reducing carbon emissions while extracting valuable metals.
 - ② **CO_2 Utilization Potential**
 - CO_2 can be obtained from filtered exhaust gases generated from surrounding production processes or obtained through Direct Air Capture (DAC) technology.

Classical Nucleation

Homogeneous nucleation

$$\Delta G = \underbrace{4\pi r^2 \gamma}_{\text{Surface free energy}} + \underbrace{\frac{4}{3}\pi r^3 \Delta G_v}_{\text{Bulk free energy}}$$

$$\Delta G_v = \frac{-k_B T \ln S}{v}$$

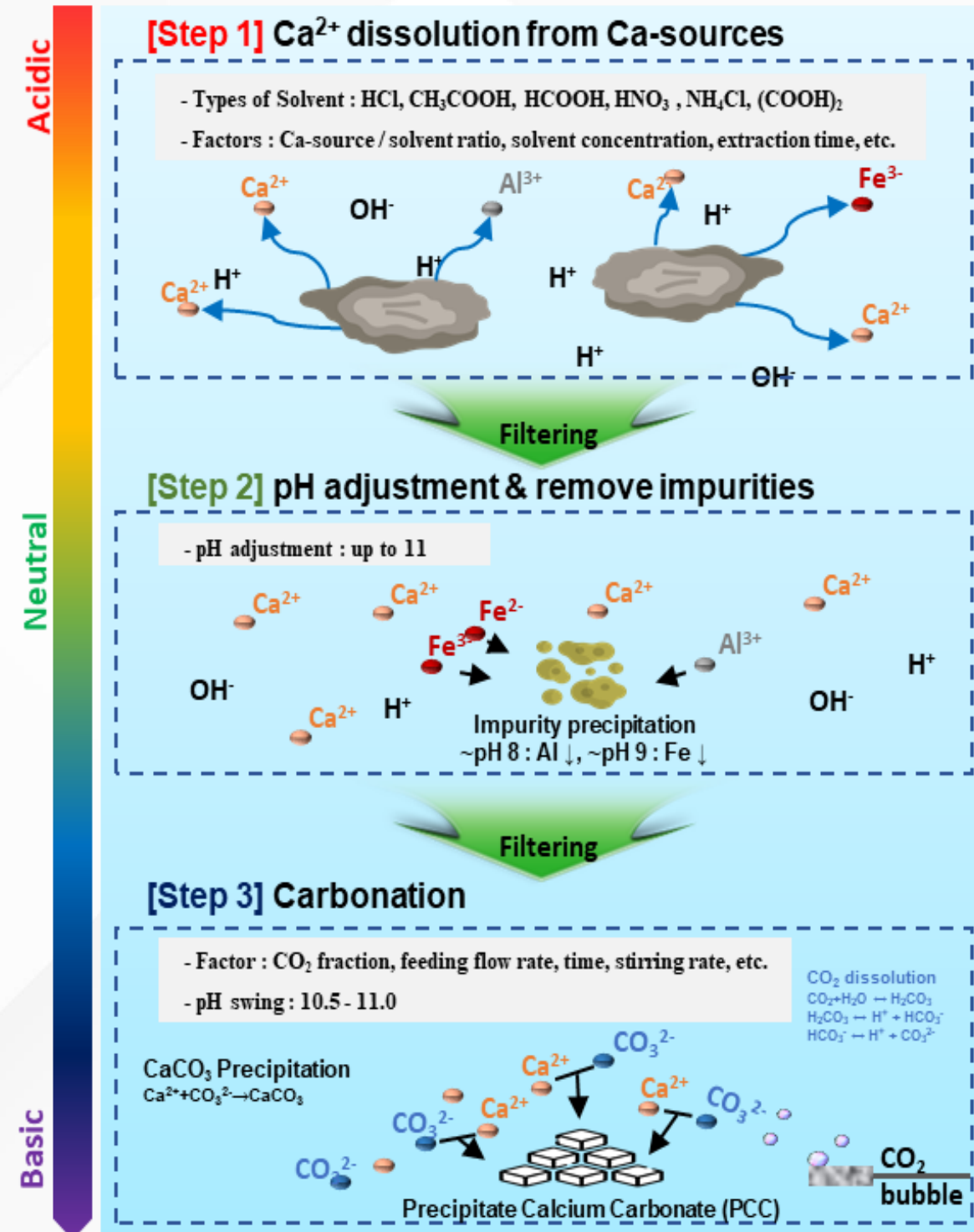
T : temperature
 k_B : Boltzmann's constant
 S : the supersaturation of the solution
 v : molar volume

