TRI-HP NEWSLETTER

ISSUE NO 2 | MARCH 2020

About TRI-HP

" will develop trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources to provide heating, cooling and electricity to multi-family buildings with an on-site renewable share of 80%, reducing installation cost by 10-15%."

FROM THIS ISSUE:

ABOUT TRI-HP

TRI-HP is a 4-year Horizon 2020 project that started in March 2019. It will develop trigeneration systems based on heat pumps with natural refrigerants and multiple renewable sources to provide heating, cooling and electricity to multi-family buildings with an on-site renewable share of 80%, reducing the installation cost by 10-15%. Within the project, mainly two systems will be developed: a) dual-source/sink heat pump system with the possibility to use ground and/or air as heat sources/sinks, and b) solar-ice system based on supercooling ice-slurry heat pump with solar energy as the main renewable heat-source.

Project duration: 48 months

March 2019 – Feb 2023

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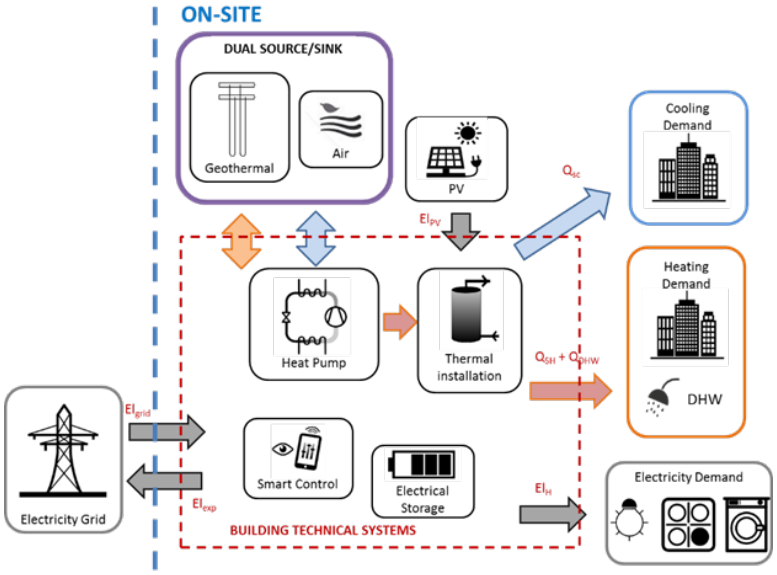

Figure 1 Dual-source heat pump system with the possibility to use ground and/or air as heat sources/sinks

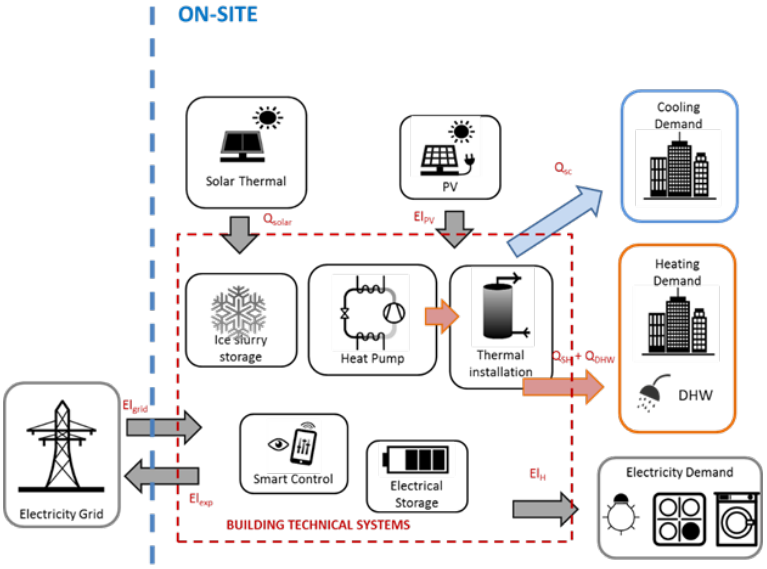

Figure 2 Solar ice-slurry heat pump system with solar energy as the main renewable heat-source

TRI-HP systems will include advanced controls, managing electricity, heat and cold in a way that optimizes the performance of the system and increases its reliability via failure self-detection. Moreover, TRI-HP will provide the most appropriate knowledge and technical solutions in order to cope with stakeholder's needs, building demand characteristics, local regulations and social barriers.

