ENOUGH

EUROPEAN FOOD CHAIN SUPPLY TO REDUCE GHG EMISSIONS BY 2050

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EUROPEAN FOOD CHAIN SUPPLY
TO REDUCE GHG EMISSIONS BY 2050

Initiatives in low- and middle-income countries to tackle decarbonisation

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NTNU

Workshop –
Decarbonising the food chain,
challenges and opportunities for the food industry

13.08.2025
Manchester, UK

Content

- Introduction
- Why clean cooling is important for the decarbonizing
- Examples from SOPHIA
- Examples from INDEE
- Summary

Why communication about clean cooling solutions?

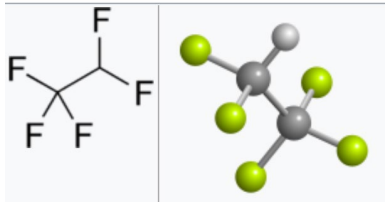
- Awareness rising is important (globally)
- End-users (owners of assets) are often not informed and aware of the environmental-, health-, safety- and economic risks related to working fluids
- (Only) informed end-users can make sustainable investment discissions when new equipment is required

Artificial Refrigerants

PFAS - TFA

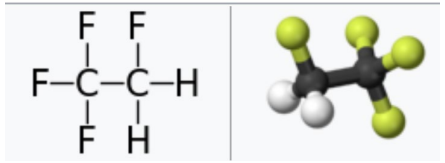
R-125

Pentafluoroethane



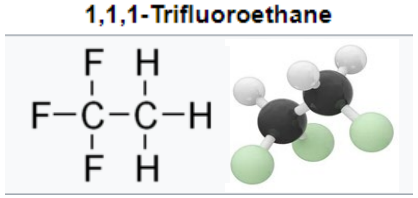
R-134a

1,1,1,2-Tetrafluoroethane



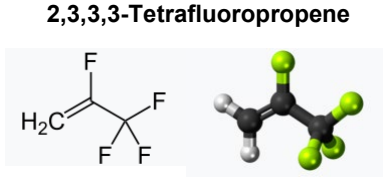
R-143a

1,1,1-Trifluoroethane



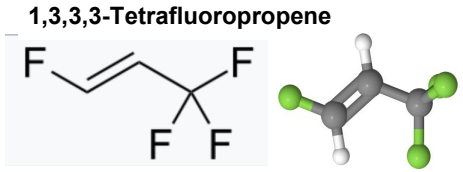
R-1234yf

2,3,3,3-Tetrafluoropropene

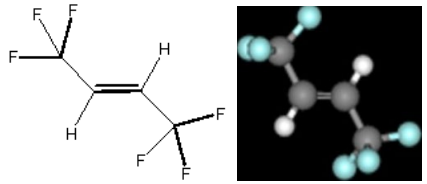


R-1234ze

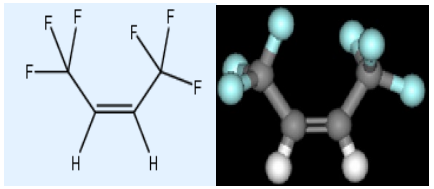
1,3,3,3-Tetrafluoropropene



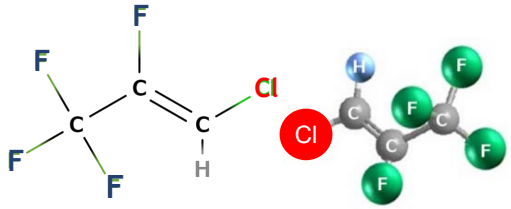
R-1336mzz(E)



R-1336mzz(Z)



R-1224yd
ODP !



R-1233zd
ODP !

ODP = Ozone Depletion Potential

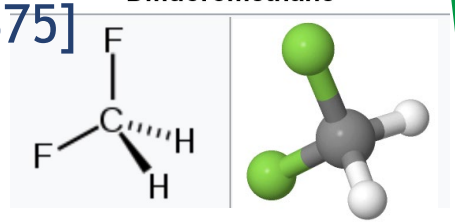
Blends:

R407x, R410A, R444B, R446A, R447, R448, R449, R450,R452,R454, R455, R456, R459, R469, R473, R508, R513, R514, R515, R472A, R454C, R468, R466A, +++

