



The LAB for Sorption Desalination, Cooling and Green Hydrogen

Mechanical Engineering Department
College of Engineering

April 2024

Who we are – Our mission



We are an innovation Laboratory
We work with the public and private sector to
accelerate innovation in their products and services

We are market developer of niche, innovative technologies in the field of environmental protection and energy efficiency engineering with more than 20 years' experience. Our ambition is to transfer our comprehensive experience on all technical, commercial and scientific aspects to assure sustainable development and achieve cleaner and safer world by a promotion of an advanced generation technologies focused on reduction of primary energy consumption, CO2 & pollution emissions, water production and sewage treatment always by environmentally friendly projects.

Objectives of the lab



- To develop cutting-edge research in water desalination and energy production, with a specific focus on applications that lead to CO2 emission reductions.
- To collaborate with industry stakeholders in piloting and testing new methods of water desalination and hydrogen production.
- To train researchers, professionals, and students in advanced water treatment technologies, thereby enhancing the skill set within the Kingdom of Saudi Arabia.
- To attract top-tier researchers from around the world to contribute to the lab's projects, thereby elevating the institution's research profile.
- To serve as a hub for industrial partnerships, offering a testing and demonstration platform to industry partners interested in adopting water treatment and hydrogen production technologies.
- To conduct research on electrolyzer and water quality, hydrogen storage and fuel cells
- To ensure that the developed facilities complies with all safety and environmental regulations, incorporating sustainable practices into its design and operation.
- To regularly assess the lab's performance against predefined metrics, ensuring that the facility remains at the forefront of technological advances.
- To develop a long-term sustainability plan that involves various funding streams, including grants, industry collaborations, and other revenue-generating activities.

What we do – Center focus

We focus on higher TRLs, to commercialize innovation



Scientific Research



Technology Development



Industrial Deployment

TRL1

TRL2

TRL3

TRL4

TRL5

TRL6

TRL7

TRL8

TRL9

Focus of Lab

The Lab takes an industrial innovation first approach:

- We start by identifying problem areas for clients and developing innovation-based solutions for specific challenges
- Multidisciplinary team, with a track record of working in industry
- Develop pragmatic solutions that are economically viable

What we do – focus

Our work is driven by the needs of industry, it is R&D with a concrete purpose



- The Lab **develops a roadmap to address the challenges** through existing or new R&D
- The Lab **combines R&D into a commercially viable solution**

The research lab has capabilities across 3 areas, with a broad set of capabilities in each area



Private Sector Priorities



Global Priorities



Food &
Environment



Health



Water Desalination
and Reuse

Public Sector Priorities



هيئة تنمية البحث
والتطوير والابتكار
Research Development
and Innovation Authority



وزارة الصحة
Ministry of Health

وزارة البيئة والمياه والزراعة
Ministry of Environment, Water & Agriculture
المملكة العربية السعودية



وزارة الصناعة
والثروة المعدنية
Ministry of Industry and Mineral Resources



وزارة الطاقة
MINISTRY OF ENERGY



Project Areas

1 Zero Liquid Discharge Desalination (ZLDD)



Designed, Manufactured and Tested.

The ZLD approach is crucial for water and wastewater treatment. It is a significant technology that will be adopted by a vast industries around the world. However, ZLD technology can be very energy consuming, therefore research on reducing energy consumption and improving process efficiency is now very important.

2 Micro Nano Bubbles in Health



Designed and Tested.

The use of micro-nano bubbles in the medical industry offers great potential for the treatment of skin diseases. Using the Micro-Nano-Bubble Laboratory Mobile Unit (MNB-MEDAP), it will be possible to carry out research to determine the effects of micro-nano bubbles of different sizes and different gases on improvements in the treatment of skin diseases.

3 Sludge Reduction and Valorization

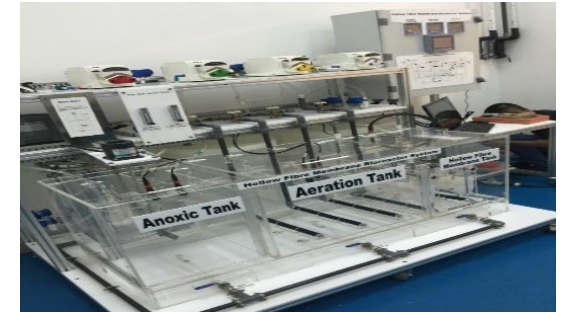


Prepared and Tested

The hydrothermal conversion process transforms the waste into a solid carbon material, the hydrochar, which can be used:

- (1) as a biofuel for the production of energy;
- (2) as soil improver;
- (3) as Advanced Carbon Material, in particular as an adsorbent of pollutants in water and gas.