About TRI-HP

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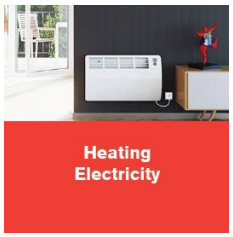


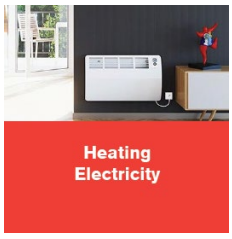
Energy demands for multi-family buildings in different climatic zones

" For the defined cases, the calculation of the energy demands of the buildings has been carried out, including electricity, heating, cooling and domestic hot water demands."

ENERGY DEMANDS FOR MULTI-FAMILY BUILDINGS IN DIFFERENT CLIMATIC ZONES

As a first step, TRI-HP aims to define the boundary conditions that will be used to design and assess the developed systems. Tecnalia and SPF have worked on the definition of reference climates and buildings, representative for the market that TRI-HP focus on. For the defined cases, the calculation of the energy demands of the buildings has been carried out, including electricity, heating, cooling and domestic hot water demands.

This reference data will be used as an input for the design of the systems developed within the project as well as for the extrapolation to various conditions, maximizing the impact of the project. Finally, the preliminary design conditions were defined for each heat pump concept. These reference design points were defined taking into account the characteristics of each concept as well as nominal conditions derived from applicable standards.



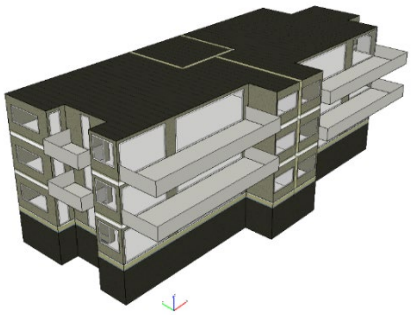
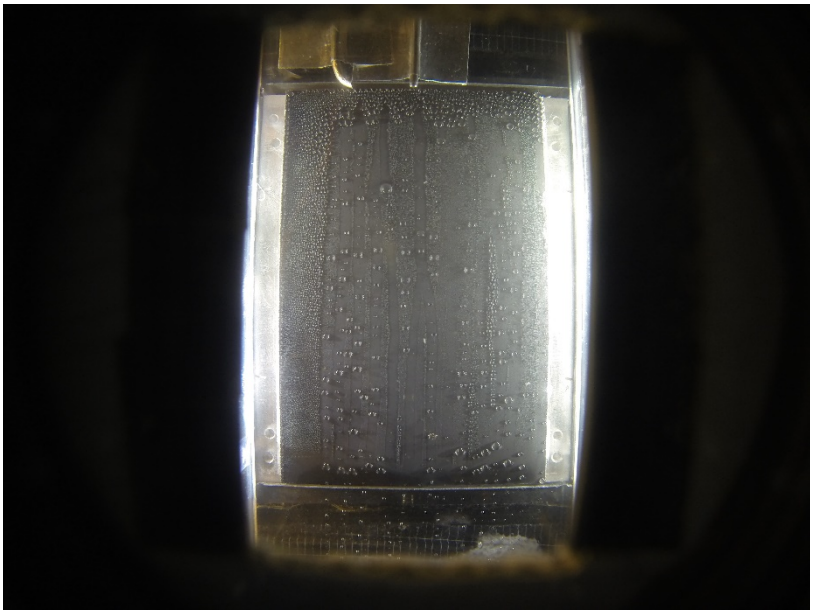


Figure 3 Reference multi-family building for Central and Northern Europe

Figure 4 Reference multi-family building for Southern Europe

Click here for more info about energy demands for multi-family buildings



Development of icephobic coatings at ILAG, Switzerland

" ILAG's role in the TRI-HP project is the development of ice-phobic surfaces that lower the freezing point of the water and reduce the attachment of the ice that may be formed."

