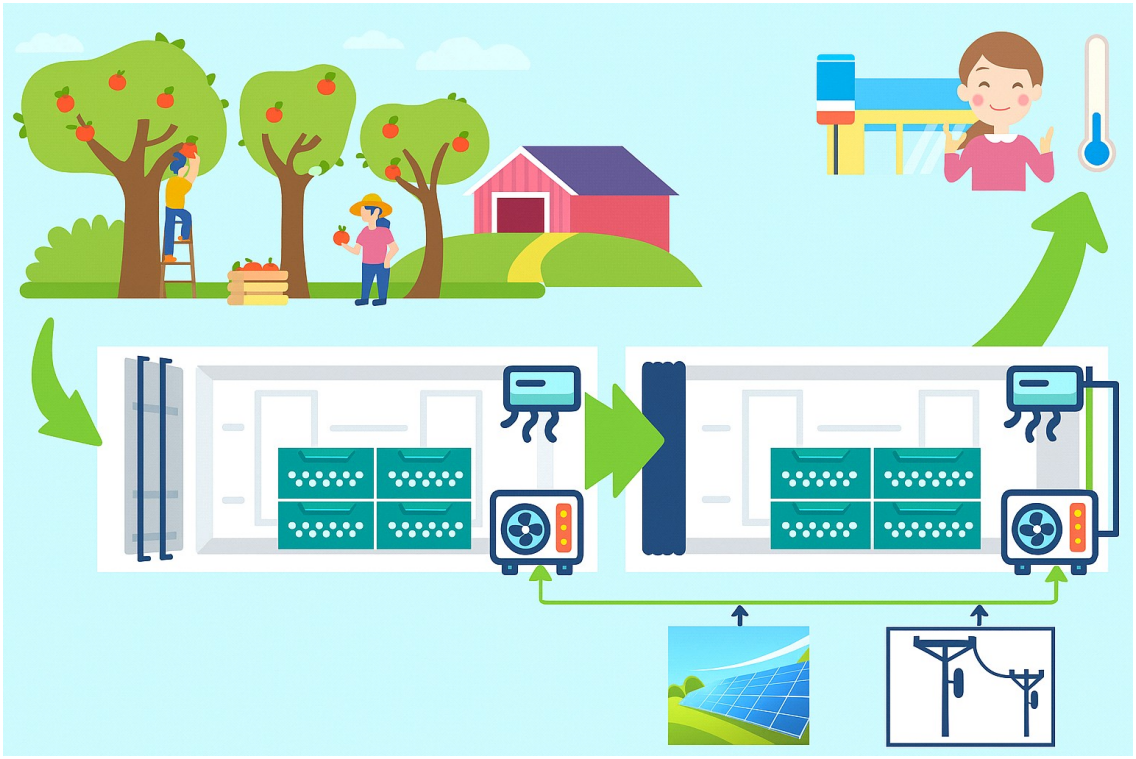
Feasibility research of Solar Electric-Based Cold Warehouse equipped with Low-temperature Latent Heat Material for Fruit Storage in Bangladesh Climate Conditions



Deliverable 1.2_First Field Survey Report for the Implementation of the Bangladesh Cold Storage Facility Technical Assistance Project

March, 2025 | Dhaka, Bangladesh

1. Background and objective

The cold storage market in Bangladesh is growing steadily, with increasing interest in investing in cold distribution networks. Imports of refrigeration and freezing equipment are reportedly growing by 10-20% annually, and demand for refrigerated towers has recently surged, too. Rising incomes among the middle and upper classes, an increase in nuclear families, a growing number of female workers and urbanization are also expected to influence the growth of the refrigerator market. Food companies are increasingly interested in investing in cold chain, and partial investments have already been made in cold chain facilities such as cold warehouses, collection centers, and refrigerated vehicles. The Bangladeshi government is expanding investment in agriculture and logistics, and is also promoting policies to expand cold storage facilities. In particular, the government seems to be actively supporting renewable energy infrastructure, such as solar power, in areas that are not well served by the grid. Bangladesh is reported to have about 47% of its population employed in primary industries, mostly in the form of traditional subsistence farming. In recent years, there has been a growing demand for high-quality agricultural products, especially in the capital region, and the demand for processed and imported foods is also reported to be on the rise.

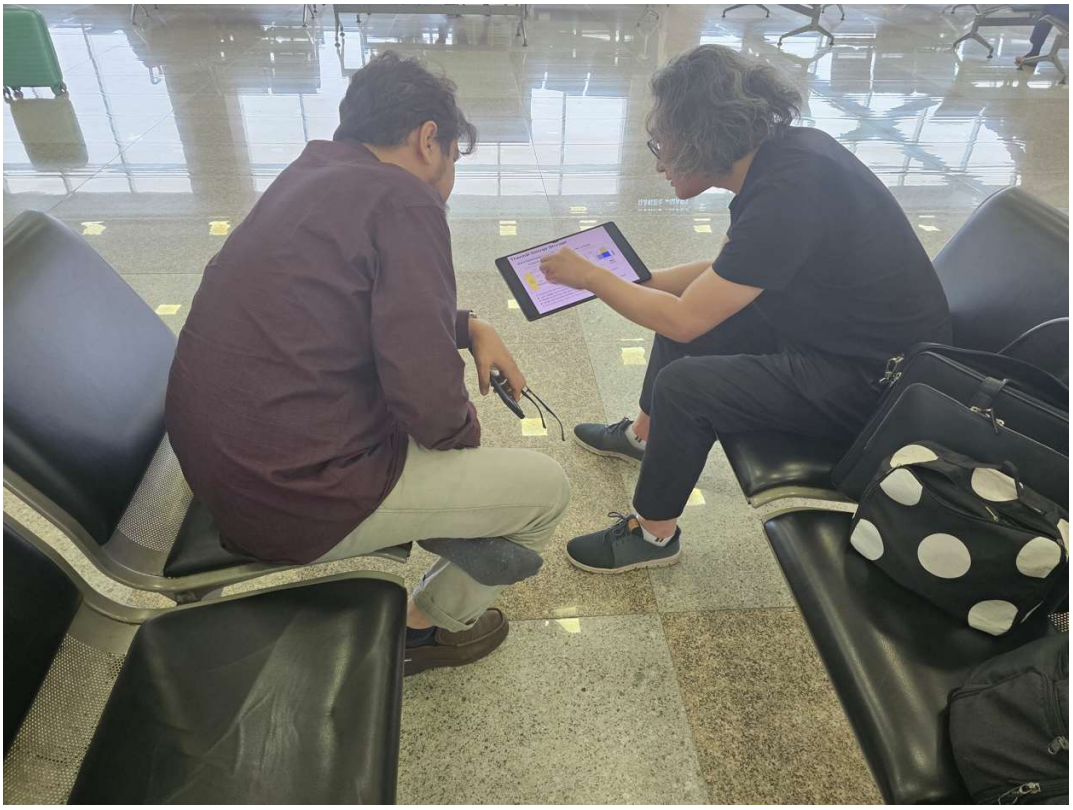
During the trip to Bangladesh, we visited the Bangladesh Ministry of Agriculture, manufacturing companies, and farms, and learned about the types of fruits and vegetables produced by local farms, the power situation, and the potential for a solar-powered cold storage facility.

