OST
Ostschweizer
Fachhochschule

Concepts for cost-effective Ice Storages

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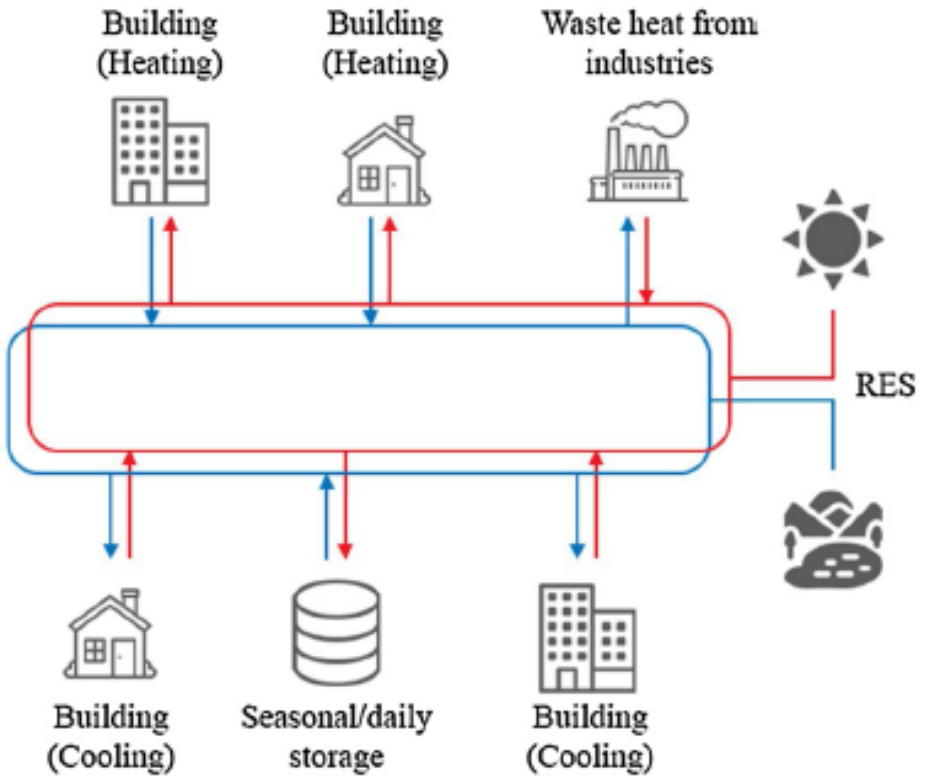
MOTIVATION : WHY ICE STORAGE?

- Energy storage is a key enabler for achieving high shares of renewables and decarbonize the energy supply system
- Most of heat/cold needs are in the range of 0 °C to 100 °C
- Water as heat storage medium offer excellent energy density, environmental, price, thermal and transport properties
- Large number of applications



To **HEAT**

- DH: anergy grids
- Solar-ice
- Thermo-electrical energy storage (ETES)

To **COOL**

- Industrial refrigeration
- Commercial refrigeration
- Residential cooling
- Cooling districts

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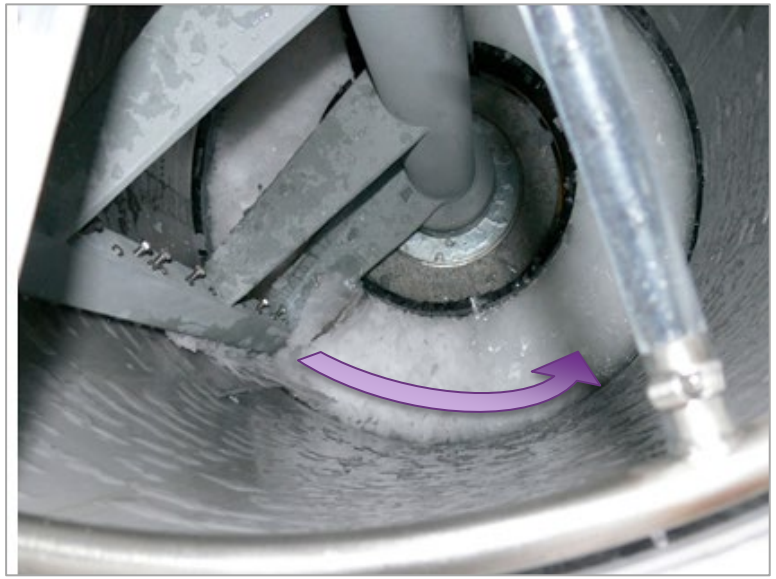
STATE OF THE ART : SOLUTIONS OF TODAY

