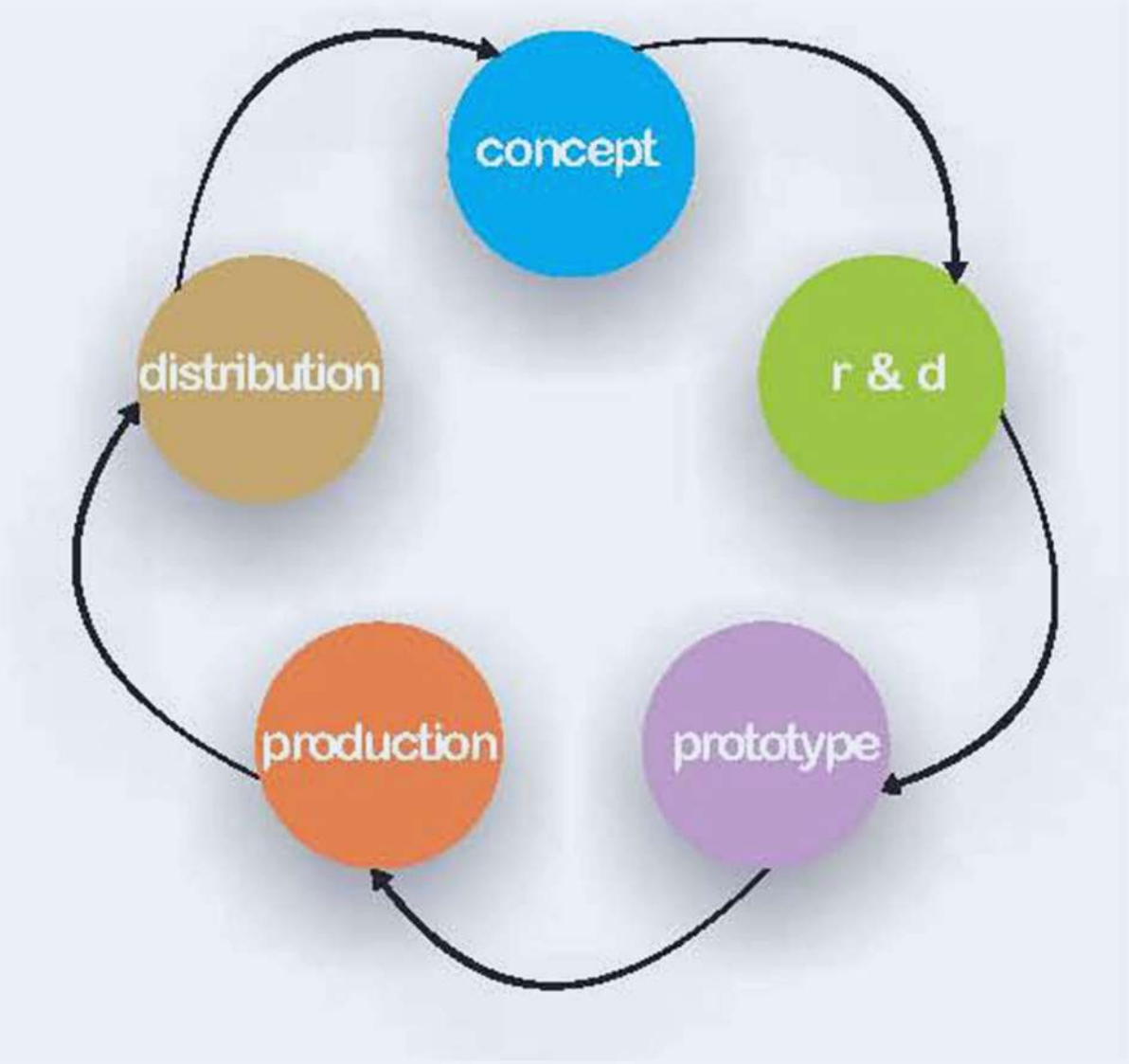
SPECIAL APPLICATIONS



PCM

PCM based Thermal Barrier Applications

Electronic systems, including data loggers, computers, and control circuits, are typically designed to function within a temperature range of approximately 45~75°C (113~167°F). When exposed to temperatures outside this range, their performance deteriorates, potentially leading to shutdowns or irreversible damage.

Phase Change Materials (PCMs), in the form of sleeves or blocks, provide an effective insulating barrier that delays heat penetration. This protective function allows electronic systems, such as data loggers, to remain operational in extreme heat environments—such as furnaces, ovens, space missions, and engine testing facilities. By maintaining a stable internal temperature, PCMs enable these systems to reliably perform critical data logging for extended periods, even in high-temperature conditions, ensuring accurate data collection for several hours.





PCM based Vaccine Logistic

The logistics of vaccines, particularly for Ebola and more recently COVID-19, have posed a significant challenge due to the need for extreme low-temperature storage, shipping, and handling. While these requirements can be managed in developed countries, the lack of low-temperature and dry ice infrastructure in many developing nations presents a major obstacle to distributing vaccines to remote locations. To address this issue, specialized solutions were developed, including -70°C (-94°F) ice packs and highly insulated containers. These innovations were crucial for ensuring the safe transport of vaccines, enabling organizations like the WHO and MSF to deliver vaccines to remote areas in Africa and overcome the logistical challenges.