Nucleation rate J

$$J = J_0 \exp\left(-\frac{\Delta G_{\text{crit}}}{k_B T}\right) = J_0 \exp\left(-\frac{16\pi\gamma^3 v^2}{3(k_B T)^3 (\ln S)^2}\right)$$

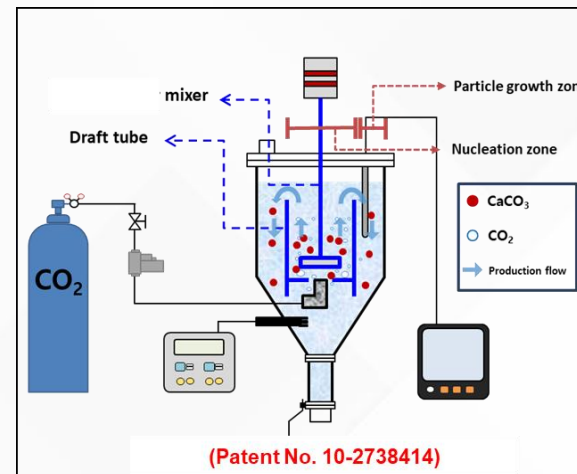
$S = 2 \rightarrow S = 4$: nucleation rate about $\sim 10^{70}$
 [LaMer Burst Nucleation]

Technology / Mineral Carbonation



Reactor Design & Development

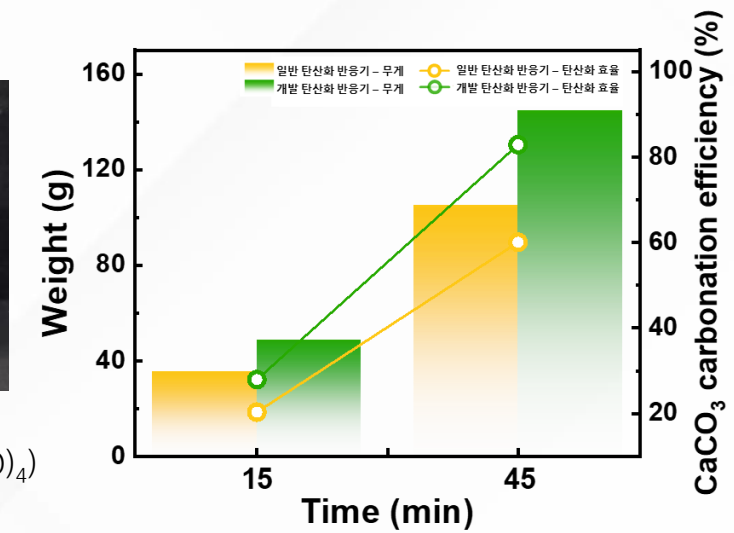
High-Efficiency Mineral Carbonation Reactor