GWP

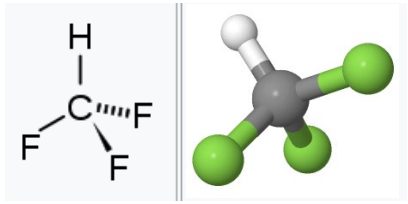
R-32 [GWP 675]

Difluoromethane



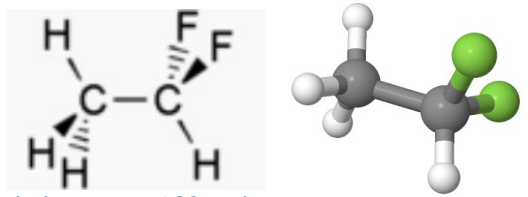
R-23 [GWP 18 400]

Trifluoromethane



R-152a [GWP 124]

1,1-Difluoroethane



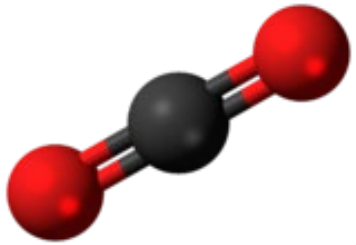
Not:
fully fluorinated methyl, except R23 -> has H on it

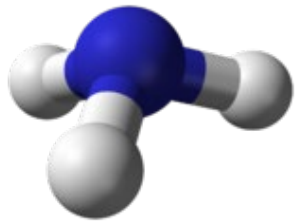
Source: Wikipedia

Clean cooling working fluids

Carbon Dioxide / CO_2 / R744

- Hot water heat pumps, Mobile AC and HP systems
- Commercial- / low temp. industrial refrigeration
- Heat pump chillers



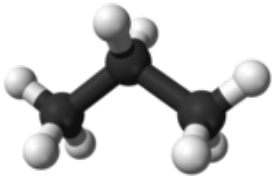


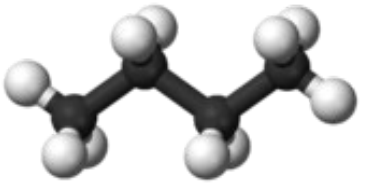
Ammonia NH_3 / R717

- Industrial refrigeration and heat pumps, chillers,…

Hydrocarbons (Propane, Butane, etc.) / R290, R600

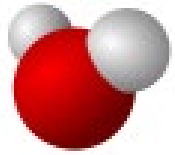
- Residential AC split units, Light commercial refrigeration,
- Transport refrigeration and mobile AC, high temp. HPs
- Home appliances (fridges and freezers)





Water – H_2O – R718

- Industrial refrigeration and heat pumps
- Data centre cooling



Air– R729

- Low temperature applications (< -50°C), Storage of vaccine, Public transport refrigeration: Airplanes, Trains etc.

Examples – of inititives

There are many….

- SOPHIA - Africa
- INDEE - India

SOPHIA

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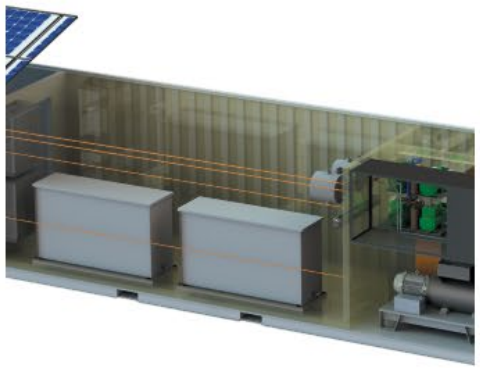
English