DEVELOPMENT OF ICEPHOBIC COATINGS AT ILAG, SWITZERLAND

ILAG's role in the TRI-HP project is the development of ice-phobic surfaces that lower the freezing point of the water and reduce the attachment of the ice that may be formed. This allows to supercool water and ensures stable operation of the system.

Different new hydrophobic coatings based on several chemical strategies were developed and tested by DTI under laboratory conditions regarding adhesion, surface energy (contact angle), freeze depression under atmospheric conditions (Figure 5), pseudo Barnacle Test (PBT) and ice adhesion. Some of the coatings (see Figure 6) showed stable freezing temperatures below -6 °C.

During the coatings development, a new adhesion promotor for the coating of fluoropolymers on copper was developed. The most promising coatings with lowest stable freeze depression were sprayed on copper tubes to validate freeze depression test results when immersed in water. The laboratory test rig developed by SPF allows coated tubes testing under controlled flow conditions.

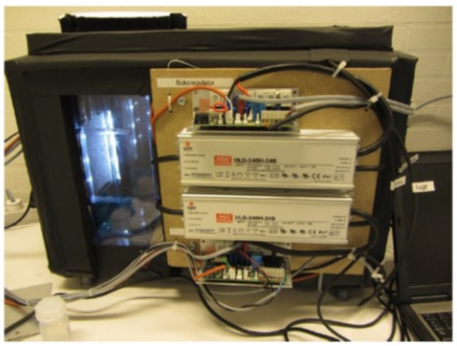


Figure 5 Test rig for characterization of icephobic coatings via freeze depression at DTI

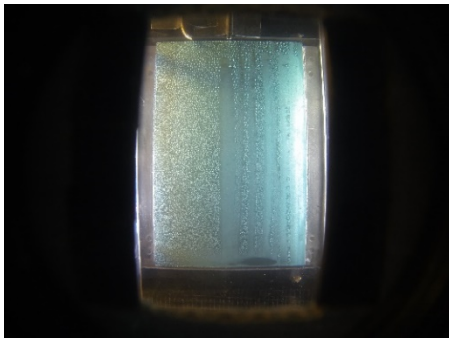
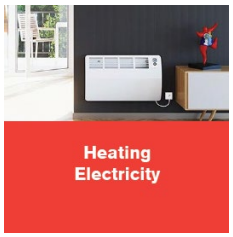
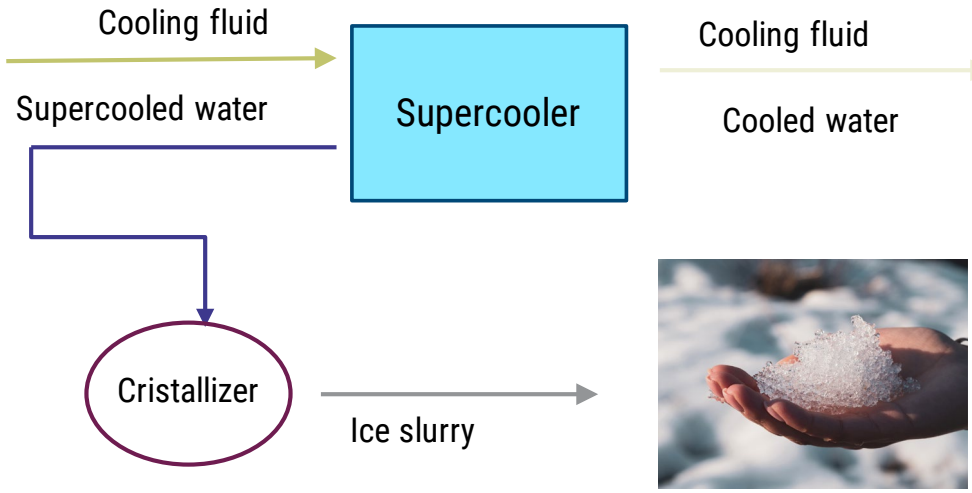