2. Discussion of major solar installation cases in Bangladesh

1. Rooftop solar systems: Bangladesh is promoting solar power generation by utilizing building rooftop space, with 1,821 rooftop solar systems installed under the net metering scheme.
2. Solar irrigation systems: With agriculture being a major industry, Bangladesh is increasing agricultural productivity through solar irrigation systems, with 2,777 solar irrigation systems with a total capacity of 51 MW installed in rural areas.
3. Off-grid solar home systems (SHS): Bangladesh is promoting off-grid solar home systems for areas without access to the grid, with more than 6 million SHS installed, making it one of the largest off-grid solar markets globally.
4. Solar power plants: Bangladesh is also actively investing in the construction of grid-connected solar power plants, with three grid-connected solar power plants reportedly under construction.
5. Future Outlook: The Bangladesh solar market is expected to continue to grow, reaching 0.76 GW in 2025 and growing at a CAGR of 38.60% to reach 3.90 GW in 2030.

3. Demonstration farm survey

We visited a farm located between Rajshahi and Natore and gathered basic information on the main cultivation and sales varieties, harvest, sales, etc. The varieties of agricultural products grown on the farm were very diverse, and mangoes were the main fruit. Through business consultations with the farm owner, we discussed the installation locations of solar panels and cold containers, and verbally agreed to build the connecting infrastructure (roads, electricity, etc.) to the installation location later with the farm owner.




46.2%
34.4°C
Mode
testo 610
45.6%
35.1°C
Mode


ওয়ালটন


ইন্টিগ্রেটেড ডেভেলপমেন্ট ফাউন্ডেশন (আইডিএফ)


ইন্টিগ্রেটেড ডেভেলপমেন্ট ফাউন্ডেশন (আইডিএফ)


আইডিএফ বিভিন্ন কর্মসূচির ওপর চিত্র
ওয়ালটন


A
~600V
~1000A
CAT III
HIOKI
3280-10
CLAMP ON HiTESTER
AUTO
222.2 V
HOLD
SAMP. F/S
~V
~A
⎓V


A
~600V
~1000A
CAT III
HIOKI
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222.8 V
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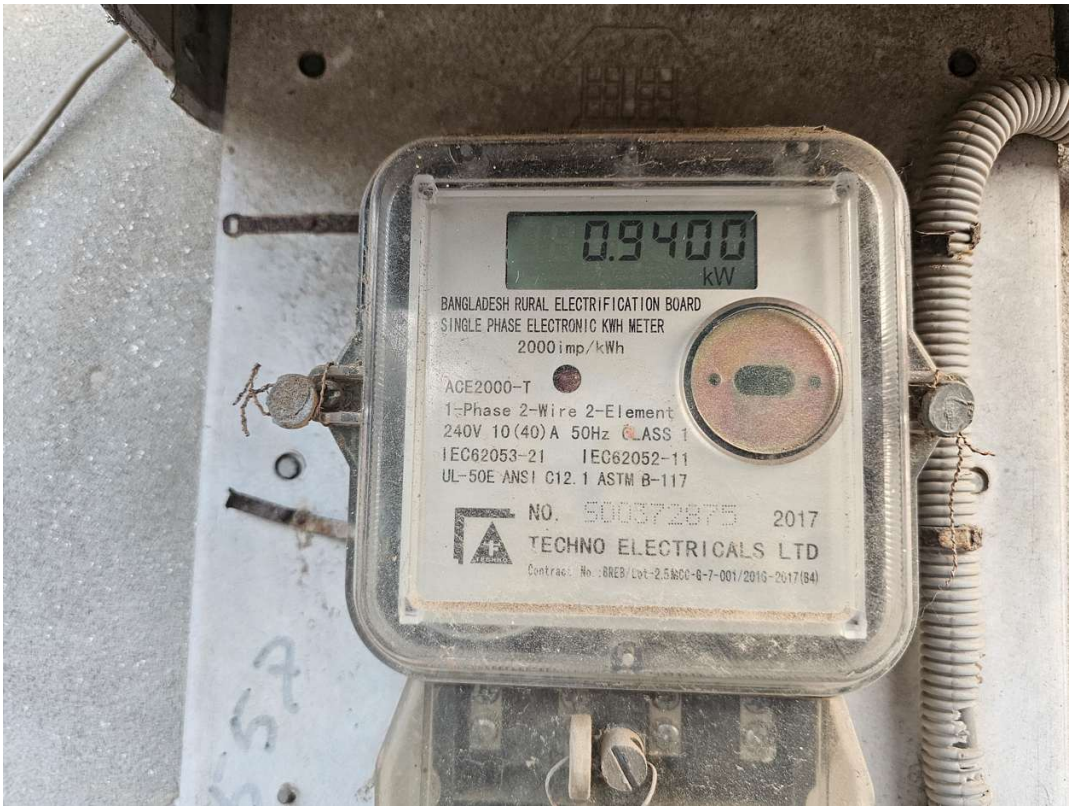
⎓V



4. Meeting with Bangladesh Ministry of Agriculture

The Bangladesh Ministry of Agriculture is actively promoting the distribution of solar systems to improve agricultural efficiency and support rural development. 2,777 solar systems with a capacity of 51 MW have been installed in rural areas, and the goal is to install more than 100,000 additional solar facilities. In addition, the company is pursuing a strategy to install 1,000 solar-based cold storage facilities to maintain the freshness of agricultural products, and it is expected that this work will be specifically promoted through the MoU with Pacific Solar.


Innovative Solar Solution For Food Security

5. Meeting with Bangladesh refrigeration system manufacturers

Bangladesh refrigeration system technology is developing and the demand for refrigeration system technology is reported to be increasing especially with the growth of the frozen food market. The Bangladesh refrigeration system industry is in the initial stage of the cold chain industry and mainly imports refrigeration and cooling equipment from China. The Bangladesh cold chain market is estimated to be about USD 1.3 billion and the frozen food market is expected to grow rapidly. However, the cold chain industry in Bangladesh is still in its infancy and demand is expected to increase in various products and sectors. Most of the refrigeration and cooling equipment is imported from China and the proportion of Korean equipment is considered to be low. EARNEST, one of the Bangladesh companies, specializes in the technology development, manufacturing and installation of high quality and energy efficient industrial and commercial refrigeration plants, HVAC and low temperature refrigeration plants. EARNEST provides products and services for all cooling system sectors including comfort cooling of public and commercial buildings, offices and factories, air conditioning applications such as pharmaceutical and all types of clean rooms, cold rooms and multi-purpose cold storages. In addition, we provide world-standard energy-saving, eco-friendly cooling solutions to enhance customer convenience and profitability.