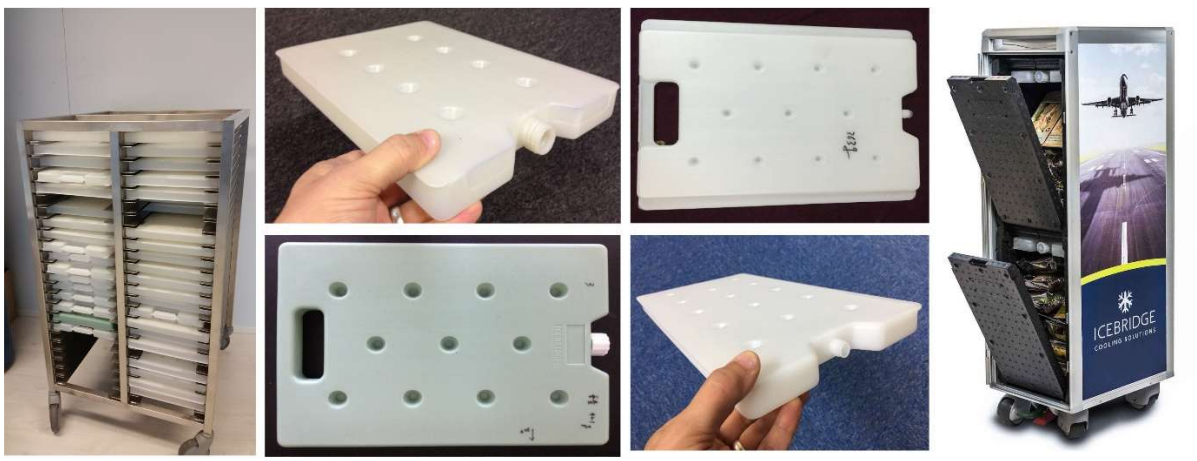
PCM based Human Comfort Applications

Phase Change Materials (PCMs) in various forms are widely used to enhance human thermal comfort in a range of applications. Whether it's in cooling vests, wheelchair cushions, or car seats, PCMs—available in powder, gel, or pure forms—help eliminate issues of body overheating and discomfort by effectively managing temperature.
In medical applications, PCMs play a crucial role in temperature regulation. For instance, they are used in external body temperature control, such as in baby incubators, to maintain a stable environment for infants. Additionally, PCMs are essential in organ transplant operations, where they help keep critical organs—like kidneys and hearts—stable during transportation from the donor to the recipient, ensuring their viability for transplantation.



PCM based Human Comfort Applications

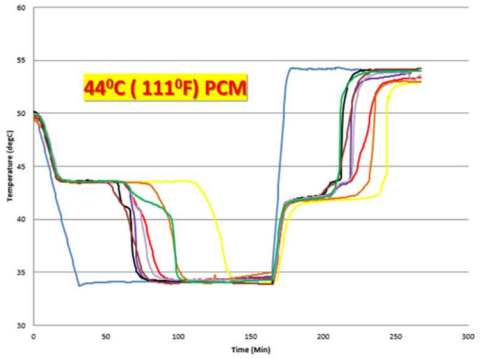
Even if we ignore the on-going cost of using Dry ice it is classified as hazardous and requires careful handling and & storage. Special ice packs are developed to replace the dry ice usage in airline trolley whereby re-using these HDPE ice packs filled with suitable PCM for many years make them very economical options for airlines.
PCM ice packs do not offer a significant operational cost savings but also having re-usable ice packs frozen either in the main cold storage areas or via dedicated quick freezers their environmental impact is far lower than total waste and very inefficiency production of dry ice.

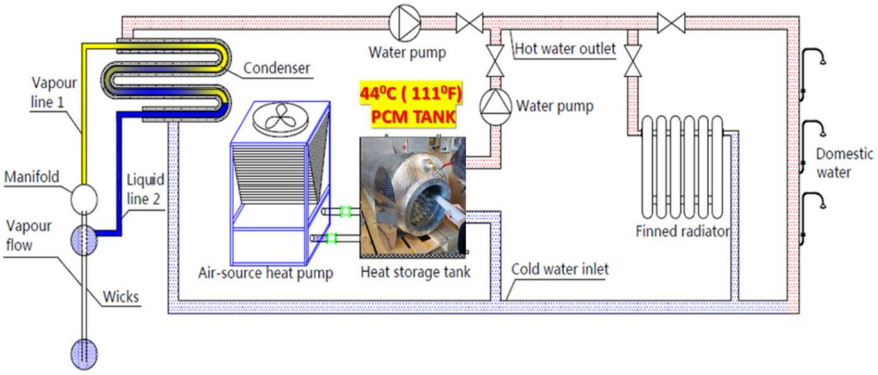


Integrate-able Solar Photovoltaic/Thermal (PV/T) System for Space Heating

A low cost, high efficiency solar thermal collection system, featuring a novel PV/micro channel thermal panel, an enhanced composite phase change material and an intelligent monitoring and control system. Key innovations include.