Figure 6 Dropwise condensation for ILAG's coating during freeze depression at DTI (temperature -6.5 °C)





Solutions for avoiding / retarding ice formation

" At DTI, ILAG and SPF we follow the approach of applying icephobic coatings on the supercoolers' surface, whereas UASKA looks into the fabrication of new supercooling heat exchangers from bulk materials with ice prohibiting properties."

SOLUTIONS FOR AVOIDING/RETARDING ICE FORMATION IN THE SUPERCOOLER AT DANISH TECHNOLOGICAL INSTITUTE (DTI)

THE CONCEPT

In the TRI-HP concept, supercooled water is used to generate ice slurry. For this, water flowing into a supercooler is cooled few degrees below normal freezing temperature without crystallizing; after leaving the supercooler, the water flow is disturbed in order to generate ice crystals. A key problem is to avoid ice formation and thus supercooler blocking.

Different methods were tested, including additives, external interference and modification of surface characteristics. However, there are no satisfactory solutions until now.

One of the goals of TRI-HP is to find an effective method to avoid/retard the ice blocking effect in the supercooler when using supercooled water without additives. At Danish Technological Institute, ILAG and SPF Institute for Solar Technology we follow the approach of applying icephobic coatings on the supercoolers' surface, whereas University of Applied Sciences Karlsruhe (UASKA) looks into the fabrication of new supercooling heat exchangers from bulk materials with icephobic properties.

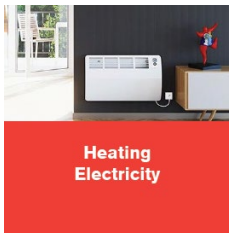
ICEPHOBIC COATINGS APPROACH

To choose a suitable coating, the freeze depression, freeze delay, ice adhesion, contact angle and stability of the coatings were assessed.

Considering the mean water freezing temperature (Figure 7) and the coatings' stability, three coatings were selected for further investigations: DTI - 3, DTI - 4 and ILAG4. These samples have a hydrophobic behaviour.

Based on the results obtained so far, we cannot make a direct connection between surface properties (e.g. contact angle, surface energy etc.) to the freezing delay or freeze depression.

Our hypothesis is that icephobic coatings may reduce the density of ice nucleation sites that is reflected in lower freezing temperature and higher freezing delay.