Ice-on-coil

- Mature technology and relatively simple
- Heat exchangers adds significantly to the cost
- ice layer reduces the heat transfer rate
- Cost scales with kWh not kW

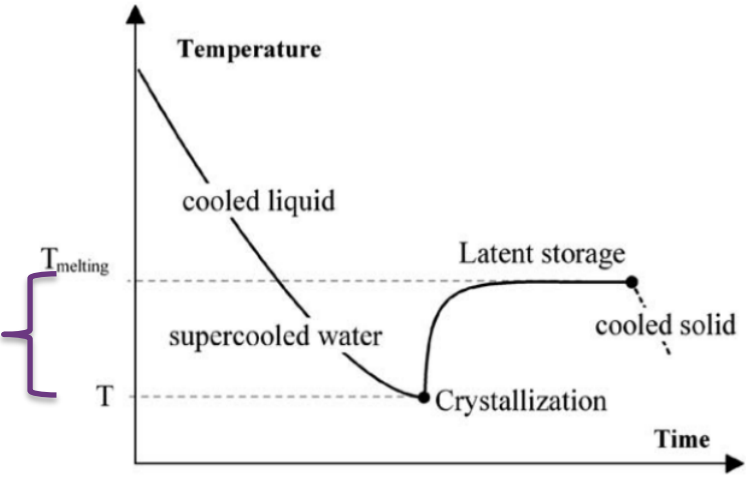
ice-slurry with scraped-surface heat exchangers

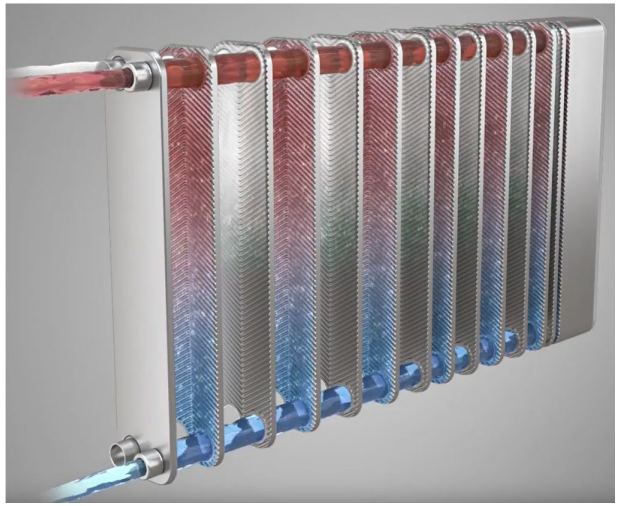
- Exist commercially in EU
- Ice is removed by a rotating auger continously
- Mechanical complexity adds capital and O&M costs
- Cost scales with kW but scalability limited