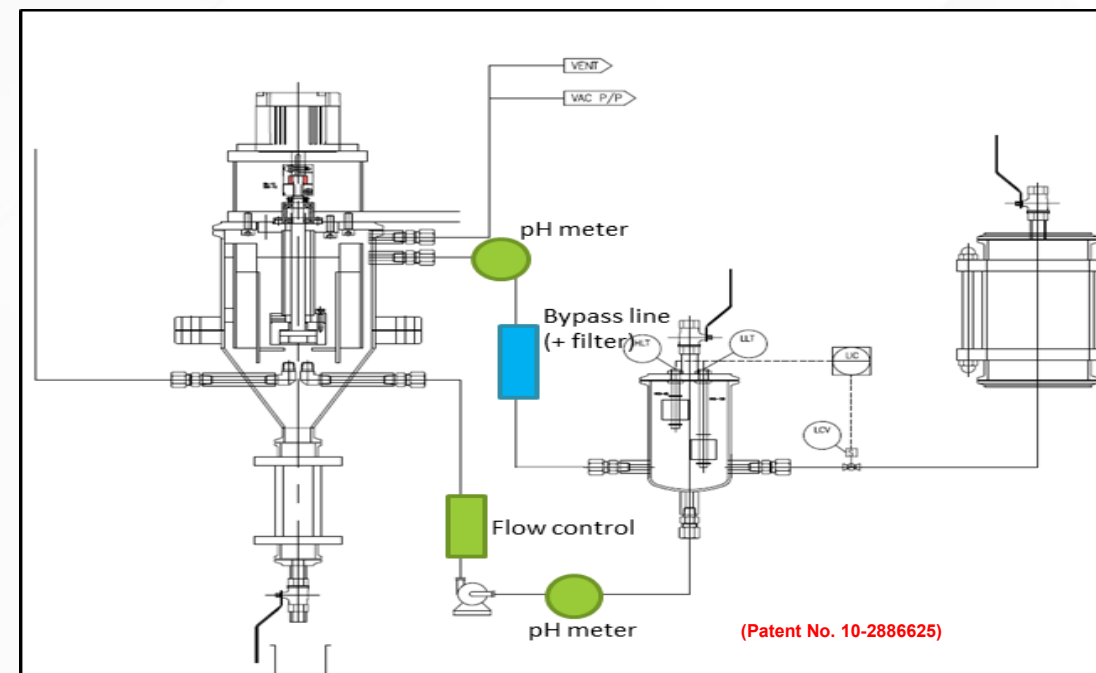
Calcite
(CaCO_3)



Hydromagnesite
($\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2(\text{H}_2\text{O})_4$)



Internal circulation Continuous mineral carbonation reactor



Previous Projects / Mineral Carbonation

Ulsan Carbon Dioxide Upcycling (Regulation-free special zones Project)

- ❖ Objectives of the Project
 - 1) Demonstration of Direct Carbonation Capture Process for use of carbon Dioxide as construction materials
 - 2) Establishment of High-quality calcium carbonate Synthetic Plant for High value-added Products
- ❖ Demonstration Period : 2021~2023 (3 years)
- ❖ Total Budget : 12.3 million USD
- ❖ Participating Institutions : KITECH and 11 others institutions



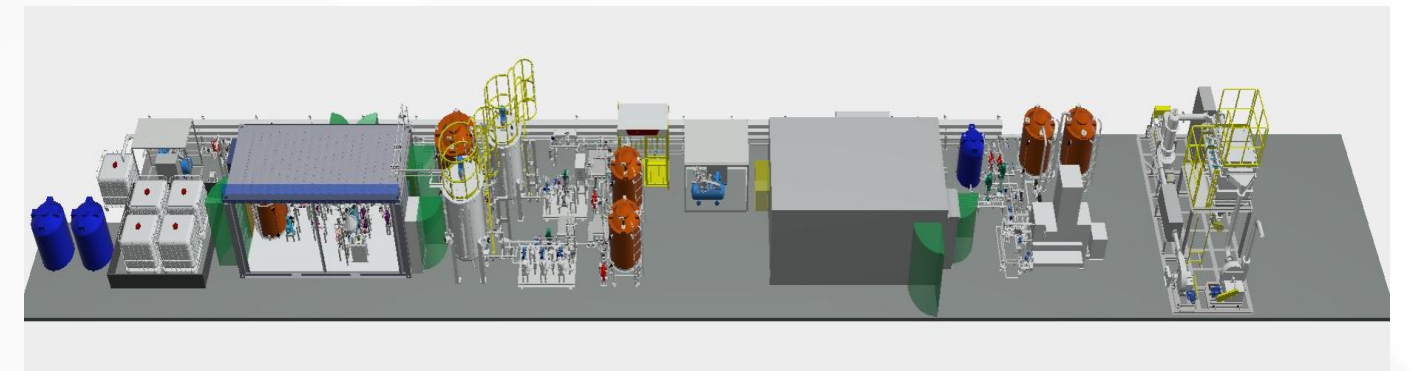
Direct carbonation PP (5 TPD)