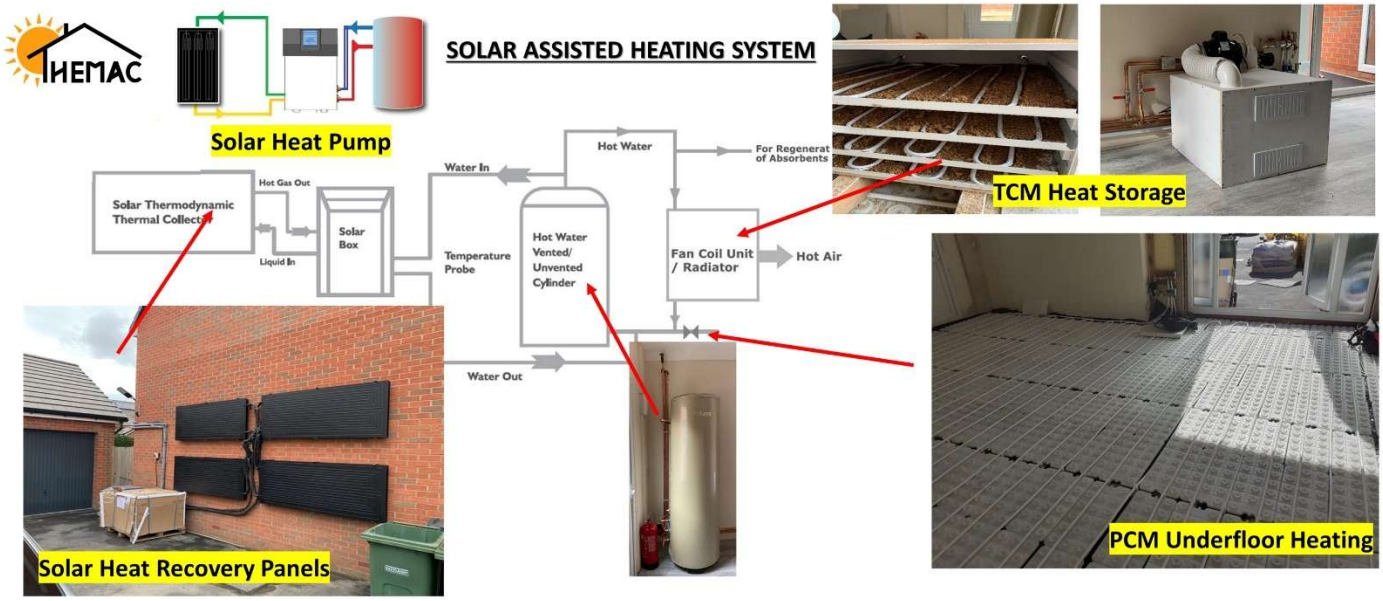
- Loop heat pipe with micro-channel evaporator and condenser, achieving a 20% higher heat transport capacity than competing systems.
- Combination of the PV module with the special micro-channel panel using thermally assisted and pressurised lamination technique.
- Combination of the paraffin/expanded-graphite composite and a heat exchanger leads to a dual-functional unit that is 40% smaller in size and 30% lower in cost compared to current heat exchangers and heat storage units.
- Internet-based intelligent monitoring & control algorithm will enable stable, automated and energy efficient operation.





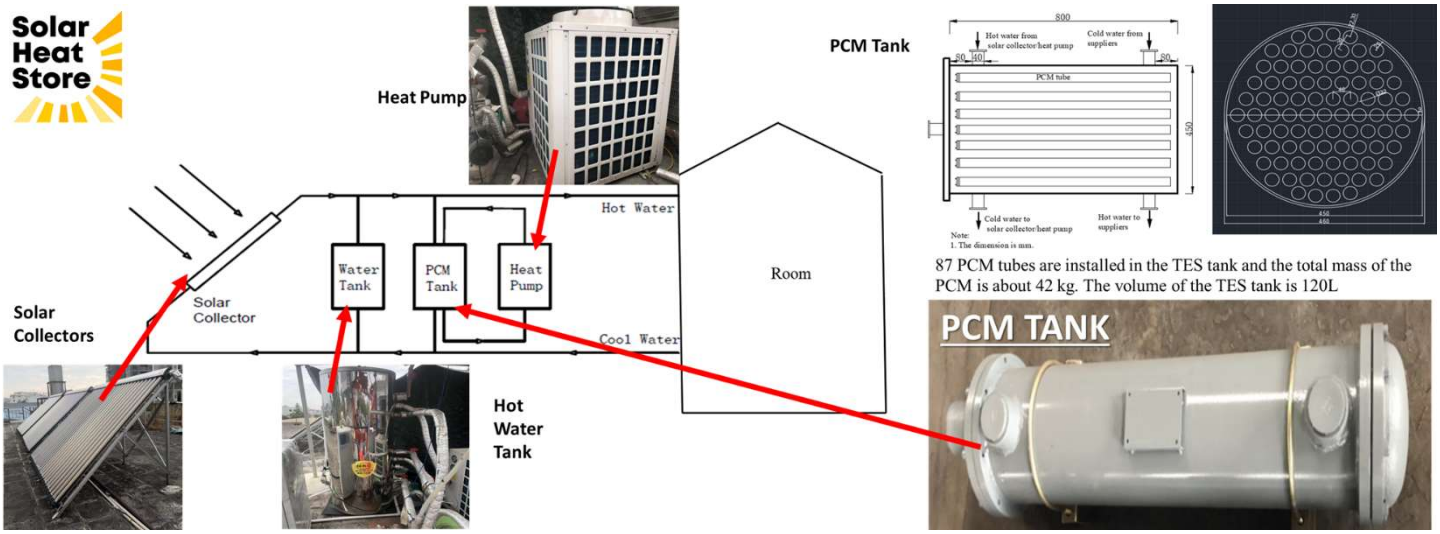
Solar driven heat pump with Thermo Chemical Material (TCM) Heat Storage

Installation is based on having a smart composite TCM materials heat storage unit charged i.e. dried via the solar driven heat pump while the sun is available and then by simply hydrating i.e. adding water into the TCM utilise the chemical reaction to generate heat for the heat recovery over-night. The system is designed to respond to varying occupancy and diurnal/seasonal fluctuations in weather conditions, minimising the energy consumption of the heat pump. PCM (phase change material) ceiling tiles are designed to store heat/coolness by the melting/freezing of the PCMs, in part driven by the difference between day and night-time temperatures and in part by the heat pump, thus providing heat in winter and cooling in summer. Heating is provided via PCM based under floor heating system. In addition, super absorbent (SA) materials handle the dehumidification demand for indoor thermal comfort, which are accommodated in a cabinet.



Solar thermal + Heat Pump based PCM based TES application

This project aims at developing a new Solar Heat Store by integrating controllable PCM and solar heat pump system whereby the Sodium Acetate based 55^{0}C (131^{0}F) PCM charged i.e. melted using solar and heat pump during off-peak / free energy periods and once the stored energy is required PCM tank triggered on demand. As the PCM sub-cools and remains liquid state at ambient conditions and therefore offers no heat losses and therefore energy can be stored for longer periods without any losses as this would be a vital requirement for any long-term storage like seasonal storage applications.