6. Annex

6.1 Field survey materials

The project description material during the field survey is attached in PPT format.

UN CTCN Project in Bangladesh

May 2025

Solar Electric-Based Cold Warehouse equipped with Low-temperature Latent Heat Material

Korea Institute of Industrial Technology
(KITECH)
Dr. KIM Jeong-Yeol

Contents

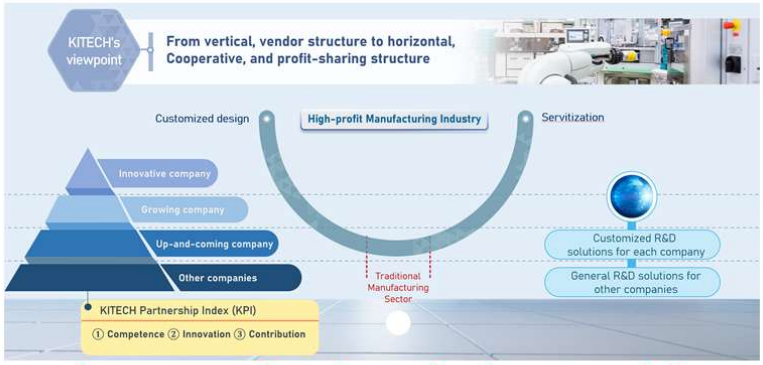
Introduction

About KITECH

KITECH is the only organization that operates 10 regional headquarters in Korea, and also operates overseas offices in four countries

Introduction

About KITECH



KITECH operates various programs to foster the manufacturing ecosystem in Korea.

Introduction

Energy crisis PERSISTS not only NOW but also in the FUTURE

Why does energy come as a problem? **Energy Needs > Energy Supply**

Energy demand is steadily increasing due to industrial development and improvement in living standards

- **In the past, We have adopted an economic system that relies on FOSSIL FUELS**
- **HOWEVER, in the CLIMATE CHANGE, we MUST prepare for new and renewable energy**
- **MUST find very effective solution to reduce energy consumption and CO2 Emission**

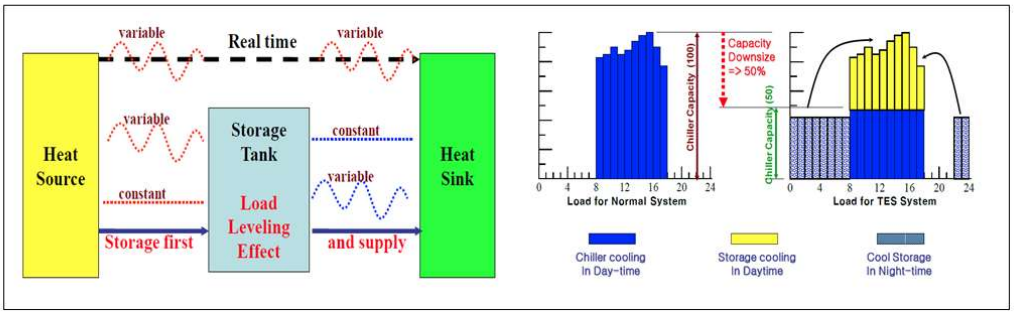
To use of energy, if only ONE SOLUTION was sufficient in the past, it is necessary to consider COMPLEX USE in the future.

Thermal Energy Storage

What is Thermal Energy Storage (TES) Technology?

To store the HEAT from heat source and Supply the HEAT to demand

In most of the generation and utilization of heat energy, there is a mismatch between supply and demand

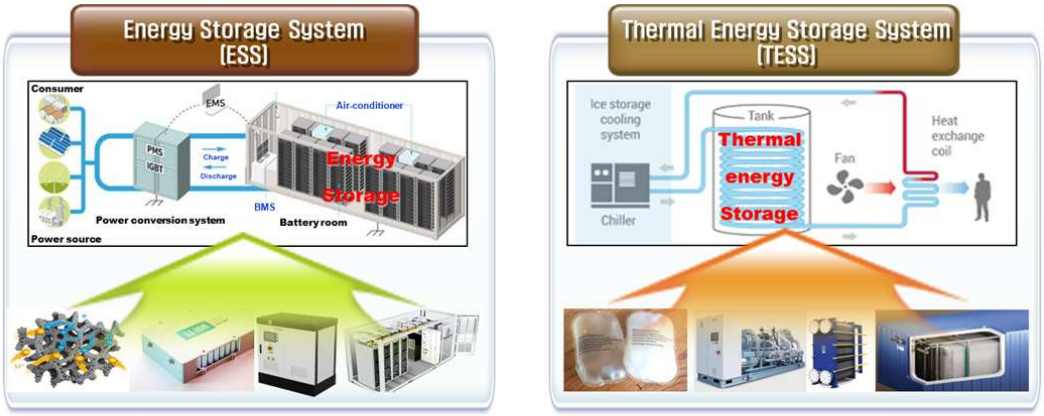


- **Resolving the mismatch between supply and demand in time, space, quality, quantity**
- **Load cutting, sharing and leveling effect by thermal storage technology**
- **Possible to electricity rate down by variable electricity rate rates**
- **Design and operating conditions for the required heat quantity for heat demand/supply**
- **Low quality energy source → High quality and high performance**

Thermal Energy Storage

Energy Storage System vs. Thermal Energy Storage System

Similar to ESS, we intend to implement TESS and develop various heat storage modules and provide them to the industry



The advantage of this technology : it can be used to reduce carbon emissions by increasing the utilization efficiency of thermal energy.

Thermal Energy Storage

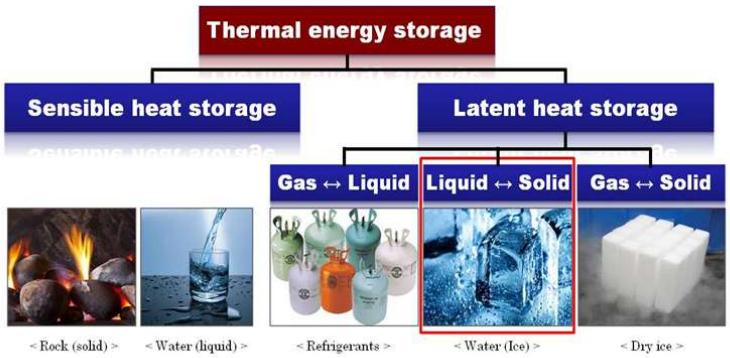
Thermal energy storage is largely divided into sensible heat storage and latent heat storage

- **Sensible heat storage**
  - Heat storage by temperature difference of sensible heat materials (rock, water etc.)

$$\Delta Q = C \cdot \Delta T = m \cdot c \cdot \Delta T$$

- **Latent heat storage**
  - Heat storage by heat of fusion during phase changing process

$$\Delta Q = \Delta H = m\Delta h$$



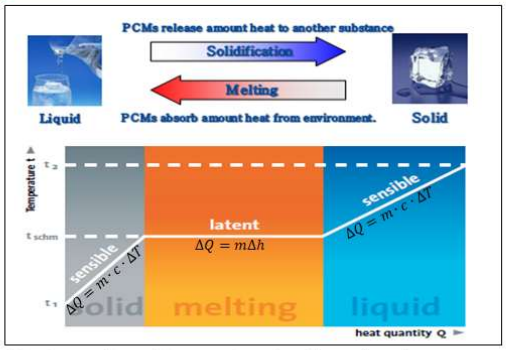
Thermal Energy Storage using LHM

What is the latent heat material (LHM) ?