SOLUTION PROPOSED : SUPERCOOLING ICE SLURRY GENERATION

Supercooling method with controlled nucleation





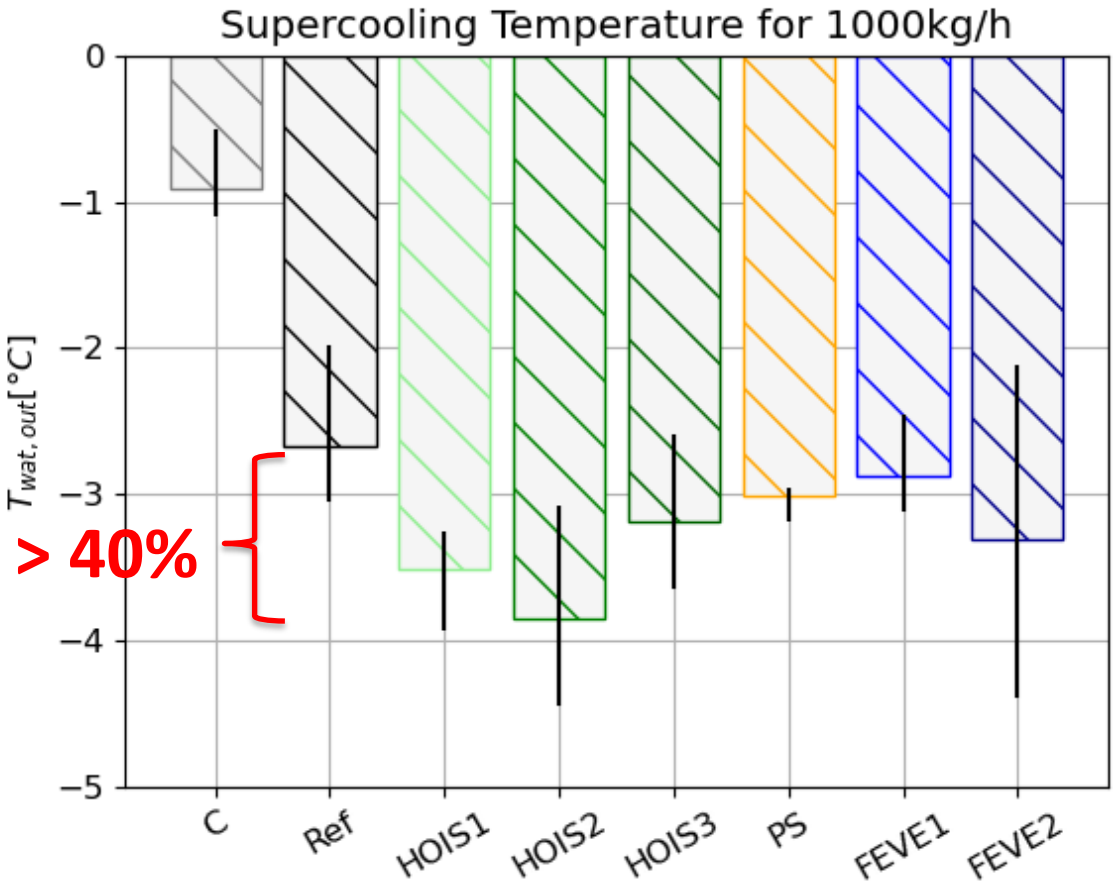
Supercooling degree (SD)