4 Green Hydrogen and Power



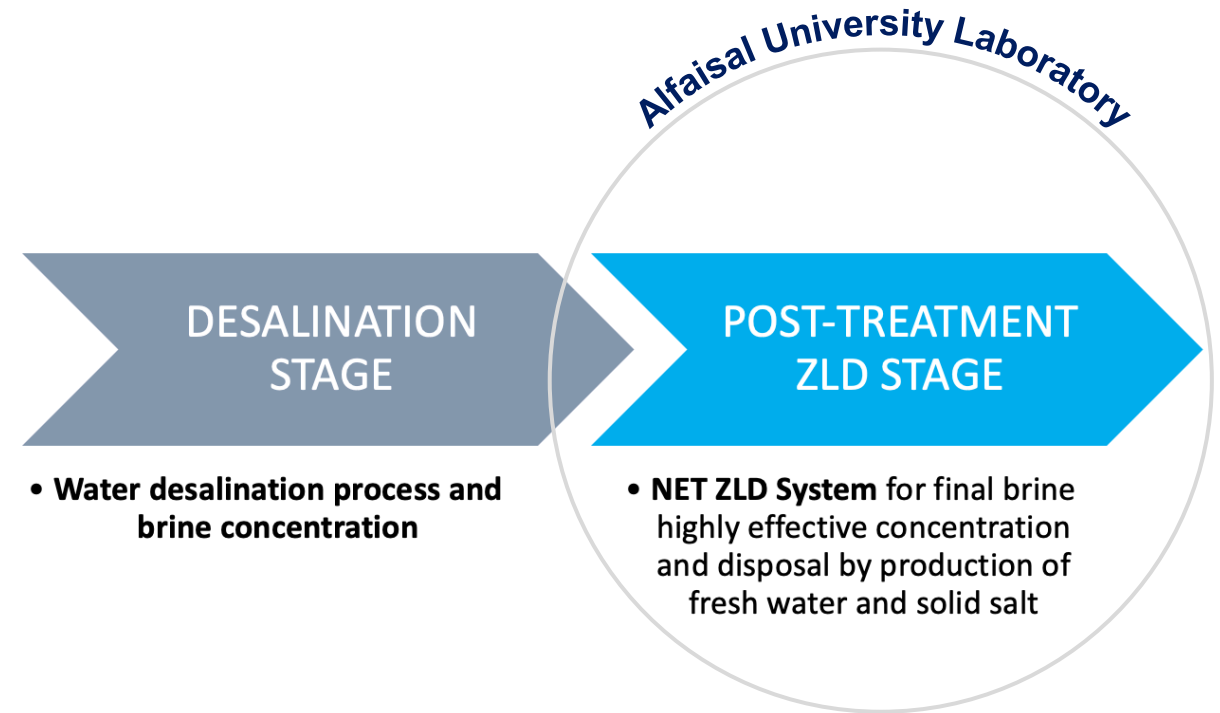
Designed, Manufactured and Tested

The technology of adsorption desalination of seawater and the production of high-purity distillate for hydrogen production will be developed in such a way that it can be scaled up at the implementation stage and obtaining a distillate production capacity of at least 40 kg / day in production hydrogen at least 1000 cm³ / min green hydrogen.

Technology Introduction

Zero Liquid Discharge Desalination (ZLDD)

Each type of the desalination system, which treat the brackish water, sea water, boiler blow down water, cooling tower blown down water or industrial process wastewater produces the desalinated water and the concentrated brine. In many cases, the concentrated brine can not be discharged directly to the outfall or the other reject point, because proper treatment has to be provided to prevent negative consequences for the environment. In that case, it is possible to use ZLD technology to achieve a Zero Liquid Discharge (ZLD) effect, which converts the concentrated brine into distillate and solid salt.



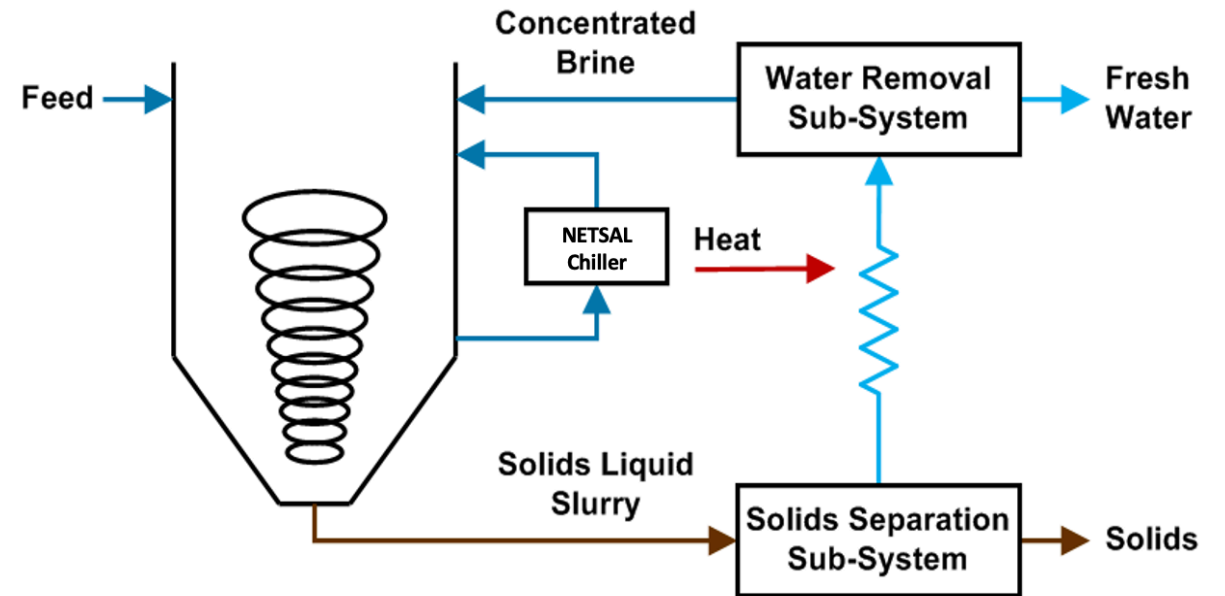
Technology Introduction

Zero Liquid Discharge Desalination (ZLDD)

Multi-Hybrid Zero-Liquid-Discharge Crystallization Technology utilizing Ultra High-Pressure Water Removal System allows to achieve solid salt production in a novel chilling hybrid device using Water Removal technology to replace a thermal evaporator providing cost effective and lower operating costs over a conventional thermal ZLD technology.