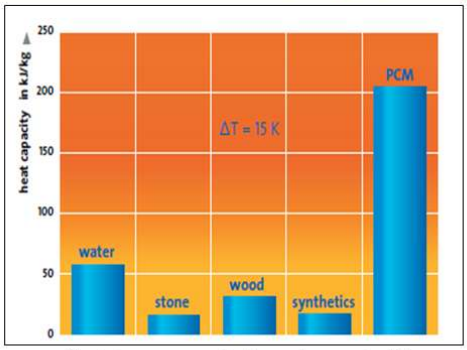
- High thermal storage density (latent heat)
- Constant temperature during the phase change process
- Low thermal conductivity, Supercooling

Water 1 kg, 80°C + Ice 1 kg, 0°C = Water 2 kg, 0°C

* Water	: 1 kg x 1.0 kcal/kg°C x (80-0)°C	=	80kcal (Emission)
* ICE(LHM)	: 1 kg (Ice → Water)	=	80kcal (Absorption)



< Heat capacity and temperature for phase changing process >



< Heat storage capacity in various materials>

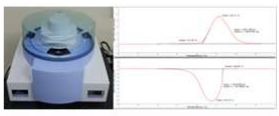
LHM Technology

Development of LHMs by KITECH

Searching for LHM candidates

HIGH TEMPERATURE PCMs

PCM Code Name	Melting TMP	Latent Heat
B 7	0℃	300-350 kJ/kg
B 18	7℃	200-300 kJ/kg
B 19	15℃	150-250 kJ/kg
B 14	29℃	150-250 kJ/kg
B 13	35℃	150-250 kJ/kg
B 12	52℃	150-250 kJ/kg
B 11	58℃	150-250 kJ/kg
B 10	75℃	150-250 kJ/kg
B 8	89℃	150-250 kJ/kg

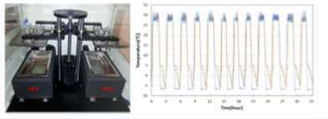


Analysis of thermal properties

(Phase changed temperature, Heat of fusion, Supercooling)

LOW TEMPERATURE PCMs

PCM Code Name	Melting TMP	Latent Heat
A 18	- 4℃	250-350 kJ/kg
A 19	- 10℃	250-300 kJ/kg
A 14	- 12℃	250-300 kJ/kg
A 13	- 17℃	200-300 kJ/kg
A 12	- 22℃	200-300 kJ/kg
A 11	- 26℃	200-250 kJ/kg
A 10	- 35℃	150-250 kJ/kg
A 8	- 40℃	150-250 kJ/kg
A 5	- 52℃	150-250 kJ/kg



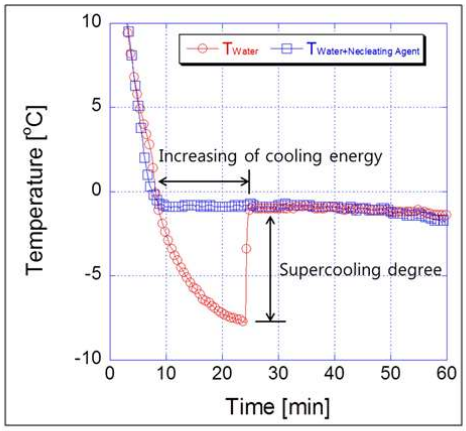
Reliability testing

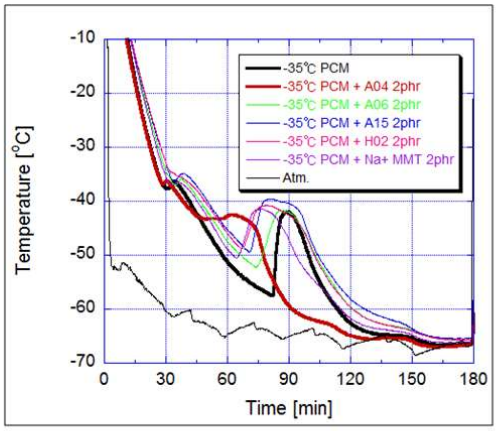
(Freezing and melting)

LHM Technology

Suppercooling Reducing

- Release of supercooled LHMs
- Nucleating agent, cold finger, ultrasonic, etc.

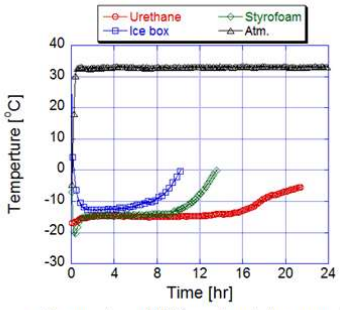




LHM Technology

Insulation

- One of the most important technical elements for TES
- Effect of insulation performance by the insulation material and manufacturing method
- Especially, main causes of heat loss are connections, joints parts and doors

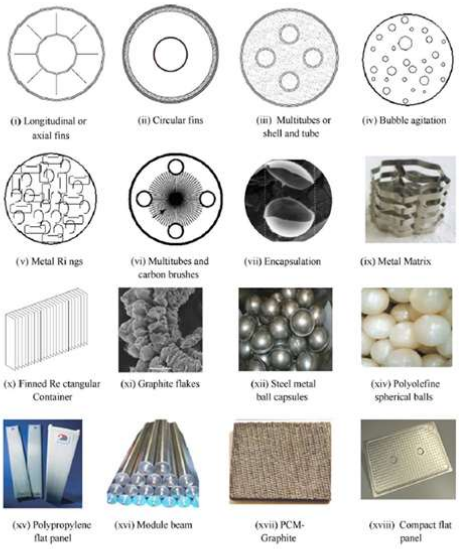


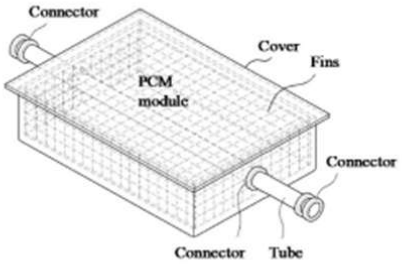
(Comparison of different insulation materials)

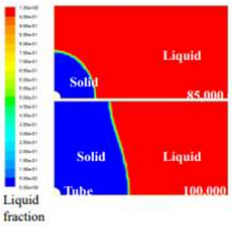
(Thermal imaging by insulation performance)