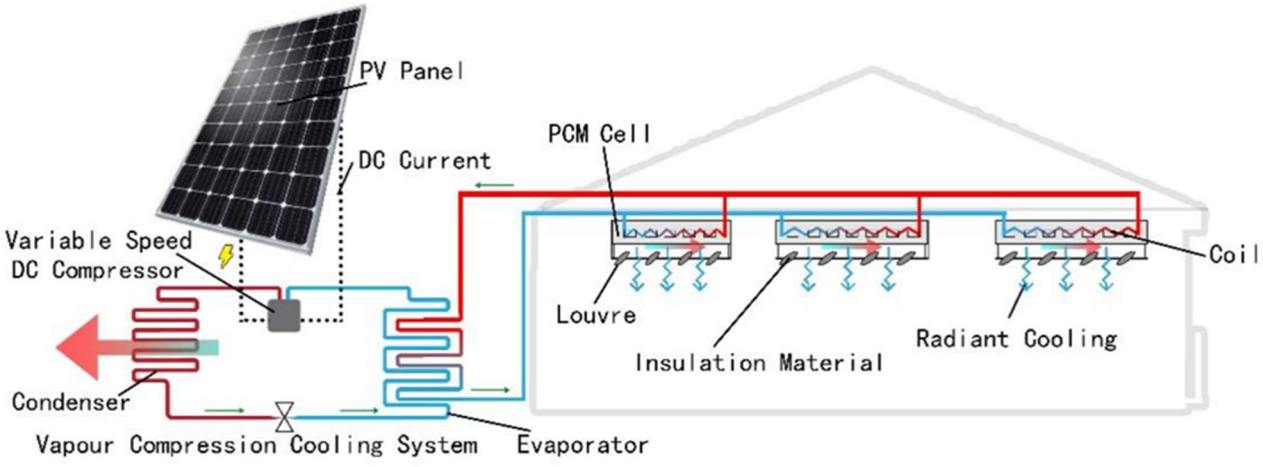


PCM COOLING STORAGE FOR BUILDING APPLICATIONS IN DEVELOPING COUNTRIES

In order to make better use of abundant solar energy resources and alleviate issues of living in high temperatures, a new concept 'PCM-Cool Store' based on the integration of PCM storage cells with a solar PV-driven vapour-compression cooling system will be investigated. The PCM-Cool Store can play an essential role in synchronising end use energy demand and supply on a short to long term basis. The PCM-Cool Store is a promising technology in addressing the "cooling on demand" energy issue in buildings in Africa.

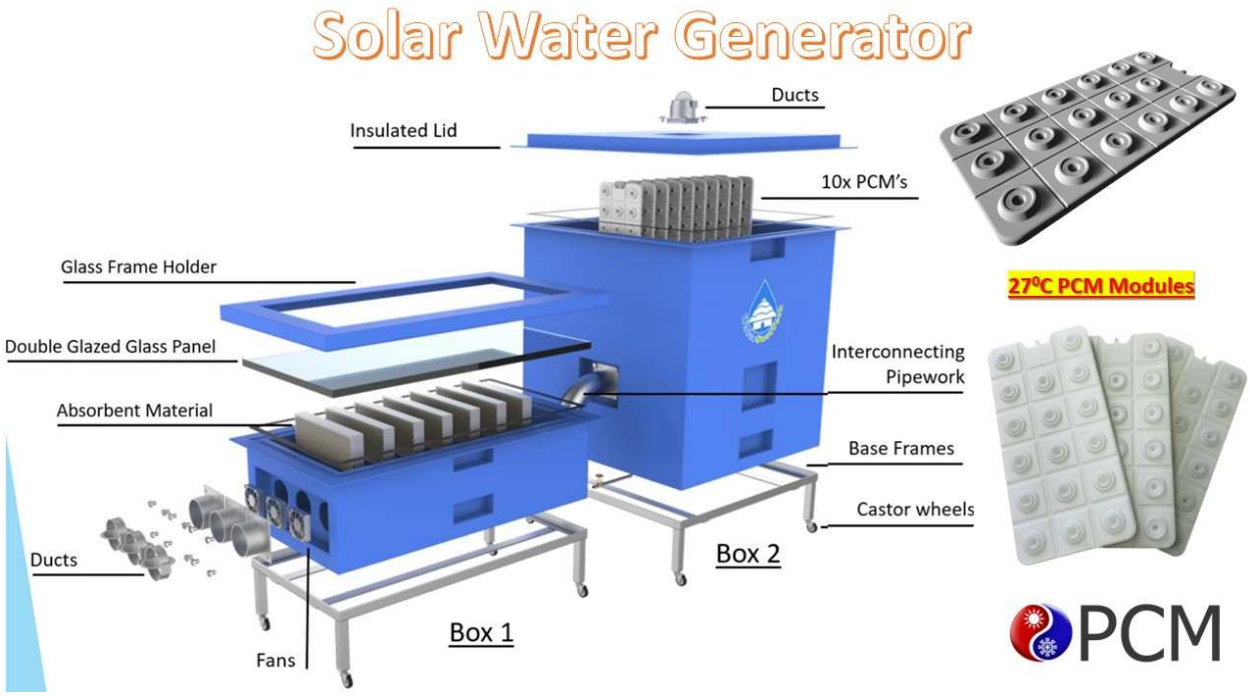
The technology developed as part of this project would be more efficient and reliable than conventional cooling technologies that use solar panels. A variable speed DC compressor will be employed which will eliminate the need for the inverter and battery storage.

The variable speed compressor differs from conventional compressors as its rotational speed can be adjusted to meet the demand and thus maximise efficiency of the PCM Cool Store system. The variable speed of the compressor will be achieved using an electronic controller driven by the solar PV panels. The controller constantly monitors the temperature variations of the system and automatically adjusts the compressor compression rate, making the system operation much more efficient. When the temperatures of the PCM cells reach the desired levels, the compression rate of the compressor is reduced. Yet when the internal temperatures of the PCM cells are high, the compression rate increases to reduce these temperatures as quickly as possible. Cooling energy will be stored in PCM cells and would be released as the building interior temperature exceeds the design temperature, greatly improving liveability in hot climates such as Africa.