POSSIBILITIES OF IMPLEMENTATION OF ZERO-LIQUID-DISCHARGE CRYSTALLIZATION TECHNOLOGY

- High Salinity Brine water reject concentration
- Salts Crystal Production
- Boiler Discharge Feed Water Treatment
- Cooling Tower Discharge Water Treatment
- High Polluted Water Treatment



Multi-Hybrid Zero-Liquid-Discharge Crystallization System process diagram

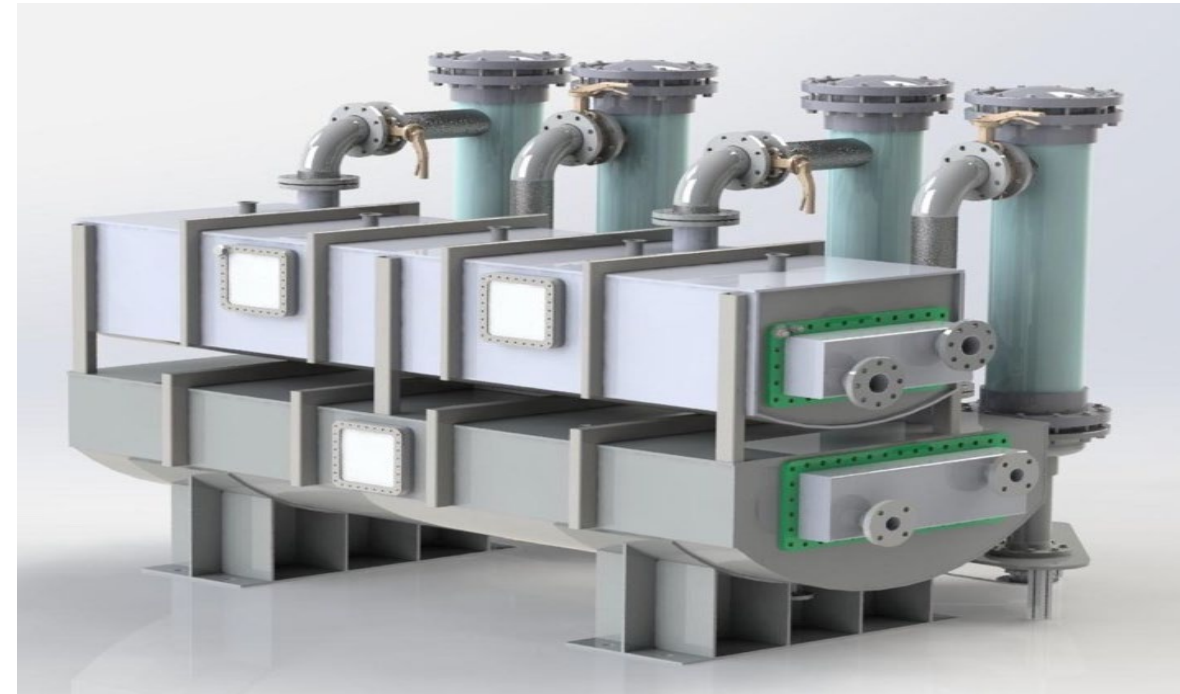


Technology Introduction

Zero Liquid Discharge Desalination (ZLDD)

Multi-Hybrid ZLD Crystallization Technology works in a semi-closed loop that concentrates water, extracts solid salt, and repeats the cycle. The concentrated brine solution enters developed chilled crystallizer (chilled by **NETSAL Chiller**), which takes advantage of steep solubility changes with temperature resulting in the formation of salt crystals, which can be then separated and removed. After cooling and salt extraction, the residual brine liquor has a lower dissolved salt content (~10%) and can be warmed up and recycled once again through the Water Removal System.

NETSAL Chiller is used to produce chilled water for cooling crystallizer and heating is used for final separation of fresh water and concentrated brine.