Analysed icephobic coatings

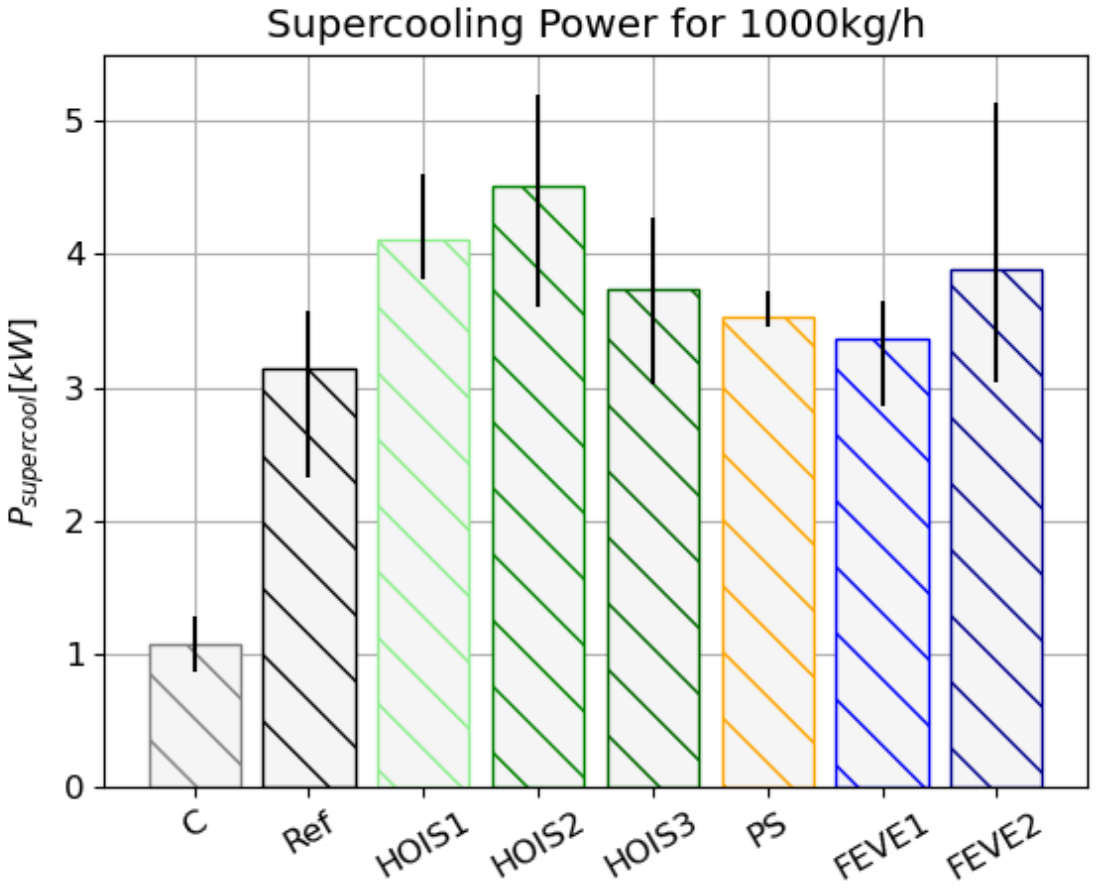
- **Icephobic Coatings for supercoolers**
  - Hybrid Organic-Inorganic Silane sol-gel (HOIS)
  - PolySiloxane (PS)
  - FluoroEthylene Vinyl Ether (FEVE)
- **Reference HX**
  - Uncoated Reference (Ref) with stainless steel and copper as inner surfaces due production process