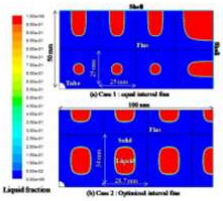
LHM Technology

TES module for heat transfer



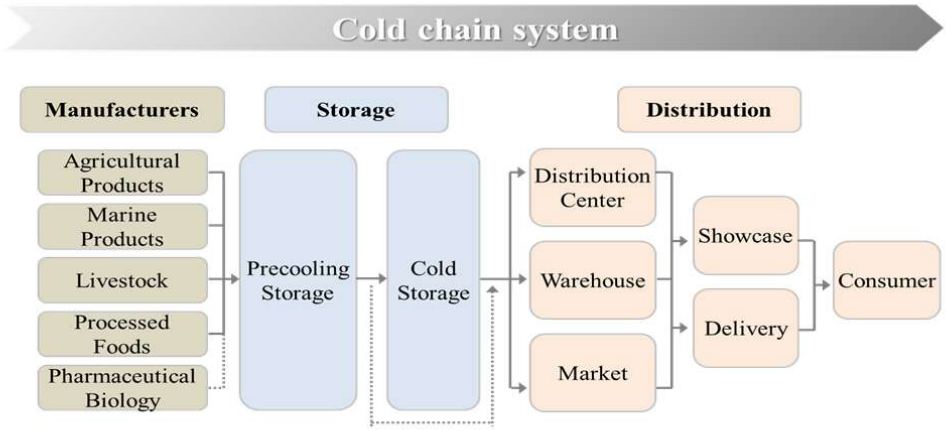






Case Study

Overview of cold chain system

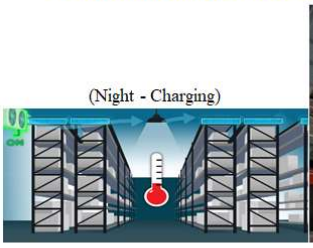


Case Study

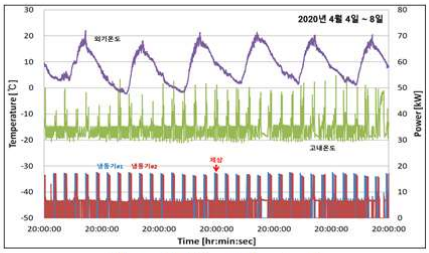
Cold warehouse

- Raw material (frozen meat, vegetable, etc.) storage for food manufacturing
- Internal temperature of cold warehouse: -18 °C or less

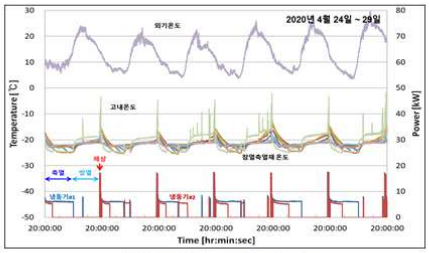
(Night - Charging)



(Day - Discharging)



(General refrigerated system)

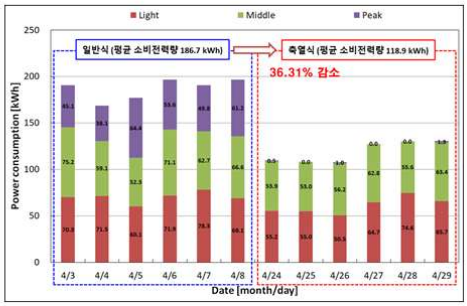


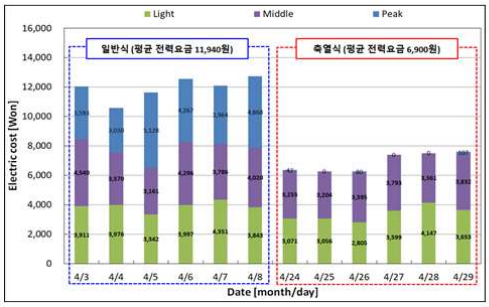
(TES refrigerated system)

Case Study

Cold warehouse

- 36.31% reduction of power consumption
- 42.21% reduction of electricity cost





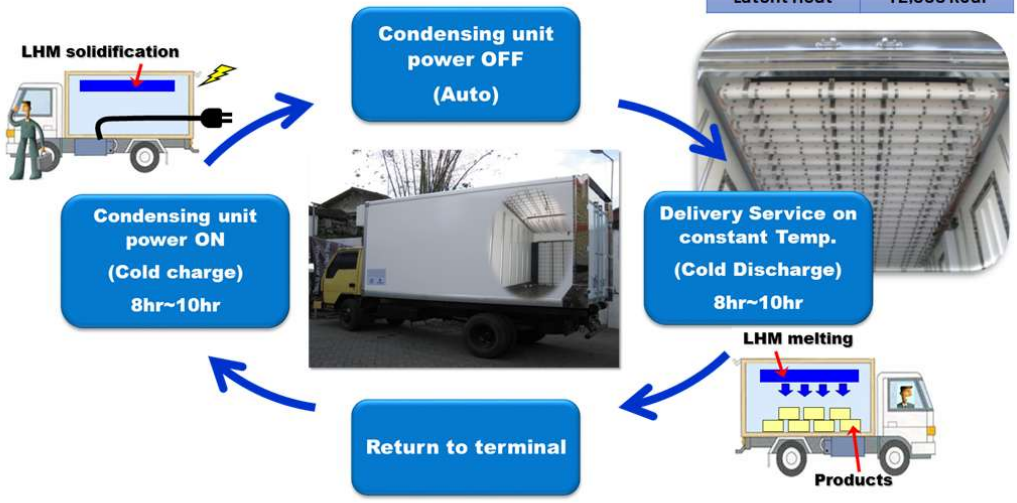
KEPCO Electricity tariff (1 July 2019)

Case Study

Holdover refrigerated truck (Indonesia)

- Target temperature range : below -10 °C
- Maintaining time : over 8-10 hours

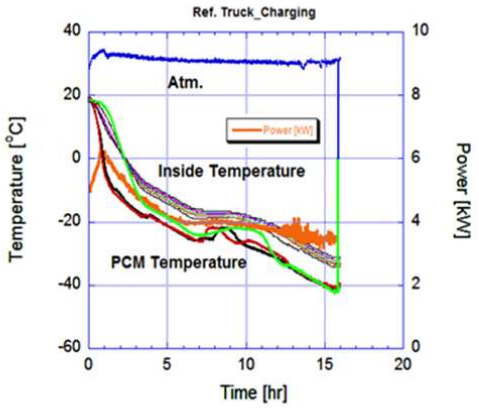
Phase changed Temp.	-21.0℃
Weight	192 kg
Latent Heat	12,883 kcal