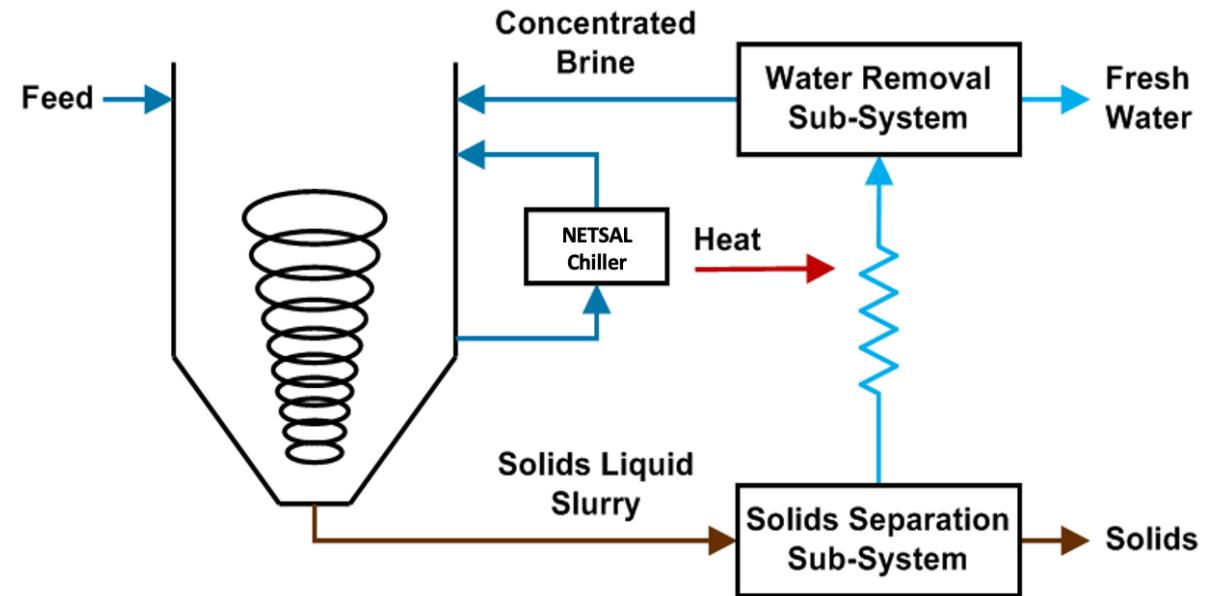
NETSAL CHILLER

Technology Introduction

Zero Liquid Discharge Desalination (ZLDD)

In the Multi-Hybrid ZLD Crystallization System, evaporation is not the main process for achieving ZLD. Elimination of complex and expensive thermal evaporation process provides a cost-effective all-in-one solution, producing distilled water and low water content salt crystals. An additional effect is the production of valuable material in the form of the pure salt crystals.

NO BOILING NEEDED MEANS LESS ENERGY CONSUMPTION AND LOWER COSTS



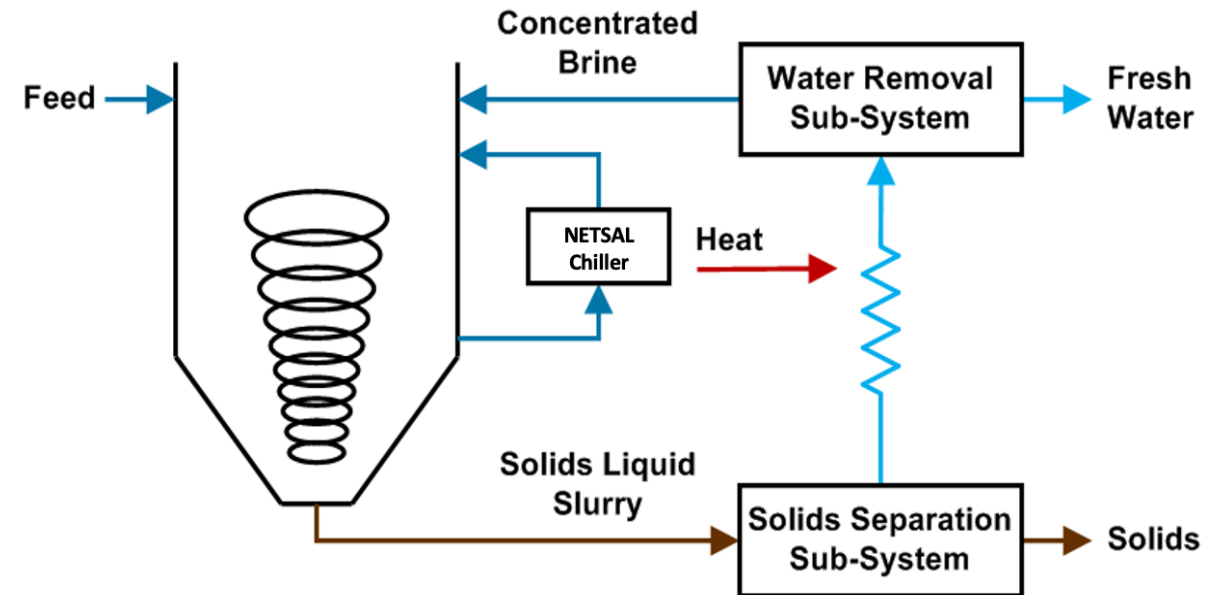
Multi-Hybrid Zero-Liquid-Discharge Crystallization System process diagram



Laboratory Equipment

Zero Liquid Discharge Desalination (ZLDD)

1. ZLD Crystallization Unit
2. NETSAL Chiller
3. Water Removal System
4. Solid Separation System
5. Micro-Nano-Bubbles Generation (MNB®) System
6. Oxygen Generation System
7. Electrical and control systems
8. Probes, measuring and sampling systems
9. Frame housing of equipment



Multi-Hybrid Zero-Liquid-Discharge Crystallization System process diagram



Project Areas

1 Zero Liquid Discharge Desalination (ZLDD)



2 Micro Nano Bubbles in Health



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3 Sludge Reduction and Valorization

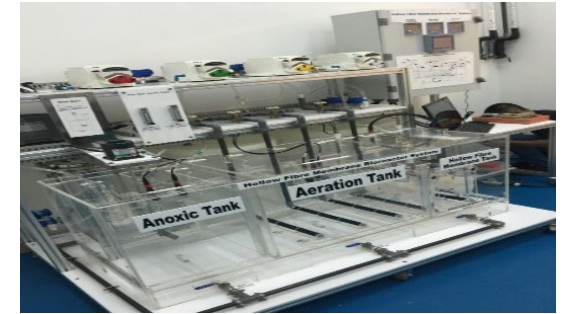


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- (1) as a biofuel for the production of energy;
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4 Green Hydrogen and Power



Designed, Manufactured and Tested

The technology of adsorption desalination of seawater and the production of high-purity distillate for hydrogen production will be developed in such a way that it can be scaled up at the implementation stage and obtaining a distillate production capacity of at least 40 kg / day in production hydrogen at least 1000 cm³ / min green hydrogen.