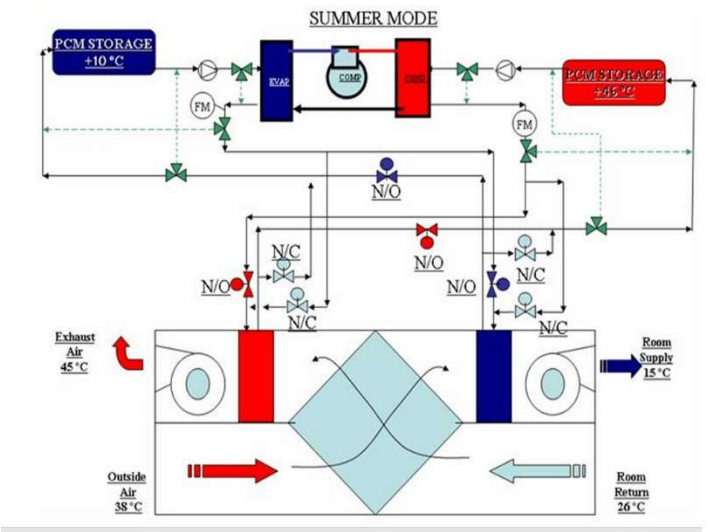
PCM based Solar Water Generator

Water shortage in developing countries is a major concern and in order to generate water from air by simply using solar energy a PCM based unit is developed whereby the PCM containers filled with 27^{0}C (81^{0}F) solution charged by cooler night ambient and during day-time incoming air is raised by solar gains and take the air below the dew point provided by the cold surfaces of the PCM plates. All kit is driven by only solar via heat and PV power as a self-standing water generator.



Hestor –Thermal Storage Application for HVAC solutions based on PCM.

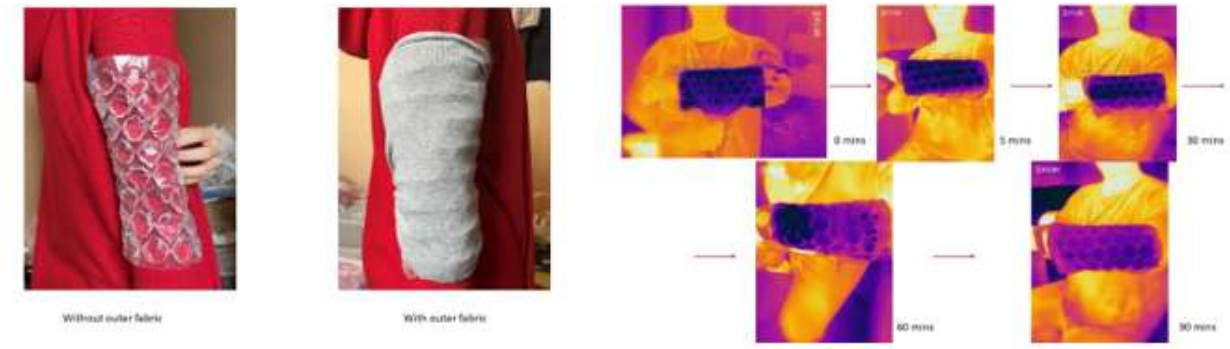
One of the major obstacles for wide scale use of air source heat pumps in cold climates can be described as the frequent defrost requirement. A custom-made heat pump is developed having hot and cold PCM based TES tank acting as the same way as ground source.
Unit installed in Lithuania and during winter tests this design worked on a daily basis without the need for defrost cycle. Using a simple air handling unit heat is extracted from 10^{0}C (50^{0}F) PCM tank and any surplus heat generated by the heat pump placed in warm PCM tank filled with +46^{0}C (115^{0}F) containers. A carefully balance warm and cold storage enables the heat pump to operate without the need for defrost in cold ambient.



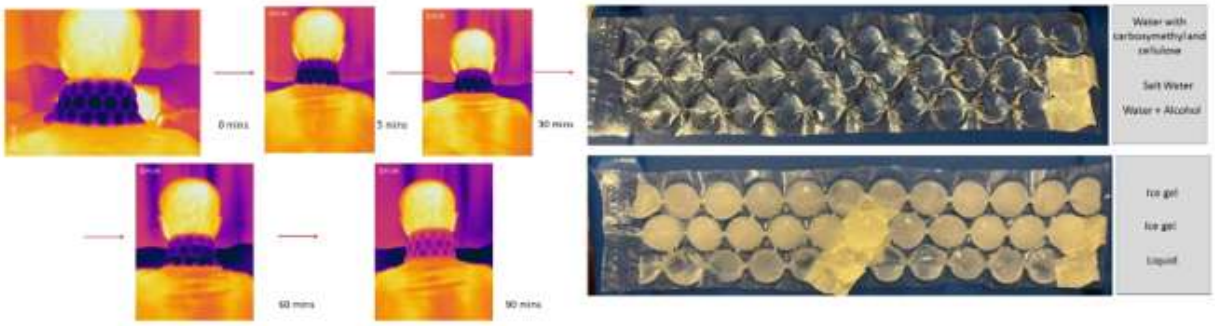


Cold Packs to Minimize Heat Stress for Wearing Personal Protective Equipment in a Health Care Environment

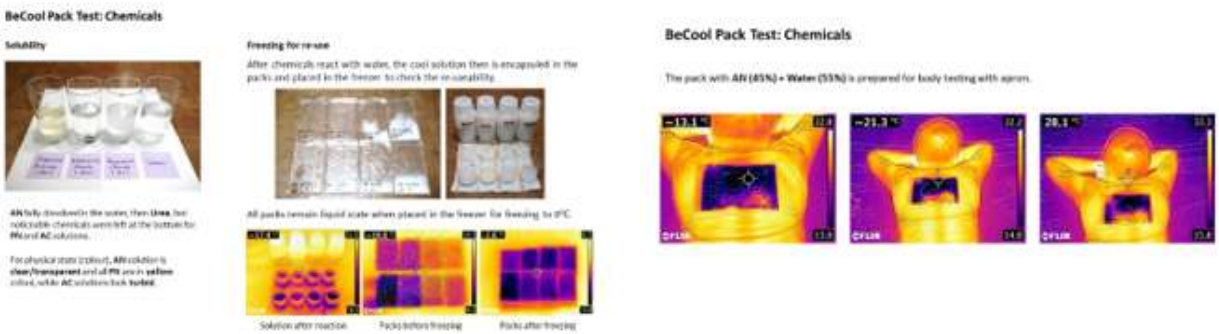
During COVID-19 crisis an innovative PCM cooling packs are designed, addressing one of direct consequences of the concerning heat stress/thermal discomfort associated with prolonged wearing personal protective equipment (PPE) for medical professionals, patients and the general public for this and future pandemics.