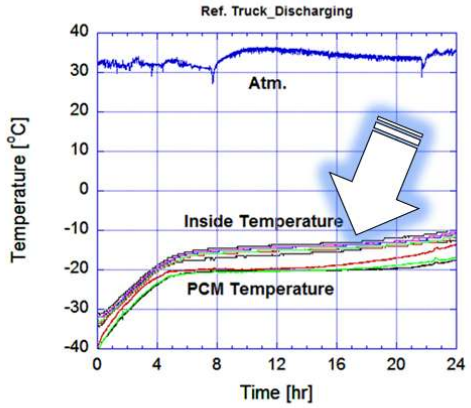


Case Study

Holdover refrigerated truck (Indonesia)

- Outside temperature in Indonesia : over 30 °C
- Internal temperature maintained below -10 °C for 24 hours for discharging





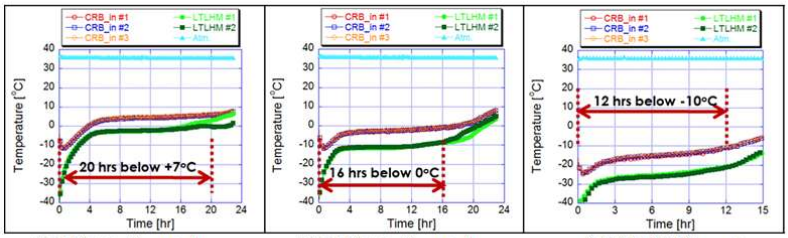
Case Study

Cold roll box (Indonesia)

- Freezing station to freezing the LHM module for CRB
- CRB to transport frozen/refrigerated goods with different keeping temperatures

To freezing the LHM module for CRB

It is possible to distribute 3 kinds of products as different keeping temp.

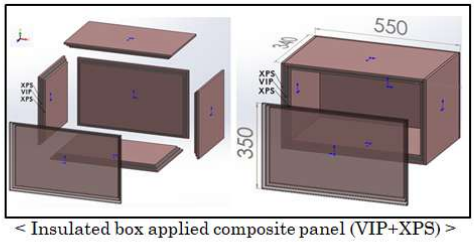


-4°C LHM (refrigerated) -12°C LHM (refrigerated) (-26°C LHM (frozen)

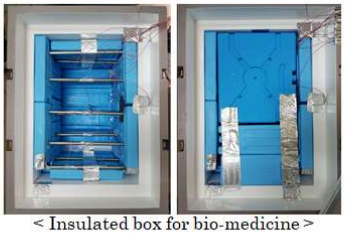
Case Study

Vaccine Transfer Container

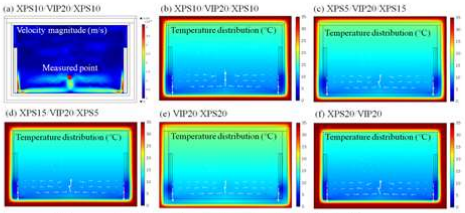
- Target temperature range : 2 °C to 8 °C (Outside temperature 35 °C)
- Maintaining time : over 72 hours



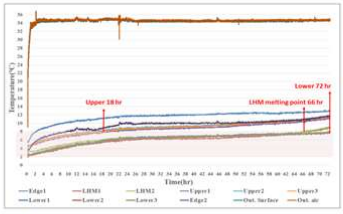
< Insulated box applied composite panel (VIP+XPS) >



< Insulated box for bio-medicine >



< Numerical analysis for the insulated box >



< Experimental result of the insulated box >

Case Study

Small logistics transport device

- Development of small transport device for low-temperature logistics delivery for Southeast Asian market
- Consisting of a DC refrigerator by battery and LHM
- Target temperature : below 10 °C for refrigerated goods
- Target maintaining time : over 3 hours

KITECH's LHM Technology

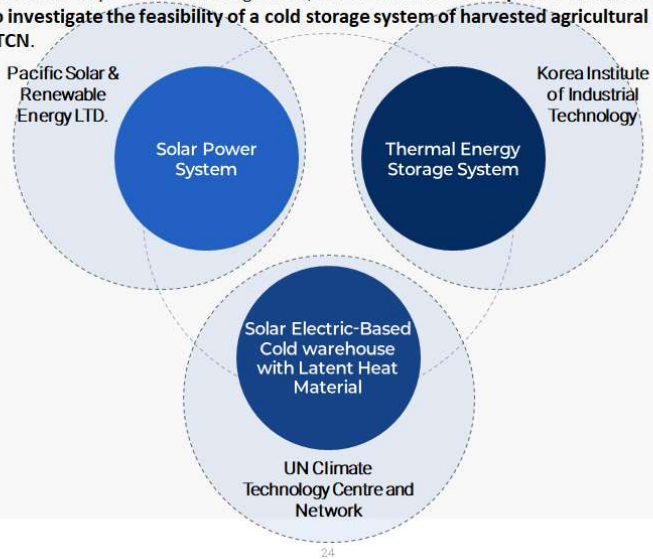
- **KITECH**'s advanced thermal energy storage group provides R&BD services to help small and medium size companies in any types of industries incorporate LHMs into their existing products or processes.
- **KITECH**'s advanced thermal energy storage group provides various kinds of LHMs that maintain a constant temperature and higher reliability.

- Theses services and turnkey projects include as follows;
  - Technical, commercial assessment and selection of suitable LHMs
  - Development of new LHMs and Modules
  - Thermal performance research of LHMs into your existing and new products
  - Testing of LHMs and prototypes in the fields
  - Consulting for advanced thermal energy storage systems

Project Review

Backgrounds

- Bangladesh's agricultural sector, critical to food security and economic stability, is suffering significant post-harvest losses due to lack of refrigerator storage facilities.
- There are no adequate refrigerated storage facilities, especially in rural and marginalized areas.
- Solar-powered cold storage provides a sustainable solution.
- However, we need technology to store thermal energy **during periods of time when solar power is not generated**.
- **In this project**, we intend to implement it in Bangladesh, which **combines solar power and thermal energy storage technology(TES), to investigate the feasibility of a cold storage system of harvested agricultural products with the support of UNEP CTCN**.



Objectives

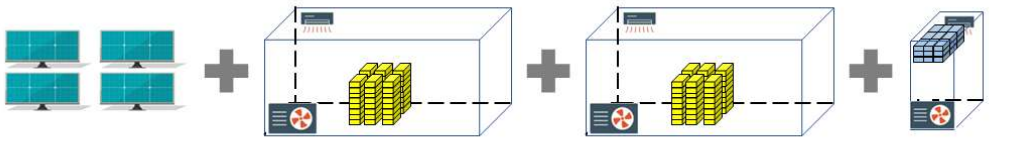
A Final Goal

Development of a pilot scale cold warehouse system for stable storage of harvested agricultural products

How to Reduce Energy Costs
How to Maintain the Quality of Products

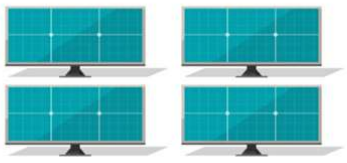
Technology Solutions

A Pilot Scale Cold Warehouse System



PV System | Pre-cooling warehouse | Cold storage warehouse | LHM cold storage Unit

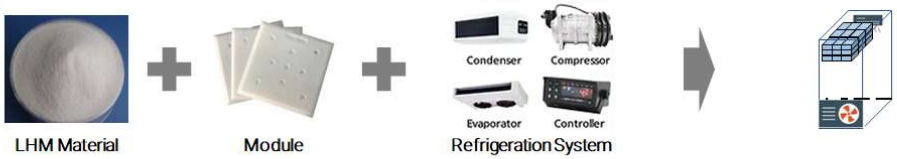
B PV System



1. Calculate the heat load of two container and LHM cold storage warehouse to determine the correct capacity of the solar panel
2. PV systems are manufactured and installed in Bangladesh
3. Installing and ESS (2~4 kwh) to support electrical system

Technology Solutions

C LHM Thermal Chamber Design and Manufacturing



LHM Material | Module | Refrigeration System

1. The LHM-based refrigeration system unit installation container will be designed and fully manufactured in Korea.
2. The manufactured containers will be shipped by sea and assembled with cold storage warehouses.