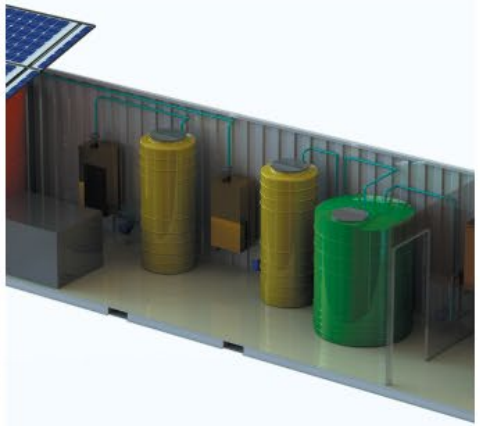
Technologies

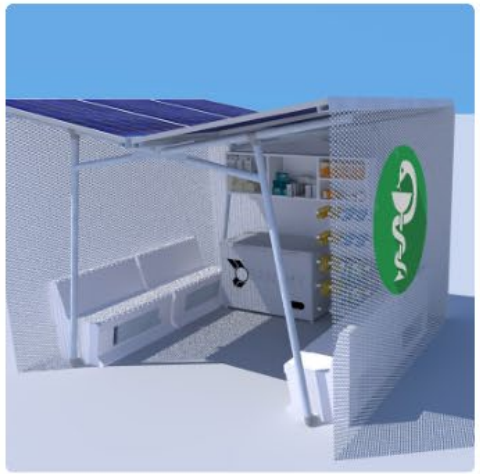
An agile and respectful approach

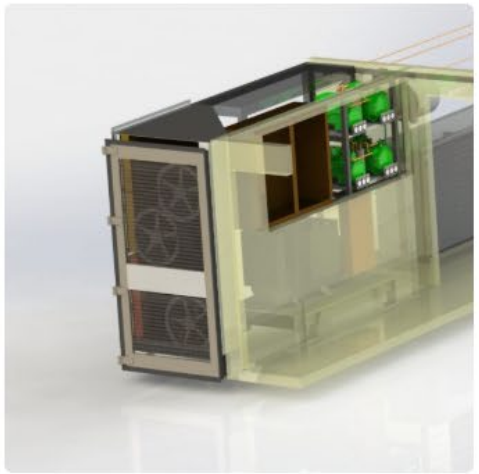
Using various green technologies, SophiA will develop and manufacture locally innovative, modular, affordable and efficient solar powered systems for providing:

- **Safe, clean drinking water and deionised water for medical purposes**
- **Hot water and steam production for thermal requirements of the hospitals**
- **Cooling of medicines and food at +5°C**
- **Low temperature storage of blood plasma at -30 °C**
- **Ultra-low temperature storage of sensitive medication (E.g. some Covid-19 vaccines) at -70°C**
- **Emergency electricity supply for surgical and intensive care units**

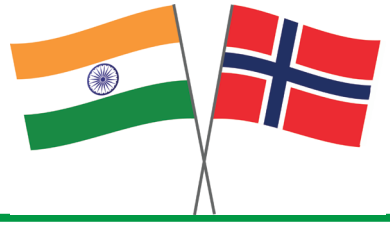








INDEE Projects



INDEE (2017 to 2020)

Funded by:

Norwegian Embassy
New Delhi

Coordinated by:

SINTEF Energy

SINTEF

NTNU

Future Refrigeration India: INDEE+ (2021 to 2025)

Funded by:

Norwegian Embassy
New Delhi

Coordinated by:

NTNU
Norwegian University of Science and Technology

NTNU

SINTEF

IIF IIR

CEEW THE COUNCIL

NORWEGIAN ENVIRONMENT AGENCY

INDEE^3 – Sustainable cooling and heating in India (2025 to 2029)

Funded by:

Norwegian Embassy
New Delhi

Coordinated by:

SINTEF Ocean

INDEE+ partners +

Alliance for an Energy Efficient Economy

ISHRAE

Approach and aim of INDEE

- Support education institutions, vendors and potential end-users
  - free access workshops and trainings across India
  - exchange of candidates and students during their MSc or PhD

- **Local** engineering and manufacturing
  - Direct support of vendors during design process
  - Follow up during manufacturing
  - FAT at laboratories
  - Follow up of units at end-users
- Policy support
  - Development of practices for End-of-Life Management of Refrigerants and Other F-gases
  - How to support growth and market introduction of natural working fluids systems