Supercooling results – Performance of selected surfaces

Supercooling Degree



Supercooling Power



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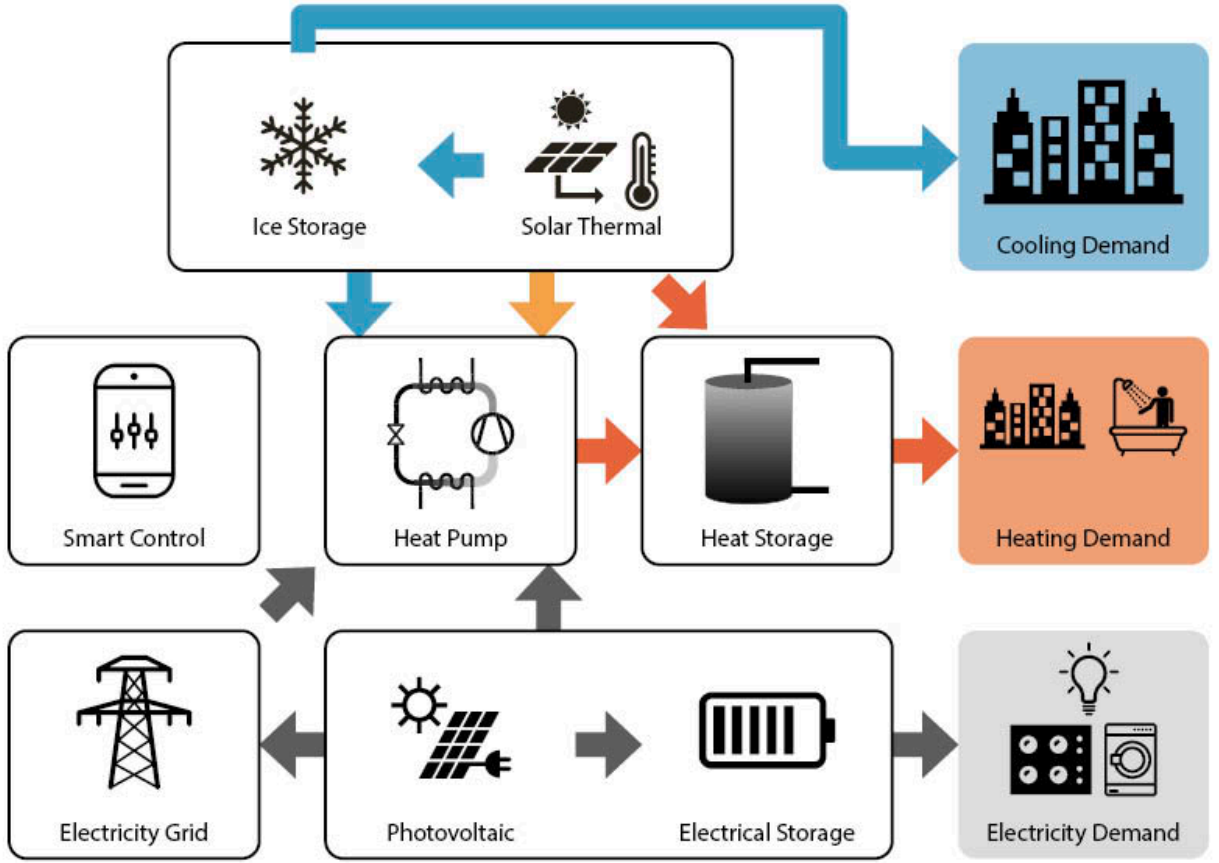
Solar-ice slurry system

- Source: solar with ice slurry as intermediate storage medium
- Heating with cooling as add-on feature