Technology Introduction

Micro Nano Bubbles in Health

Nowadays, ultrasounds are playing a crucial role in visualizing biological/pathological changes in lives as a reliable imaging technique and a powerful therapeutic tool. Latest ultrasound-based treatment modalities in association with functional micro-nano-bubbles have been highlighted as their great potentials for disease precision therapy. It is believed that these state-of-the-art micro-nano-bubbles will become a booster for ultrasound medicine and visualizable guidance to serve future human healthcare in a more comprehensive and practical manner.



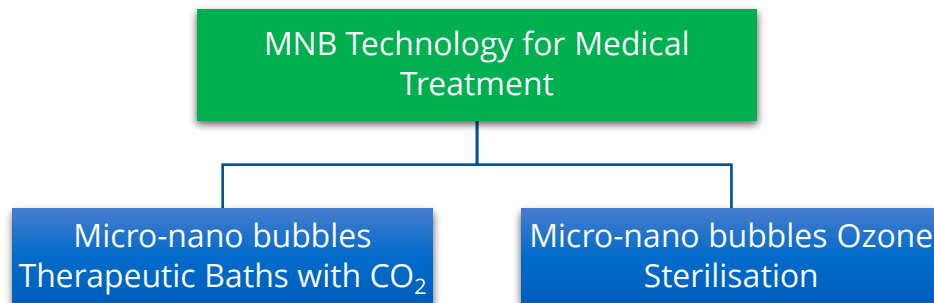
Mobile Micro-nano bubble laboratory system



Technology Introduction

Micro Nano Bubbles in Health

MNBs combined with US for tumor therapy is still in its infancy, they have tremendous appeal. Their unique structure, multifunctional characteristics, high degree of curative effect and the widespread variety of diseases give MNBs broad development prospect. It should be noted that some challenges and vital issues will need to be discussed and dealt with when they are involved in biomedical applications and future clinical transformations. The most significant areas are indicated below.



Mobile Micro-nano bubble laboratory system

TECHNOLOGIES FOR MEDICAL TREATMENT



Technology Introduction

Micro Nano Bubbles in Health

Ultrasound irradiation combined with MNBs can treat cancer by improving cancer cell membrane permeability and implosion of the MNBs to deliver drugs or genes directly to tumor cells

MNBs ozone sterilization can be used as a better alternative to traditional sterilization techniques as it is faster, degrades more substances (even ozone or antibiotic resistant), requires less ozonated water, and eliminates the need for additional chemicals like detergents

MNBs combined with CO₂ in therapeutic baths can improve local tissue microcirculation and increases local oxygen supply via the Bohr effect, can cleanse and exfoliate skin, and provides proper skin moisturization (even up to the smallest pores)

MNBs can treat diabetic feet and chronic wounds by increasing blood flow and oxygen delivery, eliminating pathogens, and improving local microcirculation

MNBs can treat a variety of skin diseases such as psoriasis, atopic dermatitis, and allergies



Mobile Micro-nano bubble laboratory system

TECHNOLOGIES FOR MEDICAL TREATMENT



Micro Nano Bubbles in Health

1. Micro-Nano-Bubbles (MNB) Generation System
2. O₃ Generation System
3. MNBO₃ Mobile Skid with Tanks
4. Instrumentation, Control & Automation System
5. Interconnection Hydraulic & Electrical Installation
6. Frame housing of equipment



Mobile Micro-nano bubble laboratory system

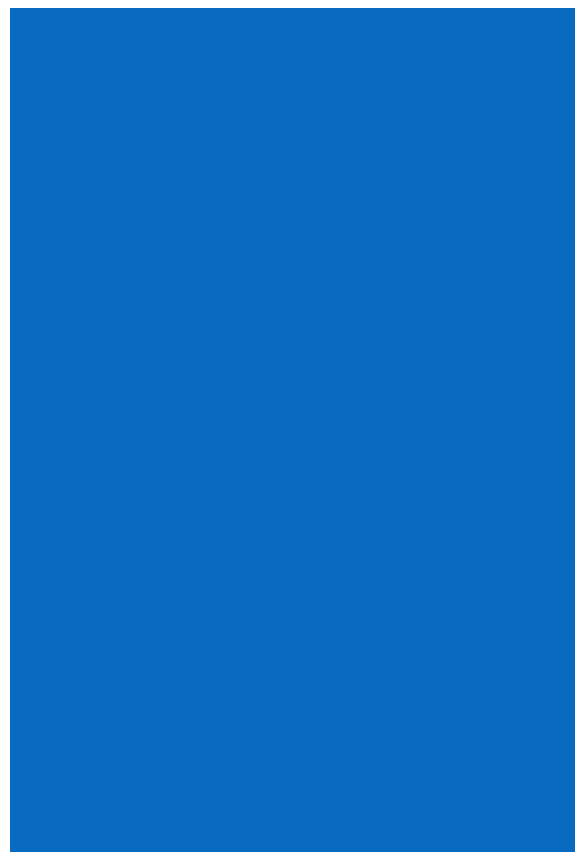


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2 Micro Nano Bubbles in Health



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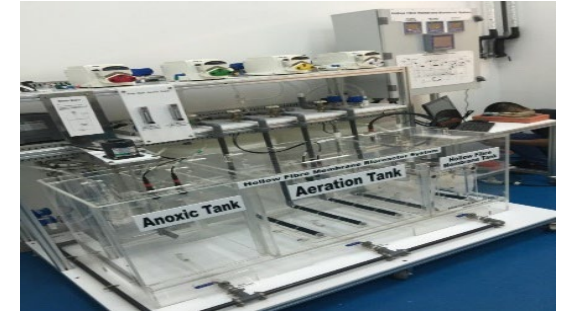