Initiatives and achievements

INDEE → INDEE+ → INDEE^3

Teamwork

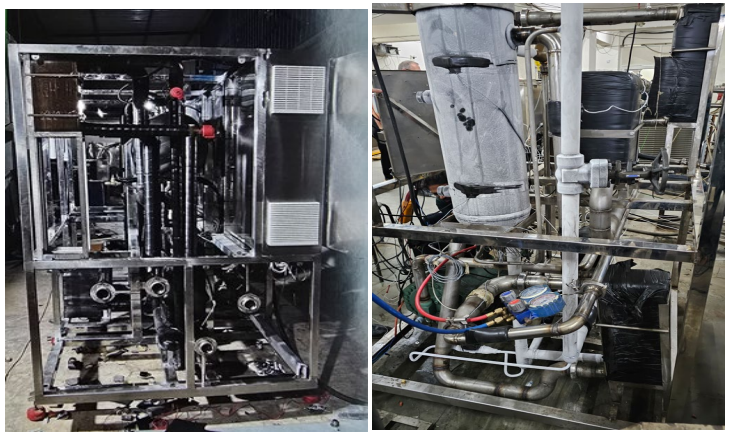
Initiatives and achievements

INDEE → INDEE+ → INDEE^3

Knowledge sharing and -transfer

Initiatives and achievements

INDEE → INDEE+ → INDEE^3



CO_2 heat pump at Hotel in Goa

Local made demonstrators

CO_2-NH_3 cascade refrigeration system at NAS Fisheries Pvt. Ltd

CO_2 heat pump at The Akshaya Patra Foundation

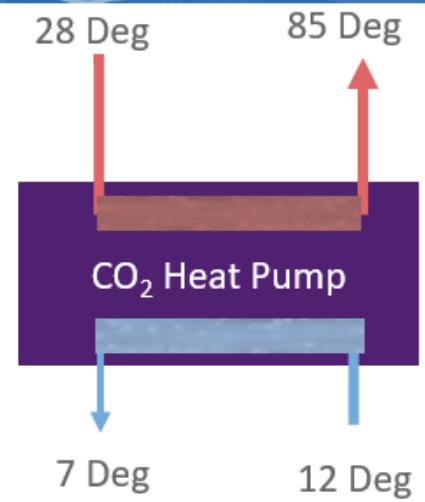
CO_2 heat pump at for Mondelez International

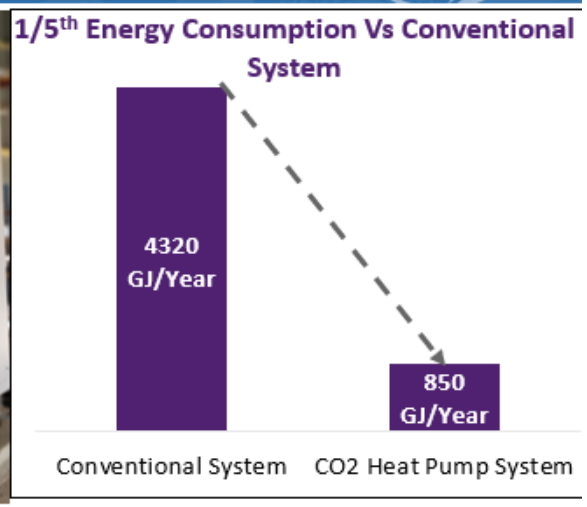
CO_2-NH_3 cascade refrigeration system at Bellfoods Pvt. Ltd

Highlights – the Chocolate Factory

Sricity CO_2 Heat Pump

To Eliminate Localized Steam Consumption in Heating process water from 28 C to 85 C





Key Highlights

- **0.15 MM $** — CAPEX
- **60 K$/ Annual Saving**
- **800 Tons/Annum Reduction** — CO_2
- **1300 Tons Steam per Annum**

- First of its kind industrial implementation in tropical climate , as well as Mondelez AMEA. Designed along with Indian institute of Science
- 1st POC Generates: 1700 L/hour hot water at 85 deg (4 Ton/day Steam Saving), At the same time 15 m3/hr Cold water at 7 Deg.
- Re-Application opportunity- Boiler Feed water, CIP Kitchen Water and Process water heating for Crumb, Bar & Candy lines.

Mondelēz International
SNACKING MADE RIGHT

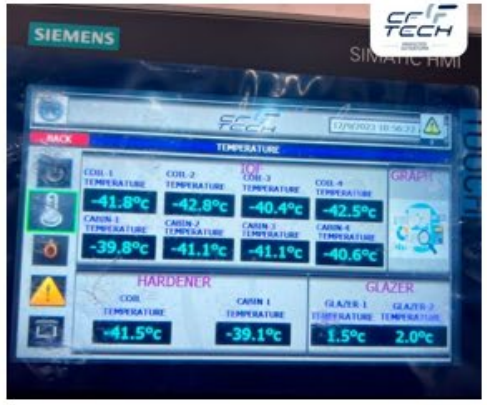
Highlights – the Fish Process Plants [Scope III suppliers to EU]