D 20-ft Container Design and Manufacturing

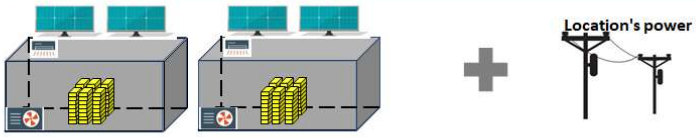
Insulation Panel | Heat Insulated door | Refrigeration System | Measurement System

1. 20-ft container consists of two units: one for pre-cooling and one for cold storage
2. Heat load calculation for 20-ft container
3. 20-ft containers will be designed and manufactured in South Korea
4. 20-ft containers will be shipped by sea to Bangladesh, and it will be assembled locally

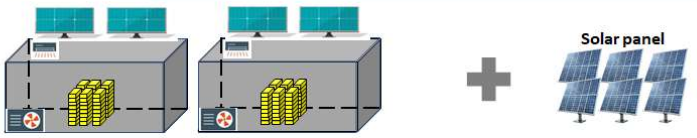
Technology Solutions

E System Optimization (Operating methodology)

Scenario 1_Cold storage warehouse operation using location's power



Scenario 2_Cold storage warehouse operation using solar panel

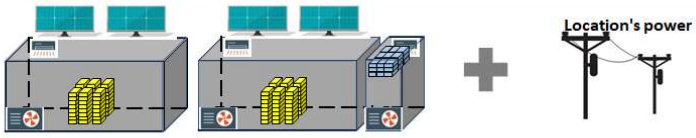


Scenario 3_Cold storage warehouse operation using location's power and solar panel

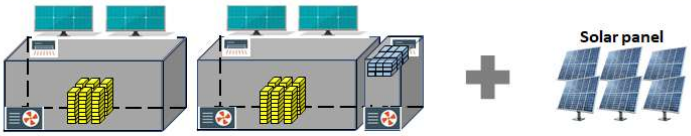
Technology Solutions

E System Optimization (Operating methodology)

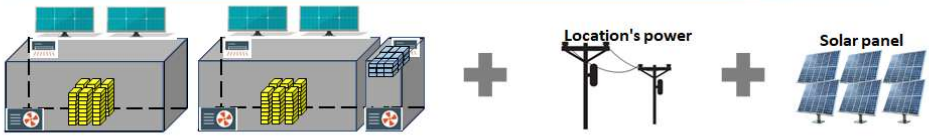
Scenario 4_Cold storage warehouse operation with LHM storage warehouse using location's power



Scenario 5_Cold storage warehouse operation with LHM storage warehouse using solar panel



Scenario 6_Cold storage warehouse operation with LHM storage warehouse using location's power and solar panel



Technology Solutions

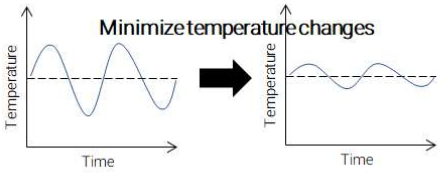
F System Operation from Harvest to Storage

Mango farm
Atmospheric temperature : 35℃

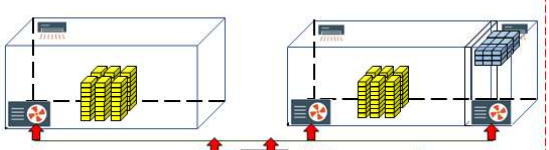
Put harvested mangoes (fruits) into boxes of a constant size

Electricity energy cost ↓

Maintain good quality ↑



Day time

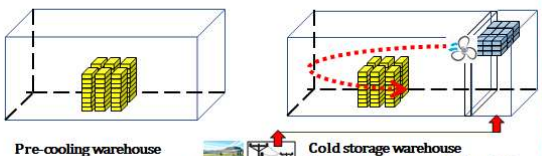


Pre-cooling warehouse
Indoor temperature : 20~25℃
- Day time : Using chiller

Cold storage warehouse
Indoor temperature : Below 15℃
- Day time : Using chiller

LHM cold storage warehouse
- Day time : Freezing LHM module using chiller

Night time



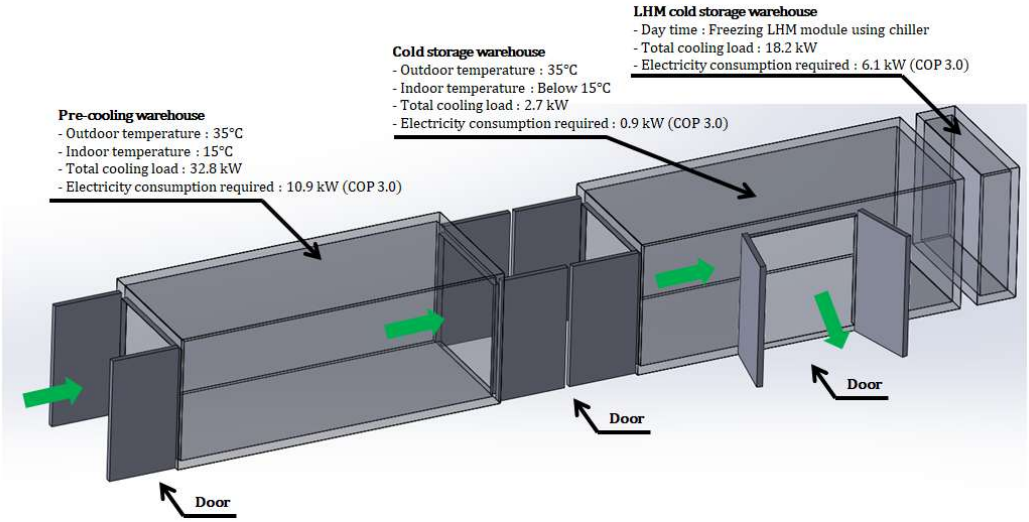
Pre-cooling warehouse
- Night time : Not used chiller

Cold storage warehouse
Indoor temperature : Below 15℃
Night time : Not used chiller
Using LHM module