TRI-HP PROJECT

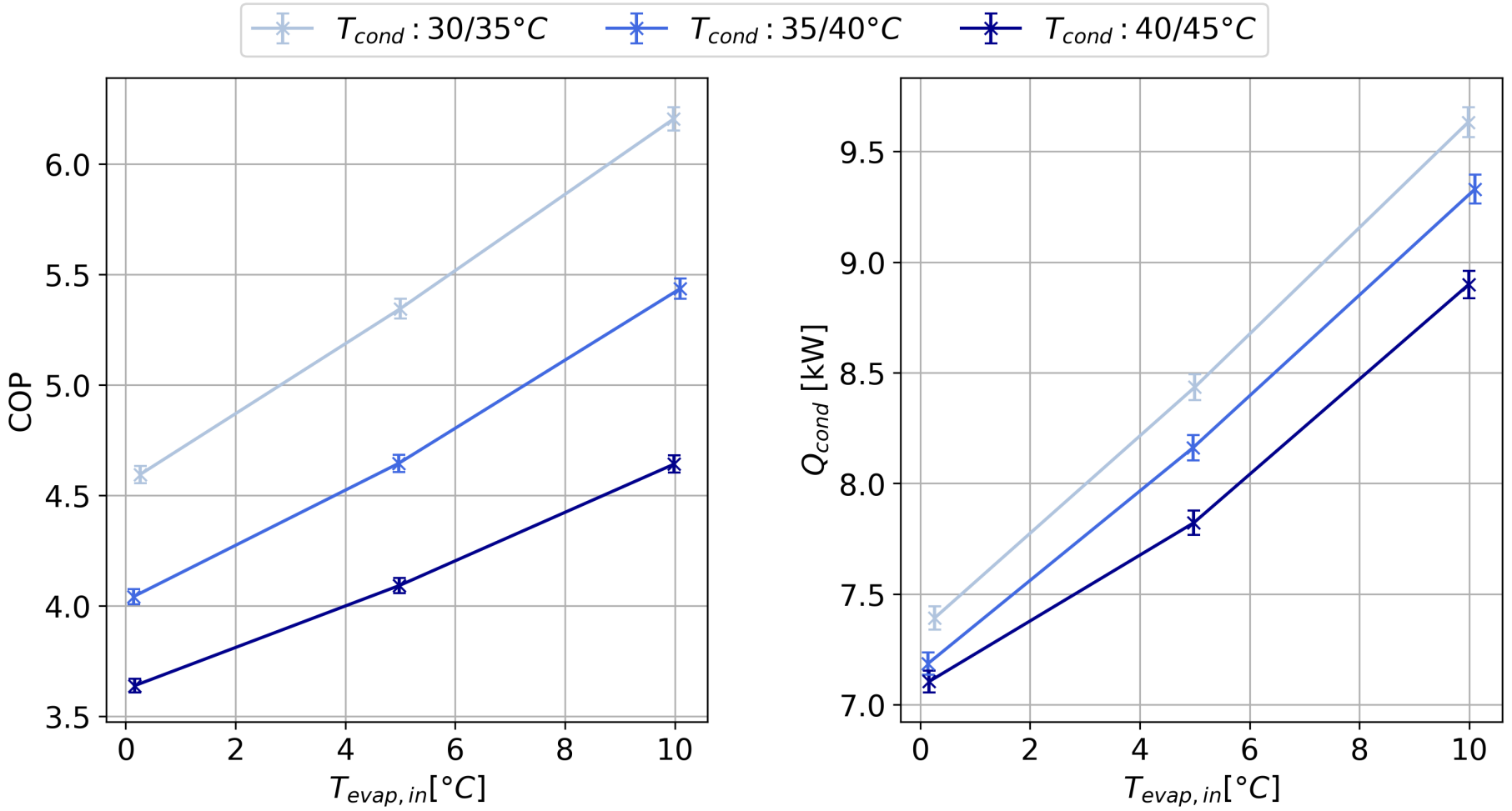
www.tri-hp.eu

Natural refrigerant heat pump - Propane

- Refrigerant R-290 (Propane)
- Power controlled – 10 kW nominal
- Simultaneous DHW and SH (with desuperheater)
- Use of a supercooler as evaporator
- Safety concept: ventilated housing
- Propane charge : 600 gr
- **Application:**
- Residential buildings with high SH share
- for mild/cold climates
- Solar - Ice slurry system

R290 heat pump test results with a supercooler

- 2 K supercooling degree
- Stable for all points
- Supercooler very small due to R290 charge concerns
- Supercooler operated between 1100 kg/h to 2300 kg/h