Outcomes

- Successfully commissioned 9th December 2023





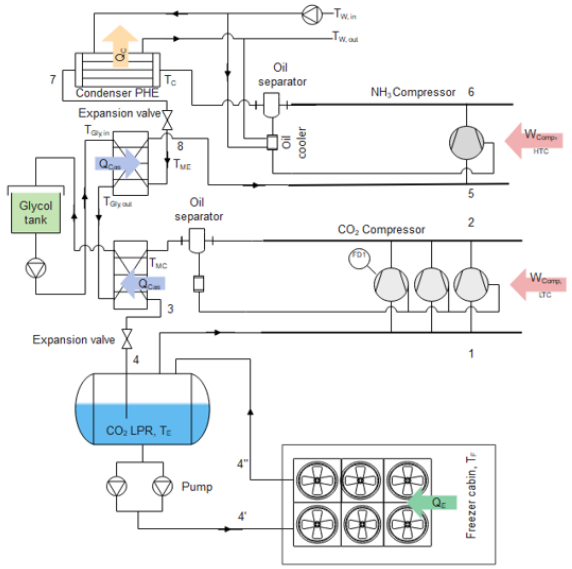


13-Aug-25 | R744-R717 freezing unit for marine sector | INDEE • NTNU • SINTEF | 9

Highlights – the Fish Process Plants [Scope III suppliers to EU]

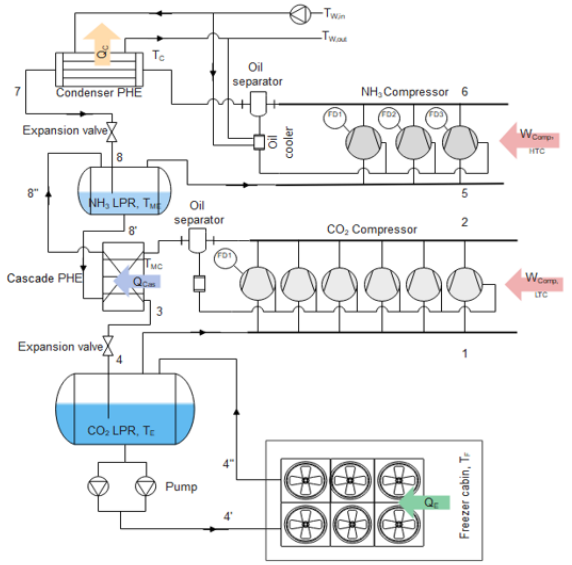
Demosite-3a, Bellfoods

- Tunnel freezer (IQF) with Cooling capacity 150 kW
- Three Fluid system, CO_2-Glycol-NH_3 cascade refrigeration
- Evaporator temperature at -44 °C
- Loading capacity 500 kg/h



Demosite 3b, NAS Fisheries

- Tunnel freezer (IQF) with Cooling capacity 350 kW
- CO_2-NH_3 cascade refrigeration system
- Evaporator temperature at -43 °C
- Loading capacity 1000 kg/h



- Each demonstration site is operated by the end-user. Local vendor (CF-Tech) will provide the service and maintenance even after INDEE+ is terminated.
- New end-users for CO_2 -NH_3 cascade refrigeration systems:
  - Veronica Marine Exports Pvt Ltd, Kollam, Kerala, 300 kW unit will be commissioned in June 2025.
  - Seafood processing industry in Mumbai (name will be revealed later). 1000 kW unit fabrication work in progress.

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Highlights – The School Kitchen of The Akshaya Patra Foundation