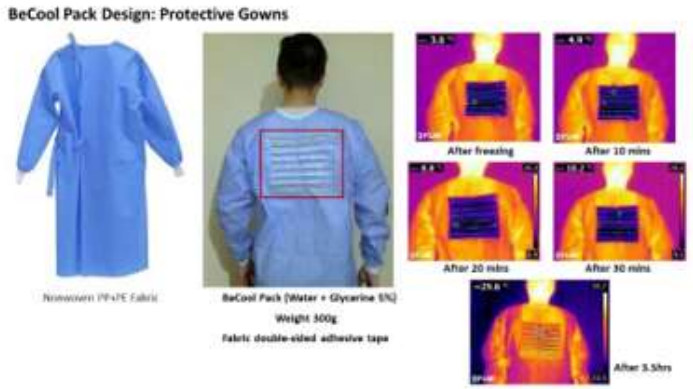


ARM COOLING



NECK COOLING



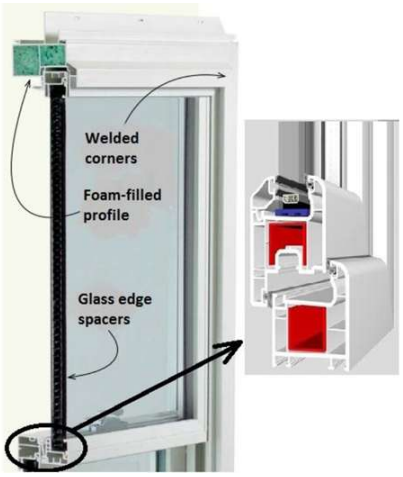


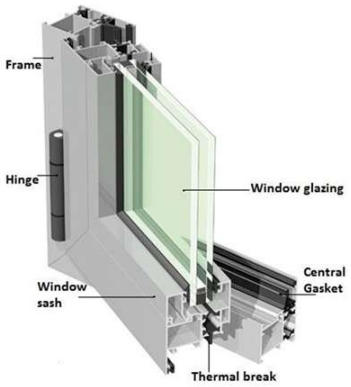
BODY COOLING

PCM embedded PVC window frames for energy efficient buildings

The heat loss per area through windows (U-value) is still much greater (around 1.0 W/m2K) than through the building's walls and roofs. Reduction of window heat loss is essential to reduce the energy use of buildings. To this end an insulating foam material made of polystyrene (PS) and polyethylene (PE) filled with a Phase Change Material (PCM) concept is developed. It is vital to follow the process in-line with the PVC profiles manufacturing techniques and therefore both mixing the PCM as part of the extrusion process and adding PCM once the profile is formed options are developed and by adding PCM as part of the window frame fabric significantly reduced the heat losses.

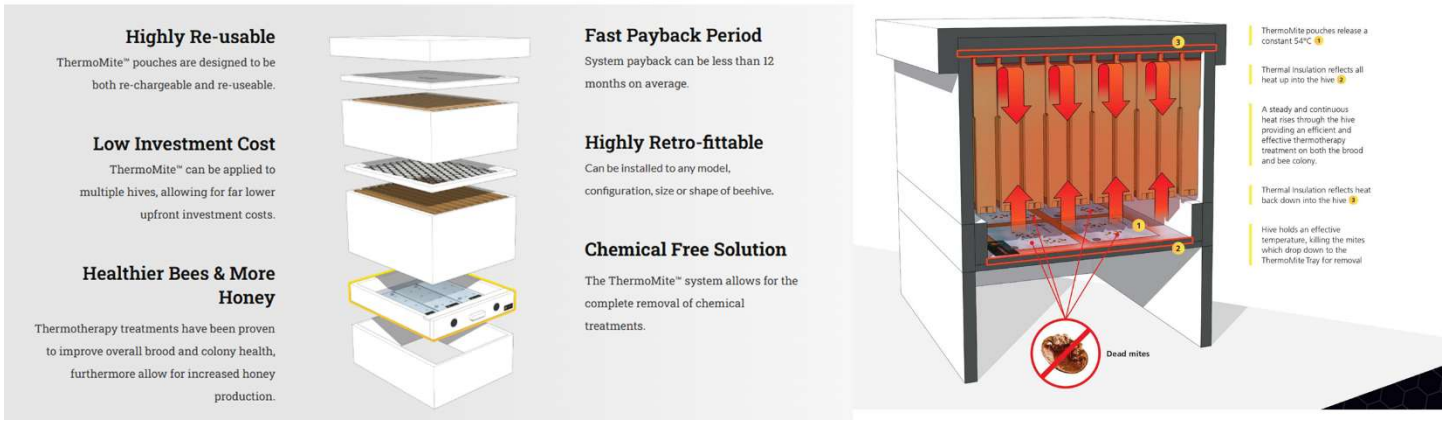






Beehive protection using PCM warmer.