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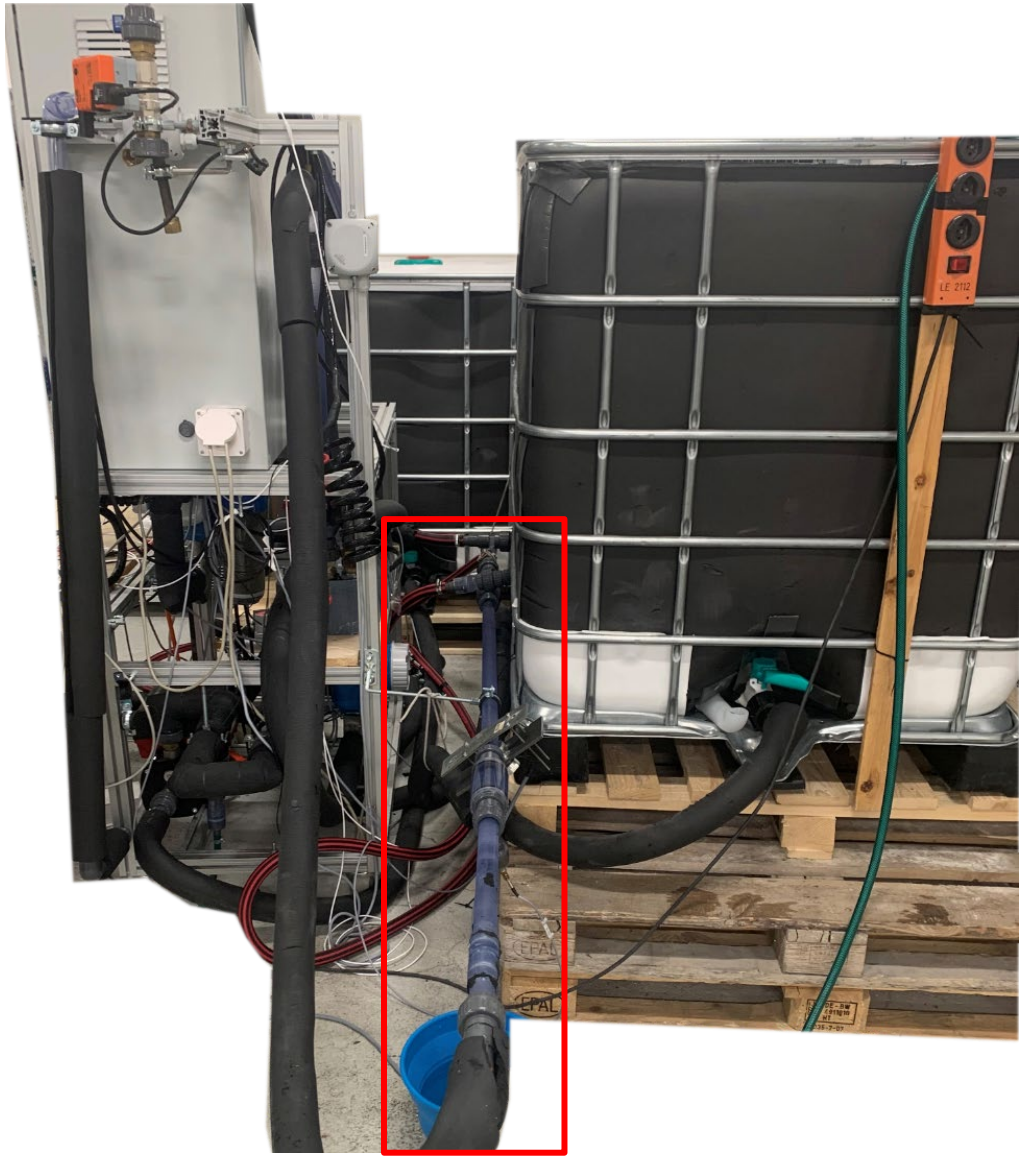
Crystallization

- Controlled crystallization is as challenging as supercooling
- Ice crystallizer must include mechanisms for:
  - Triggering nucleation when desired
  - Avoiding upstream ice propagation
  - Release all supercooling degree to avoid freezing somewhere else



Ice slurry tank design

- Third challenge
  - Distribute ice slurries homogeneously without mixer
  - Achieve 50 % ice packing factor
  - Avoid pumping crystals to the supercooler

Work ongoing and next steps

- Heat pump with supercooler operated in steady state at 2000 kg/h and 2 K without producing ice
- Current crystallizer stable at 500 kg/h with 2 K supercooling (1.2 kW)
  - Scale up to 5 kW to 2022/2023
- Combine crystallizer with a supercooler heat pump and test in dynamic real-like conditions by 2023
- Scale the supercoolers and crystallizer up to 20 kW by 2023/2024
- Demonstrate an ice slurry system in the field by 2024/2025

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