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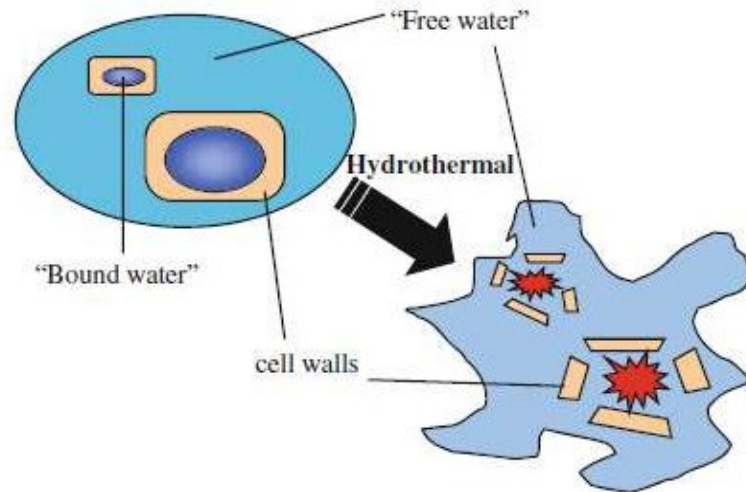


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Sludge Reduction and Valorization

What is Hydrothermal Conversion (HTC) ?



- ▶ **HTC** is a process that destroys the colloidal structure of the sludge permitting to the **«Bound water»** to become **«Free water»**
- ▶ In this way, **HTC** technology permits to easily **dewater** the sludge!
- ▶ As a consequence the volume of sludge going to landfill **will be much lower** respect the current situation

Technology Benefits

- 01 REDUCING THE DRY MATTERS (TSS, solids) IN THE SLUDGE
- 02 IMPROVING THE DEWATERABILITY (better solid management)
- 03 IMPROVING THE HYDROPHOBICITY (less water to evaporate)

Sludge Reduction and Valorization

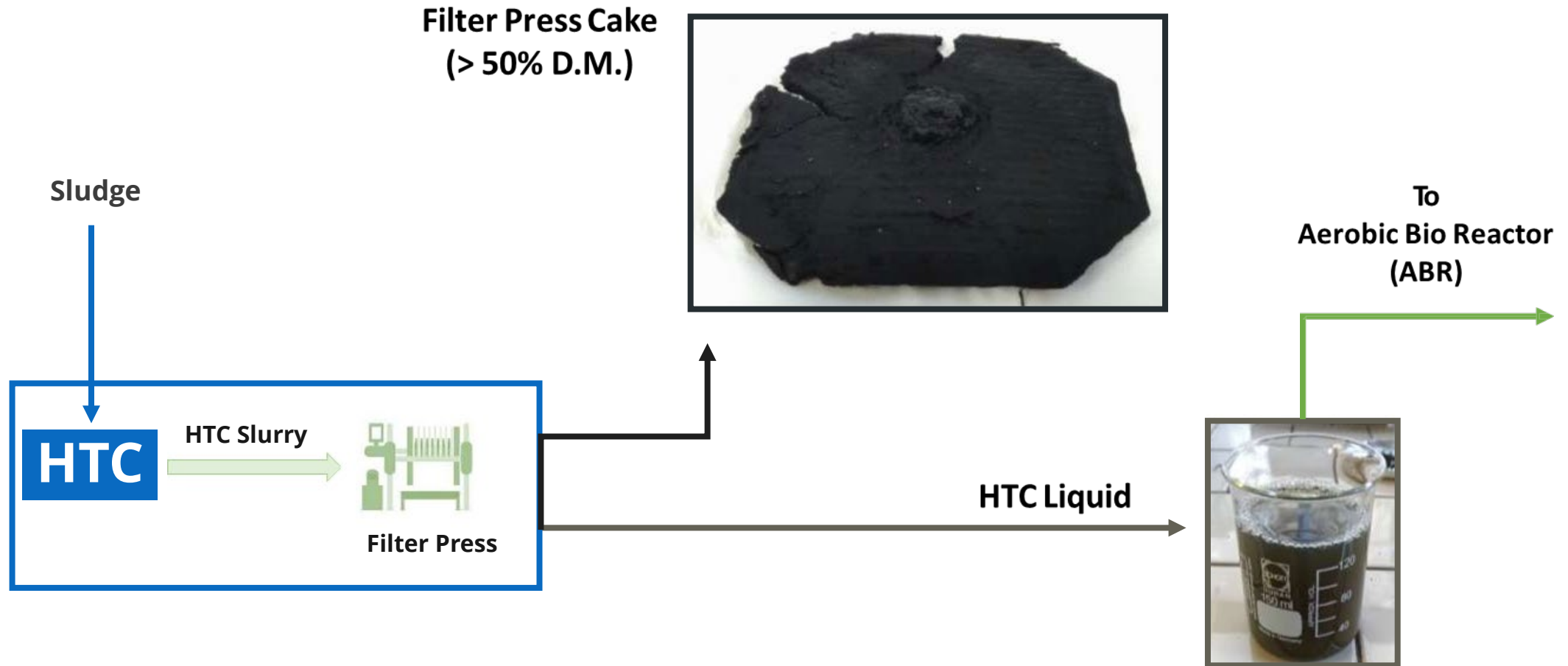
HTC Lab – HTC Pilot Plant (5 liters Batch Reactor)



This is an electrical filter press that automatically could treat Sludge/Slurries. The Operative Conditions then will be replicated in the scaled-up system.