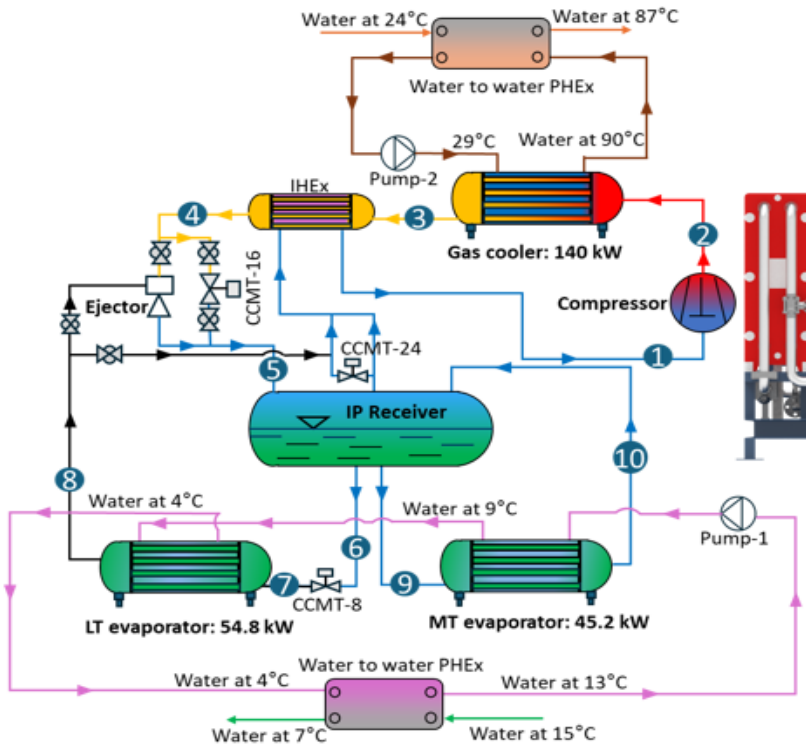
Approach used to execute the work

Demosite-01: Indian school kitchen system (Akshaya Patra Foundation, Bengaluru)

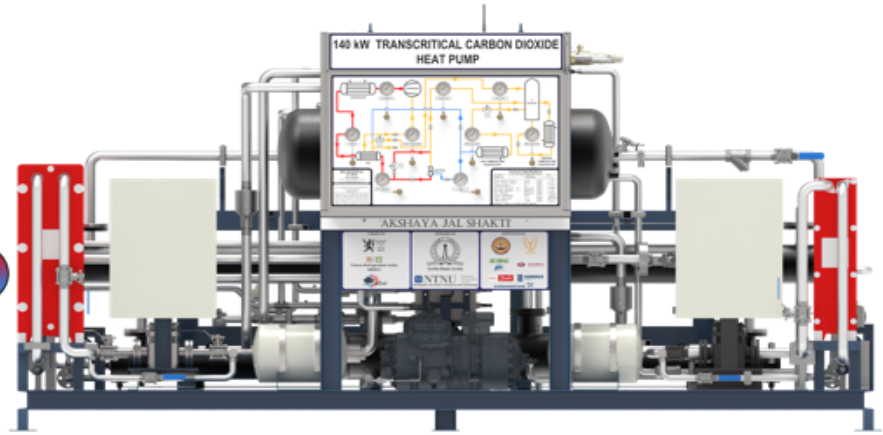
Boundary Conditions

- *Working fluid : CO_2*
- *Heating capacity : 140 kW*
- *Cooling capacity : 100 kW*
- *Hot water inlet temp.: 27°C*
- *Hot water outlet temp.: 87°C*
- *Chilled water inlet temp.: 12°C*
- *Chilled water outlet temp.: 7°C*
- *Max. ambient temp.: 40°C*
- *COP : 5.6*

Demo site-01



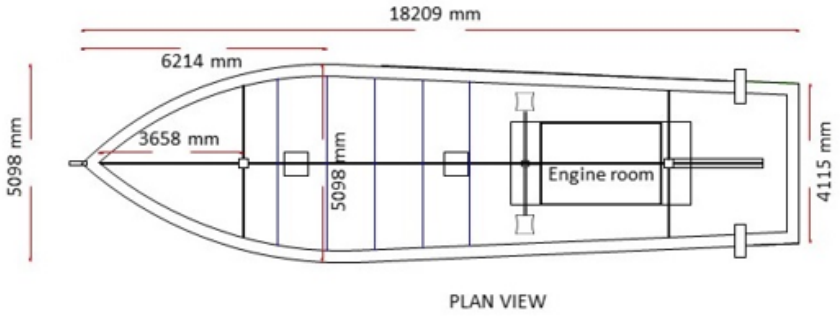
3D CAD diagram

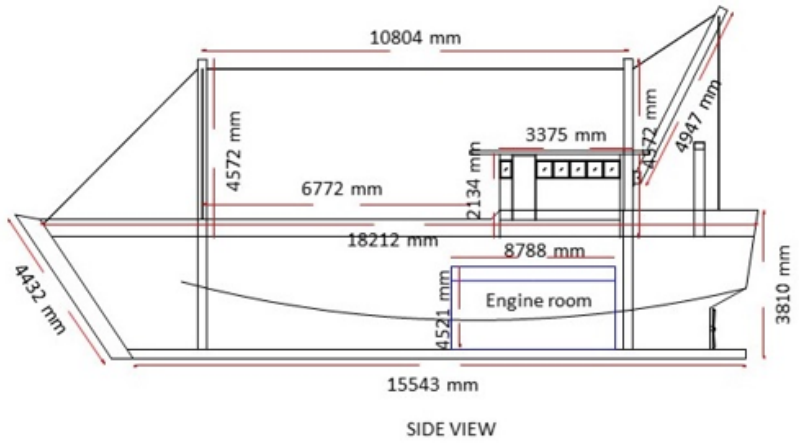


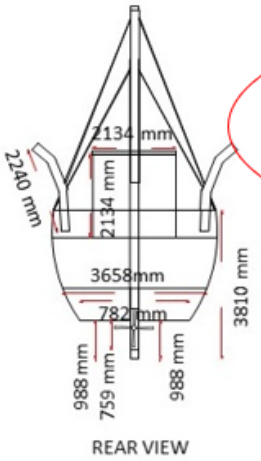
Process flow diagram of T-CO_2 heat pump and chiller system