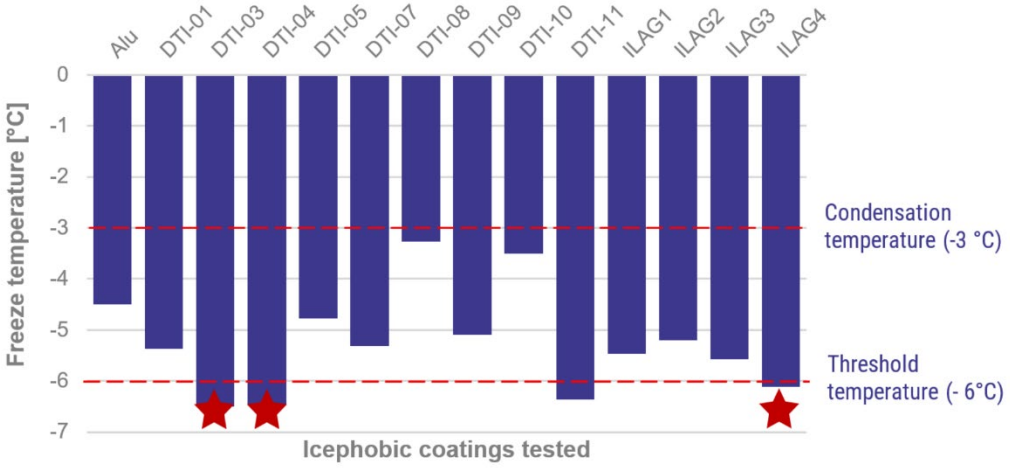


Figure 7 Mean water freezing temperature for different icephobic coatings and the reference aluminium substrate tested at DTI; coatings DTI-3, DTI-4 and ILAG4 were chosen for further testing at SPF, while DTI-11 showed durability issues

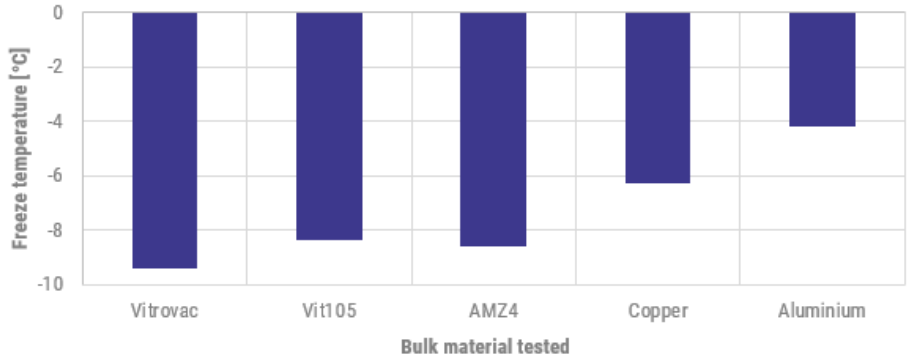


Figure 8 Mean water freezing temperature for different bulk materials tested at Karlsruhe University of Applied Sciences

BULK MATERIAL APPROACH

The phenomena of supercooled water can be found in every domestic freezer. If water is cooled down slightly below the freezing temperature, it may remain in the liquid phase. The probability increases if a smooth glass bottle is used. This is due to the amorphous structure of glass, which is the opposite of the structure of an ice crystal.

To understand the ice inhibiting properties of amorphous bulk materials (nanocrystalline), several freeze depression tests were carried out at Karlsruhe University of Applied Sciences.

The achieved mean water temperature before freezing is shown in Figure 8. Furthermore, the time holding the supercooled temperature is an indicator of the supercooling performance of the material. With the amorphous metals, like Vit105 and AMZ4, a drop of pure water can be supercooled for over two hours below -8 °C, while the droplets on the other two materials freeze well before reaching this temperature.

Solutions for avoiding / retarding ice formation

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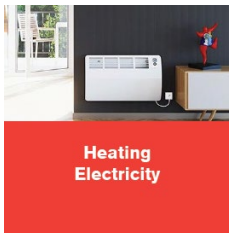


Tri-partite gas coolers at NTNU University

" The main target is to test the performance of the tri-partite gas coolers for preheating of domestic hot water (DHW), space heating (SH), and reheating of DHW."

TRI-PARTITE GAS COOLERS – PERFORMANCE EVALUATION AT NTNU UNIVERSITY

As a natural refrigerant, carbon dioxide (CO_2) has superior environmental friendliness, outstanding thermodynamic properties and excellent safety performance, such as incombustibility, nontoxicity and chemical stability. CO_2 is considered as a perfect refrigerant for heat pump water heater systems.

Because CO_2 can provide a large temperature glide, the transcritical system can benefit from multiple heating loads. In this way, the temperature profile of the water through the gas cooler most closely matches that of CO_2 and thus the temperature glide can be used advantageously.

The main target is to test the performance of the tri-partite gas coolers for preheating of domestic hot water (DHW), space heating (SH), and reheating of DHW.

The CO_2 heat pump will be tested in three different modes at SPF labs: space heating only, DHW heating only, and simultaneous space heating and DHW heating.