The precise temperature regulation within a beehive presents a valuable opportunity for Thermotherapy. By raising the internal hive temperature slightly above 38°C (100^0F) for a minimum of 2 hours, the reproductive capability of Varroa mites is disrupted, leading to their thermal stress. When the temperature is increased slightly higher, just above 40°C (104^0F), the mites immediately begin to perish and fall from the brood and bees.
A simple pouch filled with 58^0C (136^0F) PCM solution identical to hand warmers offers a stress-free solution for both beekeepers and bees. During the thermal treatment, the proteins in young mites undergo immediate and irreversible changes, causing them to suffer irreversible damage. Unlike chemical treatments, Varroa mites are unable to develop resistance to heat treatments. Moreover, the bee colony, wax, and honey remain unaffected, as thermotherapy does not leave behind any residual chemicals. It completely eliminates the need for acids and other chemical agents, making it a safe and environmentally friendly alternative.



Creating eco-efficient and competitive furnaces using PCM based heat recovery.

The main goal of VULKANO project funded by European Union is the retrofitting of two types of industrial furnaces, namely preheating and melting, applied on three energy–intensive sectors (steel, ceramic and aluminium) with a huge number of potential users in Europe. Thus, this project aimed to design, implement and validate an advanced retrofitting integrated solution to increase the energy and environmental efficiency in existing industrial furnaces fed with NG; through the combined implementation of new solutions based on high temperature phase change materials, new refractories, optimised co-firing of NG and syngas from biomass or process gas, an advanced monitoring and control system and a holistic in-house predictive tool. The trial sites indicated achievement of 20% increase in the energy efficiency of furnaces.



Data storage safe protection using passive cooing by PCM.

While a metal safe may offer protection against direct fire damage, data storage modules are highly sensitive to temperature fluctuations. Overheating within the safe can easily damage these modules, rendering them unusable. PCM (Phase Change Material) ice packs, with temperatures higher than room temperature, remain permanently frozen (or charged) under normal conditions. In the event of a fire, the stored energy in these ice packs can help maintain the internal temperature of the safe below the critical threshold for data storage units, protecting the data for a specified period of time.

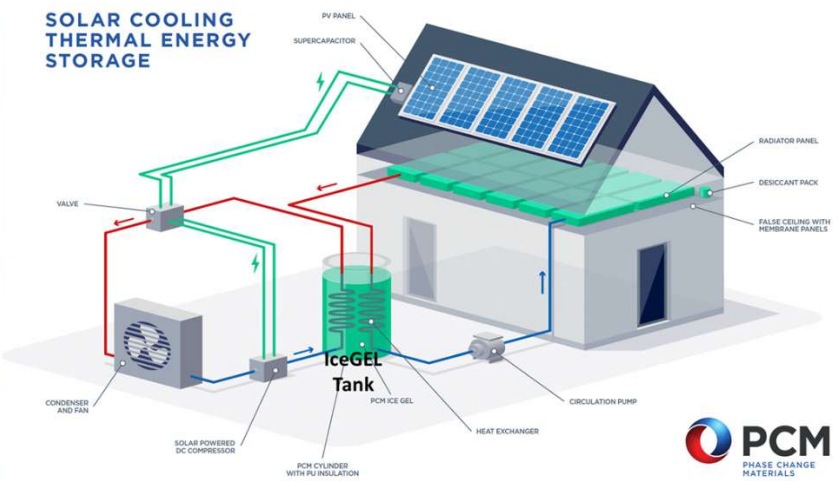


Solar driven cooling system with soft ice PCM energy storage

The overreliance on conventional cooling technologies has not only led to increased energy consumption but also to heightened greenhouse gas emissions. Consequently, there is an imperative to adopt alternative cooling methods that can efficiently utilize renewable energy sources, such as solar power, and incorporate materials like phase change materials (PCM) for energy storage and management. This innovative system is based on charging a soft ice gel tank during daytime and use this stored cool energy to carry out cooling after or no sun / over-night periods for providing a non-stop continuous cooling capability. Simple water gel tank is far more economical as well as environmentally friendly option than batteries.







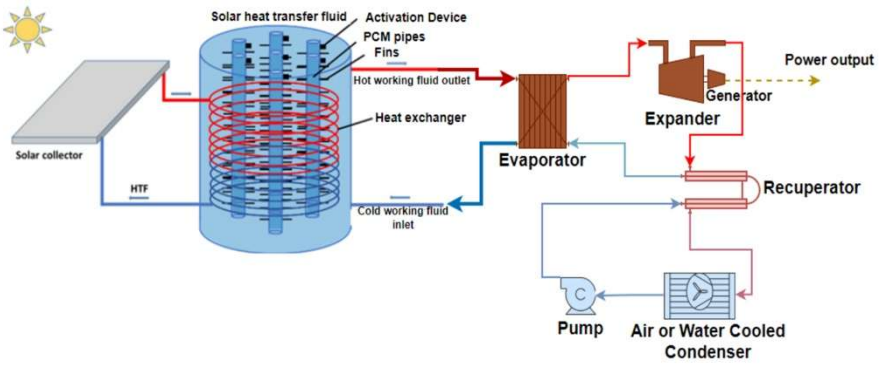
Solar ORC power generation using PCM-TES

This system integrates an innovative ORC and supercooled Phase Change Material (PCM) storage to allow operation during periods of low solar intensity or at night. Under daily solar irradiance, a solar collector energizes the supercooled PCM tank, inducing phase change to liquid, thus storing thermal energy. This stored energy is later utilised by initiating PCM crystallisation, which discharges heat to energize the ORC mechanism, optimising the system's thermal efficiency and responsiveness.

In the designed system, when energy is required, the system initiates the crystallisation of the PCM, releasing heat to power the ORC cycle. The heated fluid expands in a modified scroll compressor, generating electricity. The cooled fluid is pumped back into the PCM tank to absorb heat and continue the cycle, creating an efficient loop for power generation. The tank with PCM pipes can contain a small amount of heat transfer fluid such as water or oil. The system can be used to generate either electricity using an air-cooled condenser or electricity and hot water using a water-cooled condenser. The hot water can be used for washing, cooking, and laundry.