- ▶ Replication of the HTC Process Conditions
- ▶ Possible to use with all types of Sludge both for HTC and HTL

Results after Filter Press



Project Areas

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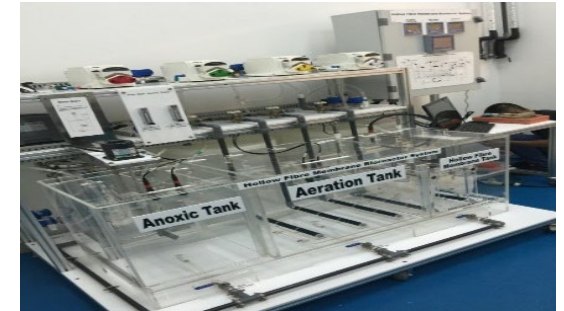
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Green Hydrogen and Power - Objectives

- ✓ To develop cutting-edge research in water desalination and energy production, with a specific focus on applications that lead to CO2 emission reductions.
 - ✓ The primary aim of this application is to reactivate of existing NETSAL Alfaisal Lab for Sorption Cooling and Desalination technology and establishment and operation of a state-of-the-art research lab and center focusing highly innovative seawater desalination technologies and its integration with hydrogen production.
 - ✓ The technology of adsorption desalination of seawater and the production of high-purity distillate for hydrogen production will be developed in such a way that it can be scaled up at the implementation stage and obtaining a distillate production capacity of at least 40 kg / day in production hydrogen at least 1000 cm³ / min green hydrogen.
- ✓ The developed technology is a response to the growing demand for desalinated water and green hydrogen, resulting from the hydrogen and pro-ecological strategies adopted and implemented in the world. For the production of hydrogen, it is necessary to prepare pure process water used in electrolyzers and existing owned by Alfaisal adsorption desalination chiller NETSAL using fluidized adsorption beds producing distillate with lowest possible energy consumption will be a revolutionary solution on the global scale.
 - ✓ The hydrogen produced can be used to produce electricity in fuel cells or burned in gas engines or gas turbines and can also be used to power hydrogen cars.

Green Hydrogen and Power : NETSAL



NETSAL Cooling and Desalination Chiller

Feed Water
RO, MED, MSF brine,
Sea water,

Very Low Electrical
input
(1.2kwh/m³)

Low Grade
Waste Heat
(60-85°C)



High Grade Pure Water
(TDS = 0 - 5 ppm)



Output

AC Chilled Water
(Temp. 7 - 12 deg C)

Alfaisal Lab

has been already equipped with adsorption desalination chiller using fluidized adsorption beds produces in the most effective by energy and cost a very high purity distillate which will be used to produce hydrogen in the electrolyzer.

Reject Water Treatment

- Able to take in RO, MED, MSF reject waters without any pre-treatment.
- Increase MED, MFS & RO Recovery Ratio from 50% to above 70%.

High Salinity Feed Water

- Handling up to 280,000 ppm of TDS – tested and certified.
- Ability to work in ZLD mode.
- Minimum chemicals demand.