Indirect carbonation PP (2TPD)

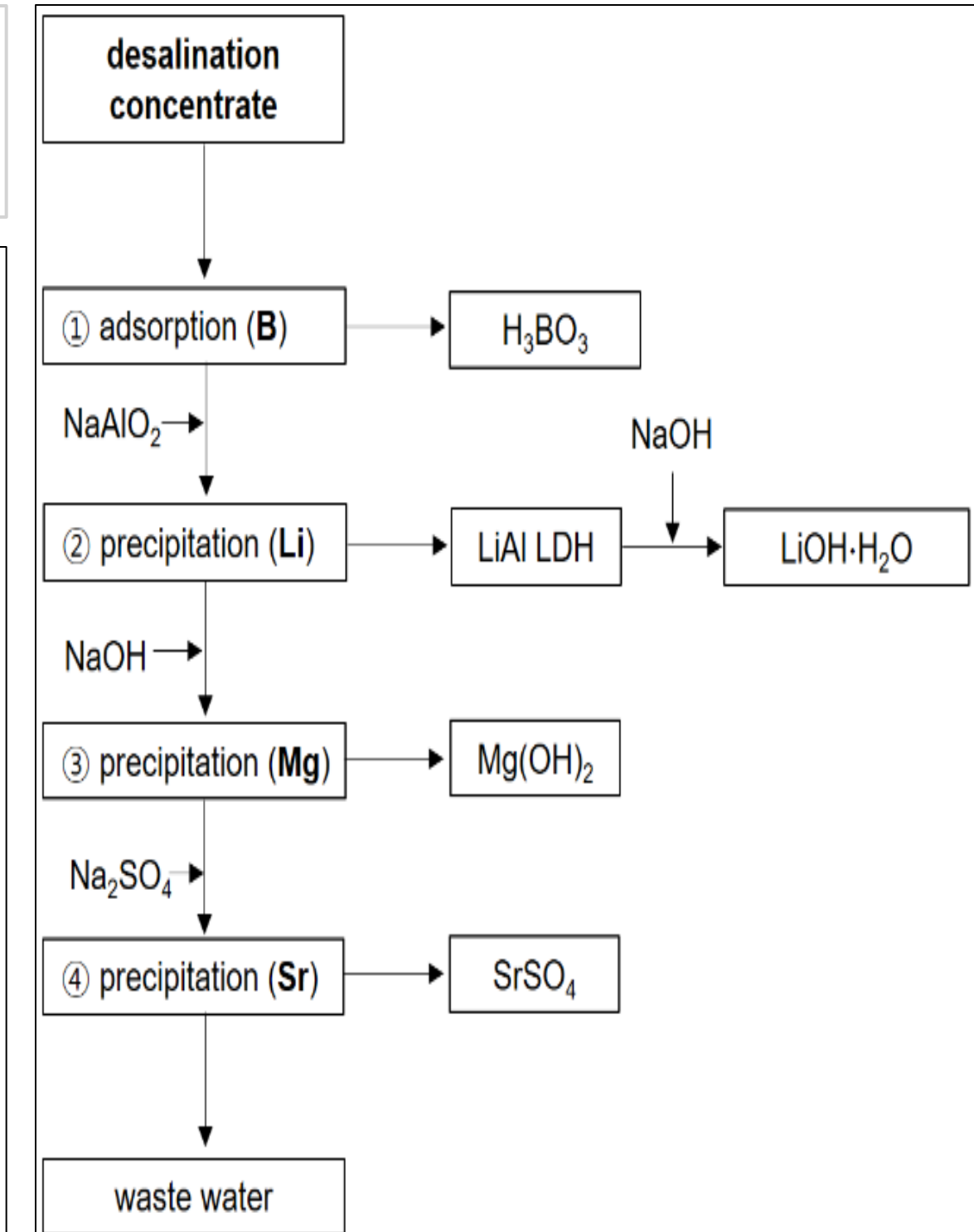
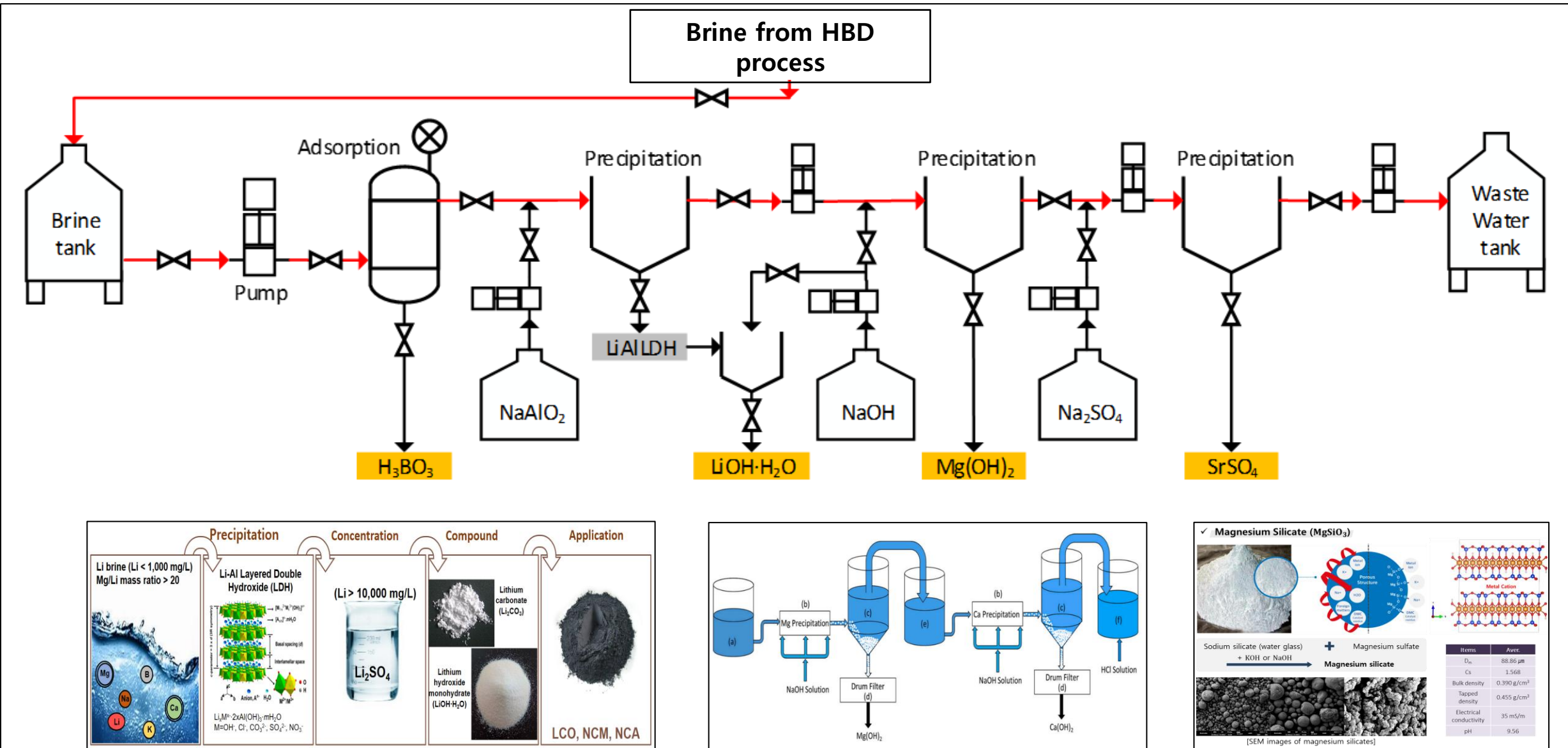
Development of Magnesium-Carbonate Production using CO₂ and Brine from Seawater Desalination