LHM cold storage warehouse
- Night time : Not used chiller

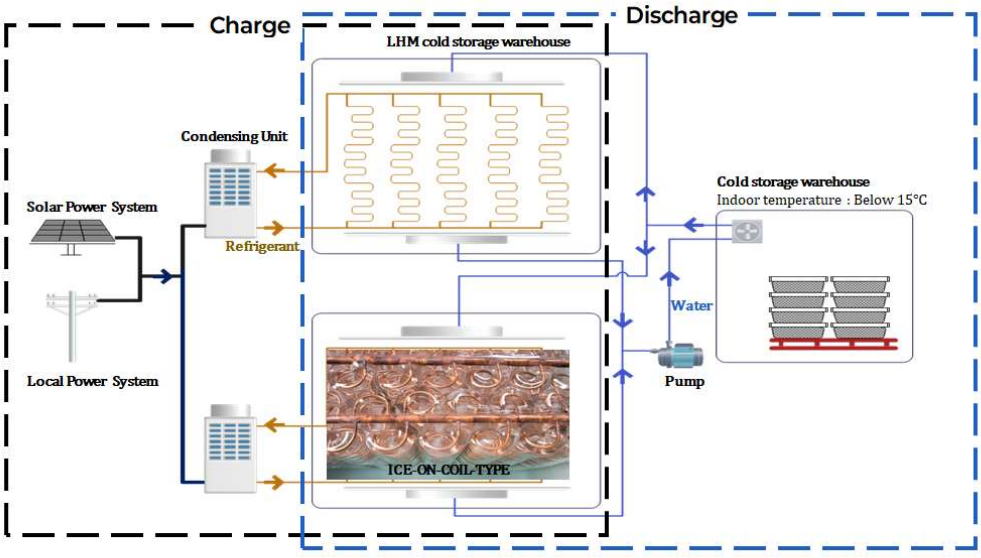
Technology Solutions

System Specifications



Technology Solutions

System Specifications



Time Line

A March, 2025

1. Project contract
2. Establishment of Steering Committee and inception workshop
3. System basic design completed (PV, LHM system, Container)

B APRIL, 2025

1. On-site investigation through visits to sites where demonstration technology will be applied (KITECH, Dr. KIM)
2. Visit to PV system manufacturing and installation company
3. System design modifications and decisions (PV, LHM systems, containers)
4. Bangladesh PV System Manufacturer Selection Completed

C May - September, 2025

1. Design of cold warehouse
2. Operation monitoring & control system design
3. Manufacturing of cold warehouse
   - Insulation panels for warehouse
   - Refrigeration systems
   - LHM modules
4. Bangladesh site visit (Final check)

D October, 2025

1. Setup of cold warehouse
   - Pre-cooling warehouse
   - Cold storage warehouse
   - LHM cold storage warehouse
2. Training on operation technology of warehouse system

E November, 2025 - January, 2026

1. Evaluation of cold warehouse
   - Providing the optimal operating methodology
   - Proposal of optimal operation methodology considering power system
2. Technical feasibility (Commissioning and operational aspects)
3. Socio-economic and financial analysis
4. Feasibility report and stakeholder consultations (Communities and government)

F February, 2026

1. Writing a concept note for a scale-up project
2. Final workshop

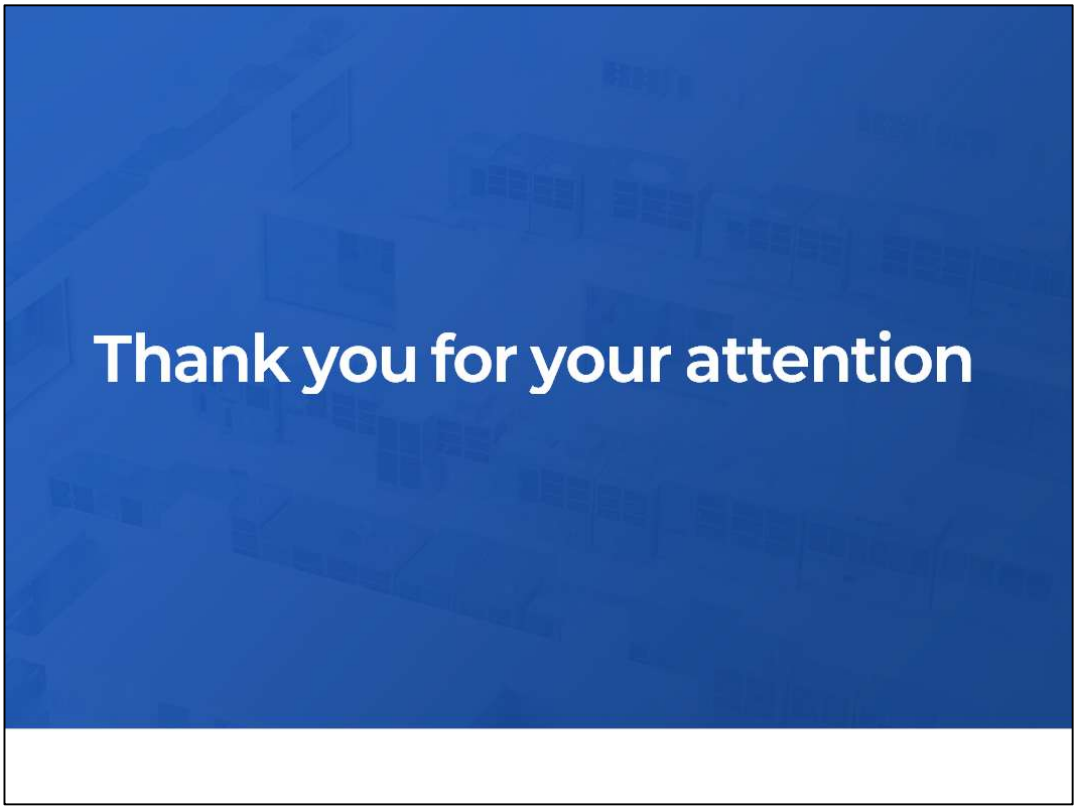
Discussion

A PV System & ESS

B Container Preparations

C Total System Installation

D Testing & Something Next



6.2 List of attendees

Attached is the list of people contacted during the field survey.

	Name	Organization	Positions	E-mail
1	Jeong-Yeol KIM	KITECH	Principal Researcher	esperant@kitech.re.kr
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4	Syed Arshad Mahmud	Pacific Solar & Renewable Energy LTD.	Director	pacific.xpo@gmail.com
5	Mohammed Zabir Hussain	Mover Solar	Director	
6	MD.Farid Uddin	Earnest Engineering	Manager	Manager.earnest@gmail.com

		Works (PVT.) LTD.		
7	Partha Podder	Earnest Engineering Works (PVT.) LTD.	Director	Partha.earnest@gmail.com
8	MD. Aktarozzaman ZSohag	Earnest Engineering Works (PVT.) LTD.	Director	Sohag.earnest@gmail.com