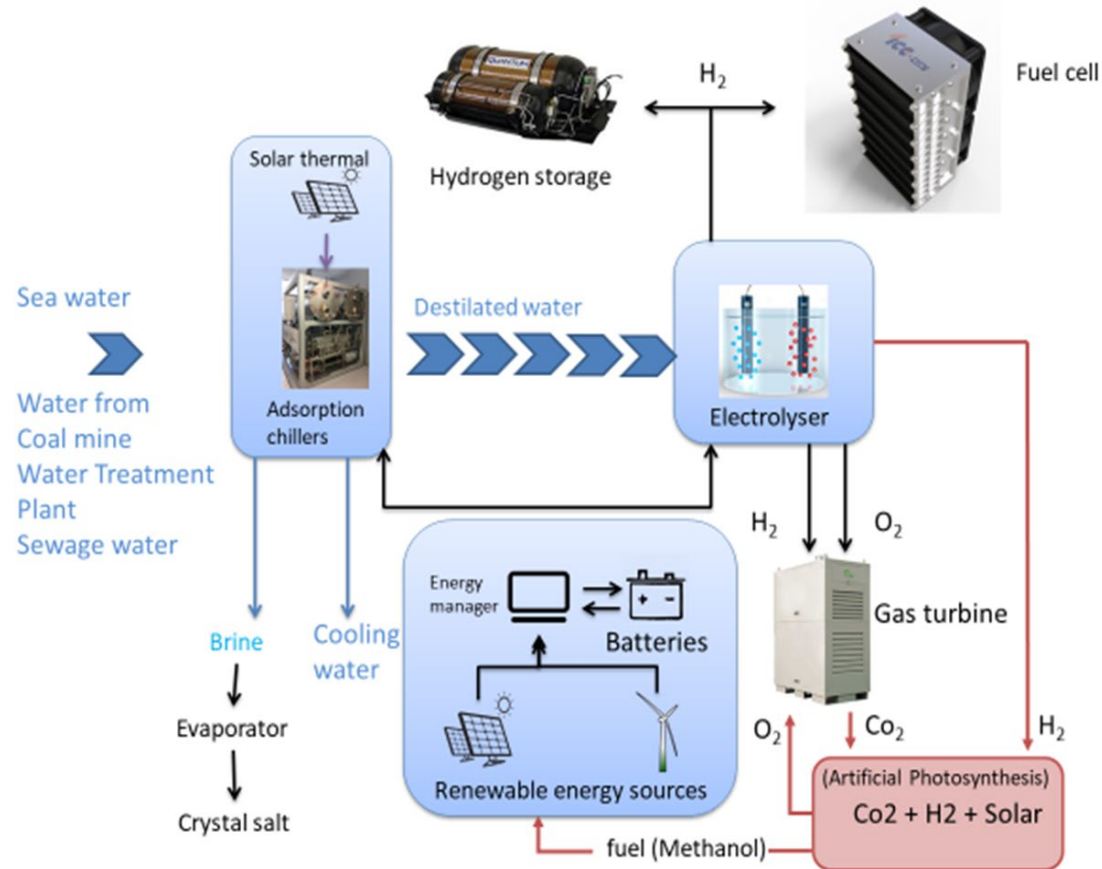
High Purity Product Water

- Utilize waste heat from power plants and industry.
- Utilize 100% of solar energy.
- Produce ultra pure high quality water for boilers and electrolyzers.



TECHNOLOGIES FOR WATER
DESALINATION & RE-USE

Green Hydrogen and Power : NETSAL



Benefits | Project Performance and Economical Target

To reduce the cost of green hydrogen production from the current level of 4 - 10 EUR per kg H₂ towards 2 euro per kg H₂ in 2050;

To develop offshore hydrogen production by means of water electrolysis installations.

To decrease transport costs and avoid large investments in electrical grids, since transporting gases is less expensive than transporting electricity additionally already existing gas infrastructure can be used.

The electrolysis process requires ultrapure water, which is an expensive feedstock in the KSA.



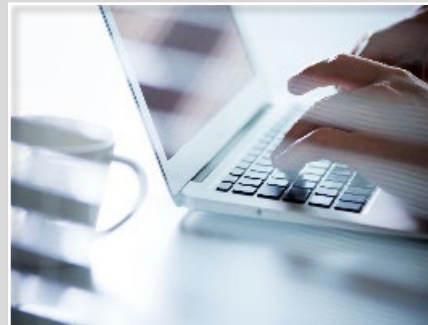
TECHNOLOGIES FOR WATER
DESALINATION & RE-USE

Lab Services

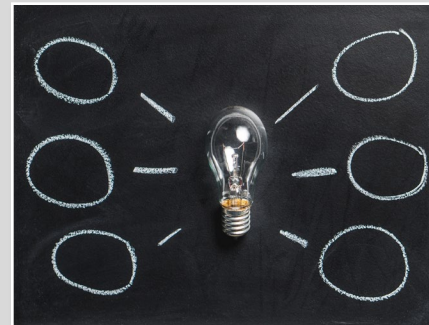
The Lab provides a full suite of innovation services



Lab Services



Research &
Consultation



End-to-end innovation
solutions



Spin-off Incubator

Lab Services

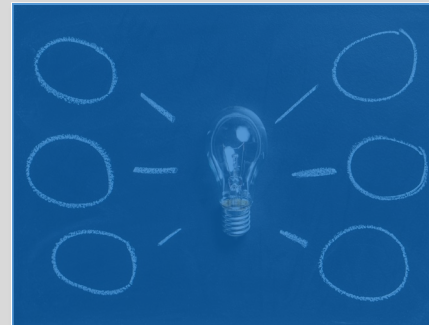
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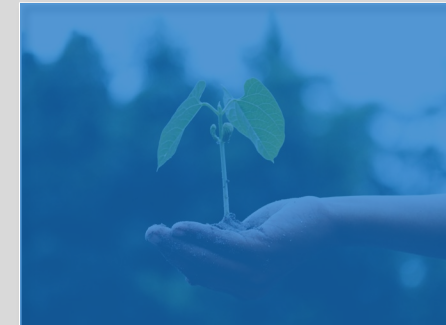
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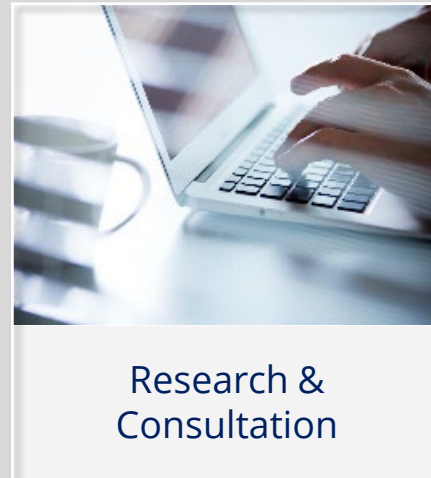


Spin-off Incubator

Lab Services – Our multidisciplinary labs are offered to outside users to either utilize under our supervision, used for training programs or accessed with our technical teams conducting all activities under your direction

Lab Services

The Lab provides a full suite of innovation services



Research & Consultation – Access our subject knowledge expertise through one-to-one consultations or funded research work

Lab Services

The Lab provides a full suite of innovation services



End-to-end innovation solutions - We work closely with you to identify your innovation related challenges to develop tailored solutions through focused R&D work across multidisciplinary teams

Lab Services

The Lab provides a full suite of innovation services



Spin-off incubator – License our IP for your own requirements or take an equity stake in some of our promising research that is spun-out into a stand alone company



Thank You,

**The LAB for Sorption Desalination and Cooling
for Green Hydrogen
Mechanical Engineering Department
College of Engineering
Alfaisal University**