- ❖ Objectives of the Project
 - 1) Development of high-efficiency mineralization technology using seawater desalination concentrate
 - 2) Development of a greenhouse gas reduction methodology using CO₂ mineralization technology
- ❖ Demonstration Period : 2022~2024 (3 years)
- ❖ Total Budget : 4.2 million USD
- ❖ Participating Institutions : KITECH and 4 others institutions



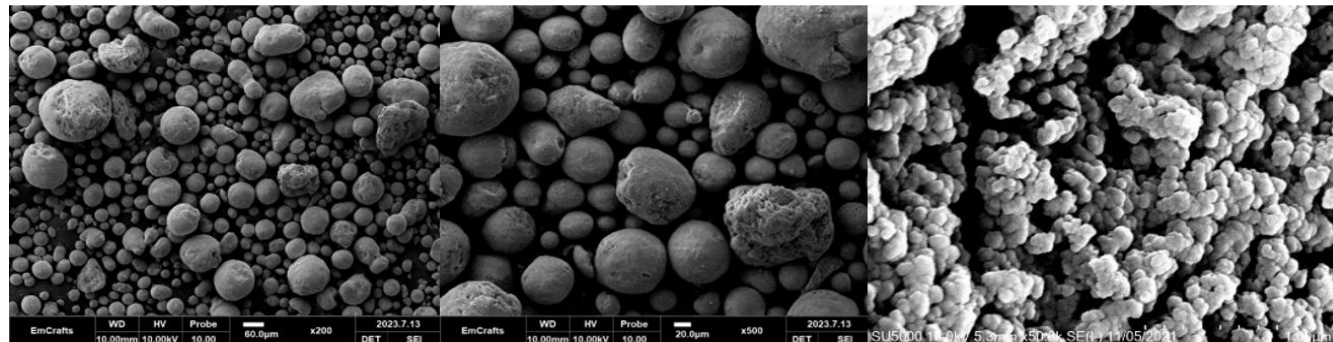
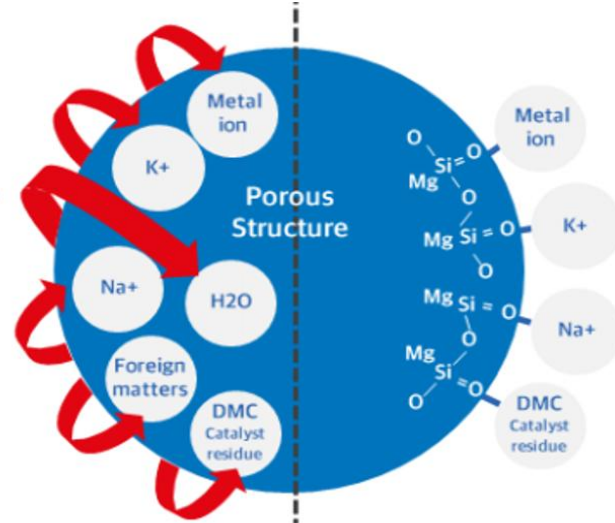
Resource Recovery

- 💧 Solvent Extraction, Precipitation, Adsorption, Electrochemical method, Membrane Filtration, etc.
- 💧 Establishment of step-by-step recovery of useful resources according to the characteristics of the brines