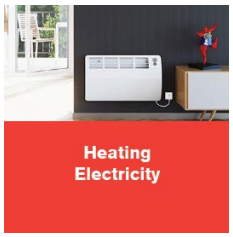
Presented results are expected to offer useful guidelines for optimal systems design and for selecting appropriate operating conditions.

CURRENT STATUS

Using the test facility located at NTNU University (in Trondheim, Norway), three individual gas coolers AXP14 were tested (see Figure 9). The selection was done together with the TRI-HP partner ALFA LAVAL.

The experimental tests for the performance evaluation of the tri-partite gas coolers have been evaluated under certain cases.

During each experiment, the setup has been run in accordance with the prescribed experimental design, and parameter values have been recorded as a set of steady data once all parameters attained steady state operating conditions.



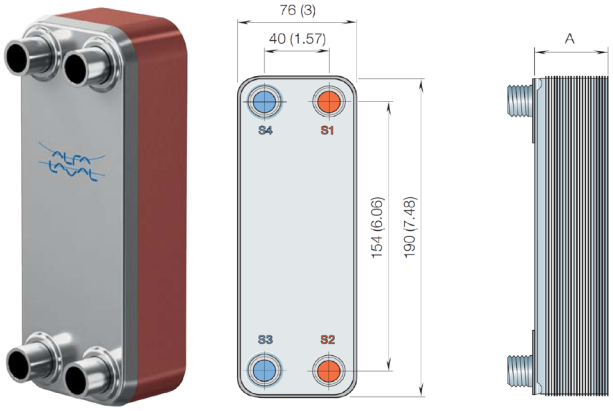


Figure 9 One out of the three heat exchanger models selected from ALFA LAVAL to be used in the tri-partite gas cooler

The final target is to test and compare the performance of 1-pass and 2-pass heat exchangers, and to design a compact and integrated gas cooler.

Social issues of novel renewable energy heating/cooling systems

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SOCIAL ISSUES OF NOVEL RENEWABLE ENERGY HEATING/COOLING SYSTEMS

As TRI-HP aims to bring to the market innovative heating/cooling systems, it was considered as high importance issue to investigate and understand the potential social impacts of TRI-HP systems and improve the stakeholders' acceptance towards them.

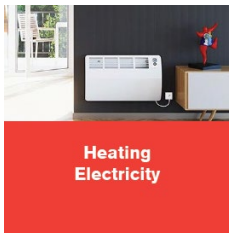
Particular emphasis was given to market acceptance in order to understand potential barriers and hindrances for the adoption of TRI-HP by market participants.

Based on a literature review focusing on empirical social science studies on the acceptance and adoption of innovative renewable heating and cooling systems (RE H/C), ISOE has identified the key social and contextual factors that could promote or impede further developing and upscaling of TRI-HP systems.

The findings show that both economic and noneconomic factors, like socio-cultural issues, local contexts and user practices play an important role for the acceptance of RE H/C systems and must be seriously considered by TRI-HP partners. In a nutshell, the main barriers that are considered to hinder the roll-out of TRI-HP systems are the following:

Lack of awareness towards heat pumps

- High installation costs & long payback periods
- Technical barriers (e.g. structure of the buildings)
- Legal restrictions (e.g. restrictions regarding historical buildings)
- Complex decision-making processes in condominiums
- High complexity of hybrid systems
- Reluctancy to adapt heating habits to a new technology



Click here for more info about social issues of novel renewable energy heating/cooling systems

TRI-HP CONSORTIUM

TRI-HP MESSAGE RELATED TO COVID-19 PANDEMIC

Keep your positive spirit up and stay healthy! At home, wherever your home is.

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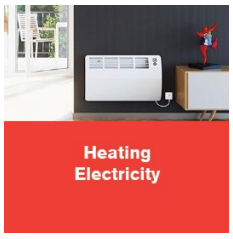

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