Highlights – Ice produced on-board small fishing vessels

Demo-Site Project - On-board Ice Production







Small boats come in many variety!

Mumbai coast: RSW system, Demand: Cooling load 3.5 kW, intermittent running, 50% support.

Gujarat coast: Flake ice system Demand:100 kg ice per hour for 10 hr. daily, 50% support.

Kerala coast: block ice system 24 hours of compressor running, 50% support.

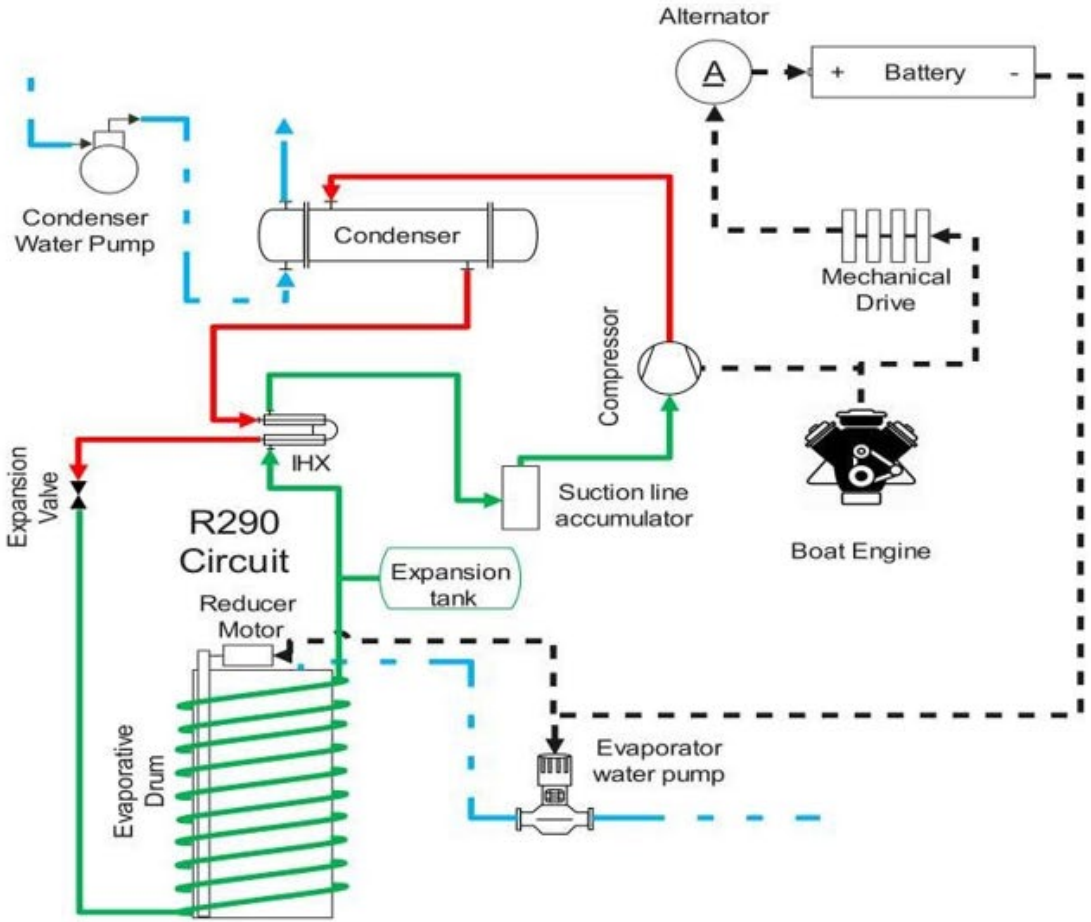
Highlights – Ice produced on-board small fishing vessels