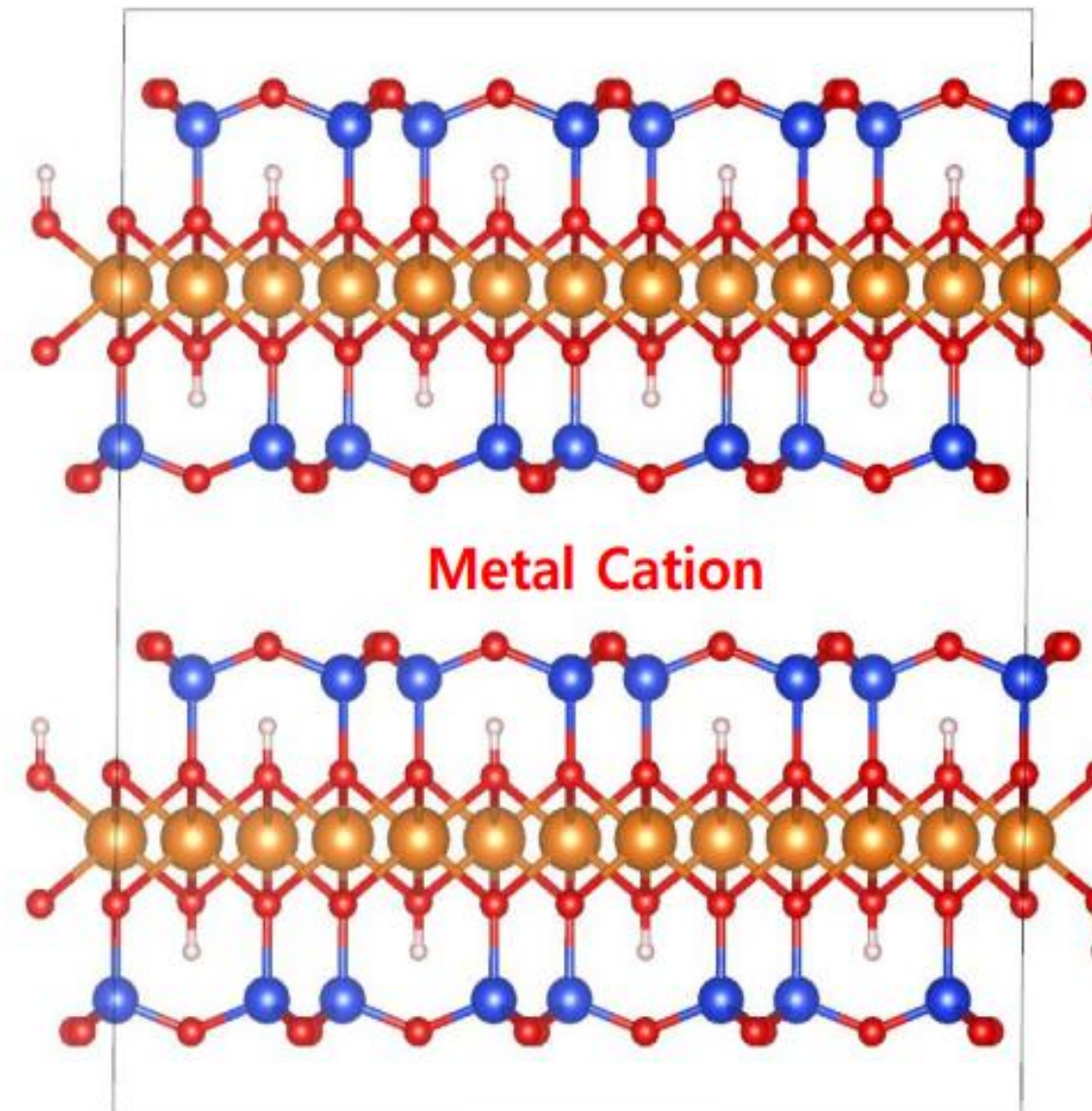


Adsorbents - Magnesium Silicate

- White, odorless powder with a porous structure, insoluble in water and alcohol
- Widely used as an adsorbent for industrial and environmental purification, a cosmetic additive, and a medical antacid.



[SEM images of magnesium silicates]



Items	Aver.
D_m	88.86 μm
Cs	1.568
Bulk density	0.390 g/cm ³
Tapped density	0.455 g/cm ³
Electrical conductivity	35 mS/m
pH	9.56

Thank You !!