Schematic

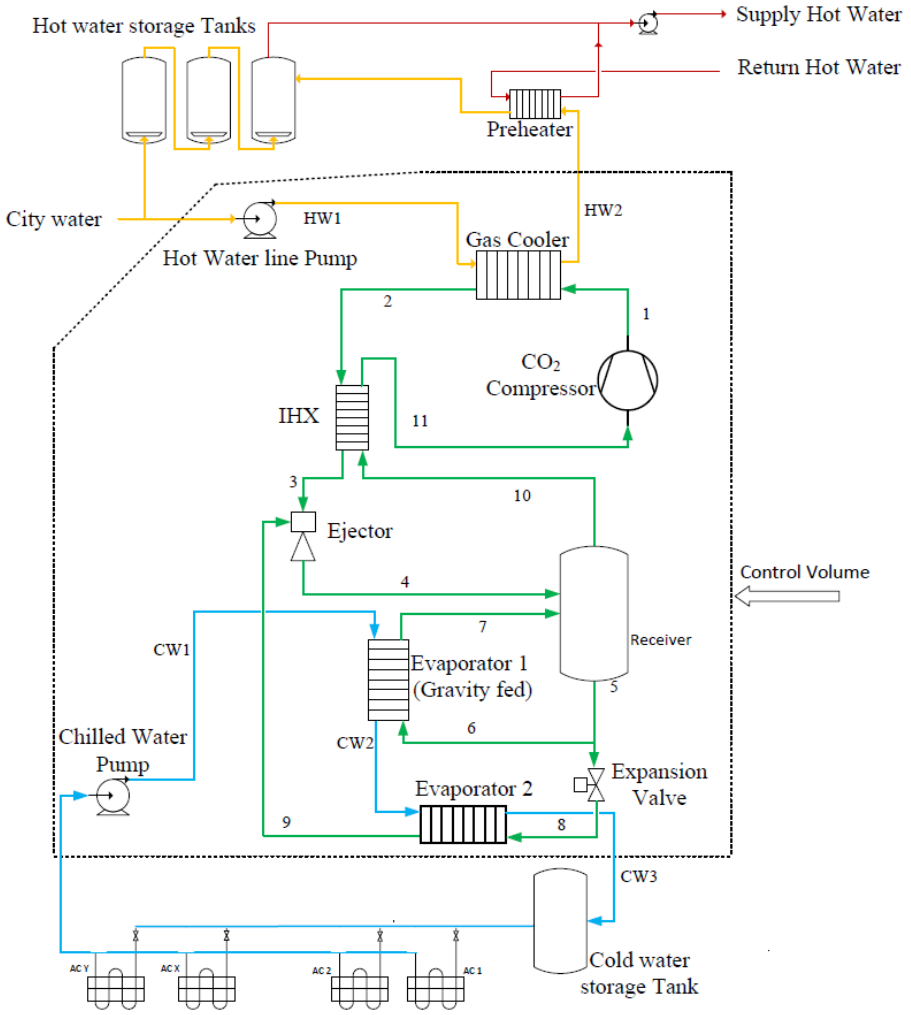
Direct loop R290 system configuration

Cooling Load 13 kW

R290 Compressor



Highlights – Hotel in Goa



Presented during

Paper 1168

R744 Heat Pump Chiller Implemented in a Hotel in India

- The compressor, ejector, and plate heat exchanger were imported
- In-house development of the control system
- Siemens PLC-based control system with a proprietary SCADA platform
  - oil return management
  - ejector control
  - gas cooler and evaporator load balancing
  - water flow regulation and
  - demand-based hotel controls
- Data is logged at three-minute intervals
- Exemplifies make in India
- Manufactured and integrated into the hotel infrastructure by Medors Renewable Energy Pvt. Ltd.

- Following the successful operation **Medors Renewable Energy Pvt. Ltd. has received requests to manufacture additional 15 units**.
  - Aligns with the primary objective of INDEE+ project which is promoting the adoption of natural refrigerant-based heating and cooling systems in India.

Topics – INDEE^3

- Increased awareness and adoption of sustainable HVAC&R solutions.
- Reduced use of harmful synthetic refrigerants and fossil fuel-powered boilers.
  - Low global warming potential
  - No PFAS
- Expand sustainable solutions to food chain, and other sectors
  - Improving cold chain efficiency

Take home message

From now on:

reminded by the PFAS restriction proposal on its way,

there should be no doubt that **our sector must leave the artificial refrigerant chapter**,

the sooner the better.

Heat pumps are enablers of successful decarbonisation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 101036588

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THANK YOU !

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