This PCM-based system harnesses the latent heat of materials, maintaining them in a liquid state below freezing to create a supercooling effect. Tailored for a wide operational temperature range and rapid crystallisation, it efficiently releases energy for the ORC system. This system proposes an economical, zero-emission solar ORC solution by replacing costly ORC expanders with modified, cost-effective low-cost vehicle AC scroll compressors.





Hot food delivery using PCM board.

Boards loaded with PCM (Phase Change Material) charged to +82°C (180°F) using a simple electric oven and placed in insulated boxes can help maintain hot food products above critical delivery temperatures for the desired duration. In addition to conventional hot meals for takeout, these plates are especially effective for pizza deliveries. They prevent moisture from accumulating within the cardboard box, ensuring that the pizza remains crisp until it reaches the delivery point.







Under Floor Heating (UFH) graphite based PCM enhancement

PCM embedded graphite into powder can be produced in 25~30 micron / 350~500 mesh size extremely fine powder having a density of as low as 0.001 kg/m3 which enables us to load 85~90% loading oof Bio based organic or hydrated salt-based Phase Change Materials (PCMs). The degree of imprecation, ranging as high as 90% of PCM, plays a pivotal role, as it determines the PCM energy storage capacity of the PCM embedded expanded graphite. The high loading of PCM powder not only optimizes its energy density but also creates a practical and versatile format for energy storage applications.

The ability to varying the loading levels allows for fine-tuning the composite's PCM absorption capacity to suit specific requirements. Whether for building insulation, industrial processes, or renewable energy integration, this innovative approach provides a customizable solution that can be adapted to diverse applications. In essence, PCM addition opens new avenues for efficient and scalable thermal energy storage, with the potential to significantly improve energy management, reduce environmental impact, and advance sustainability goals.






Defrost free heat pump design using PCM as the heat source.

Heat pumps typically extract heat from the air, ground, or water sources. Since most heat pumps are air-source, when the ambient temperature drops below 30°C (86°F), they enter a defrost cycle. This cycle not only wastes significant energy but also disrupts the heating supply. Using a PCM (Phase Change Material) reservoir to store and extract heat offers a solution to eliminate the need for the defrost cycle. By incorporating a PCM tank as part of the heat pump system, heat can be efficiently stored and released without interruptions to the heating process.



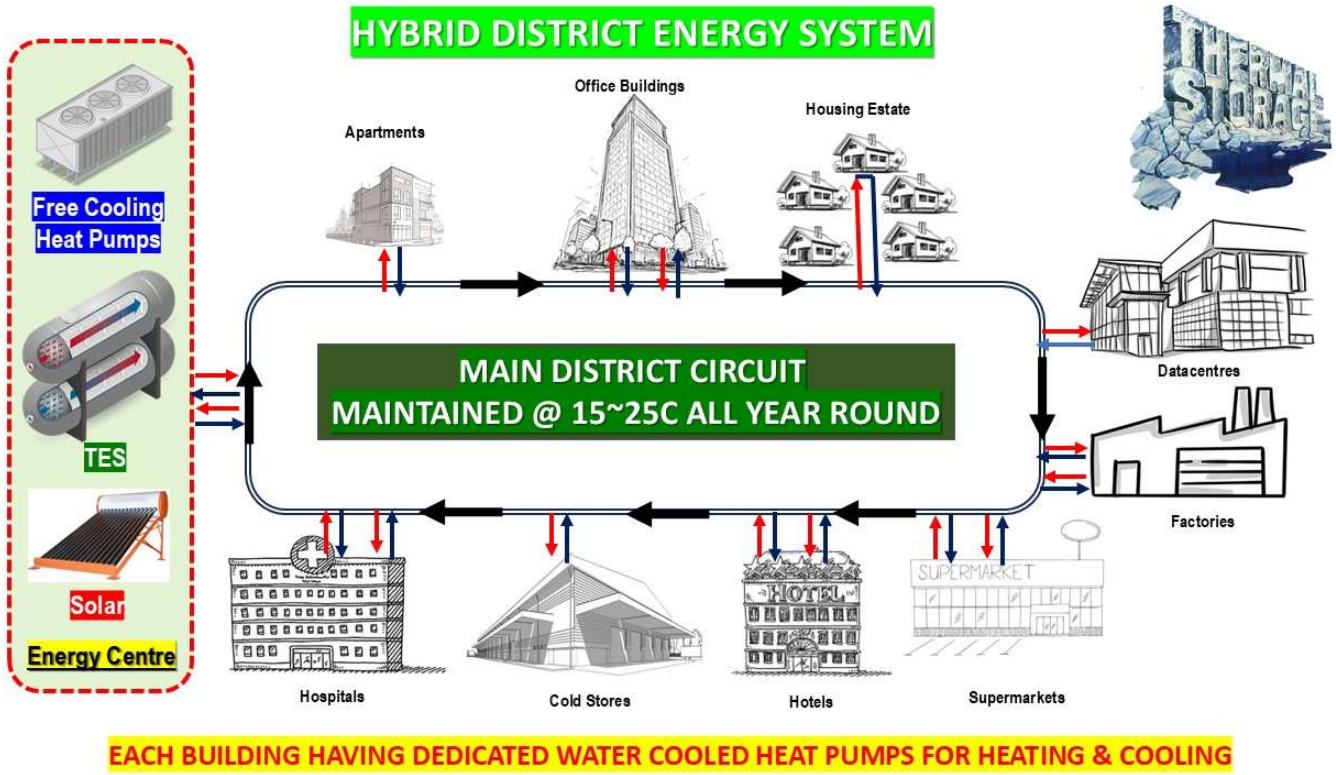


Run Around District Energy Concept (RADEC).

When it comes to district energy, it is crucial to balance heating and cooling loads in order to minimise overall energy consumption. The goal is to maximise the use of renewable energy sources, such as daytime solar energy and the natural cooling provided by the night.

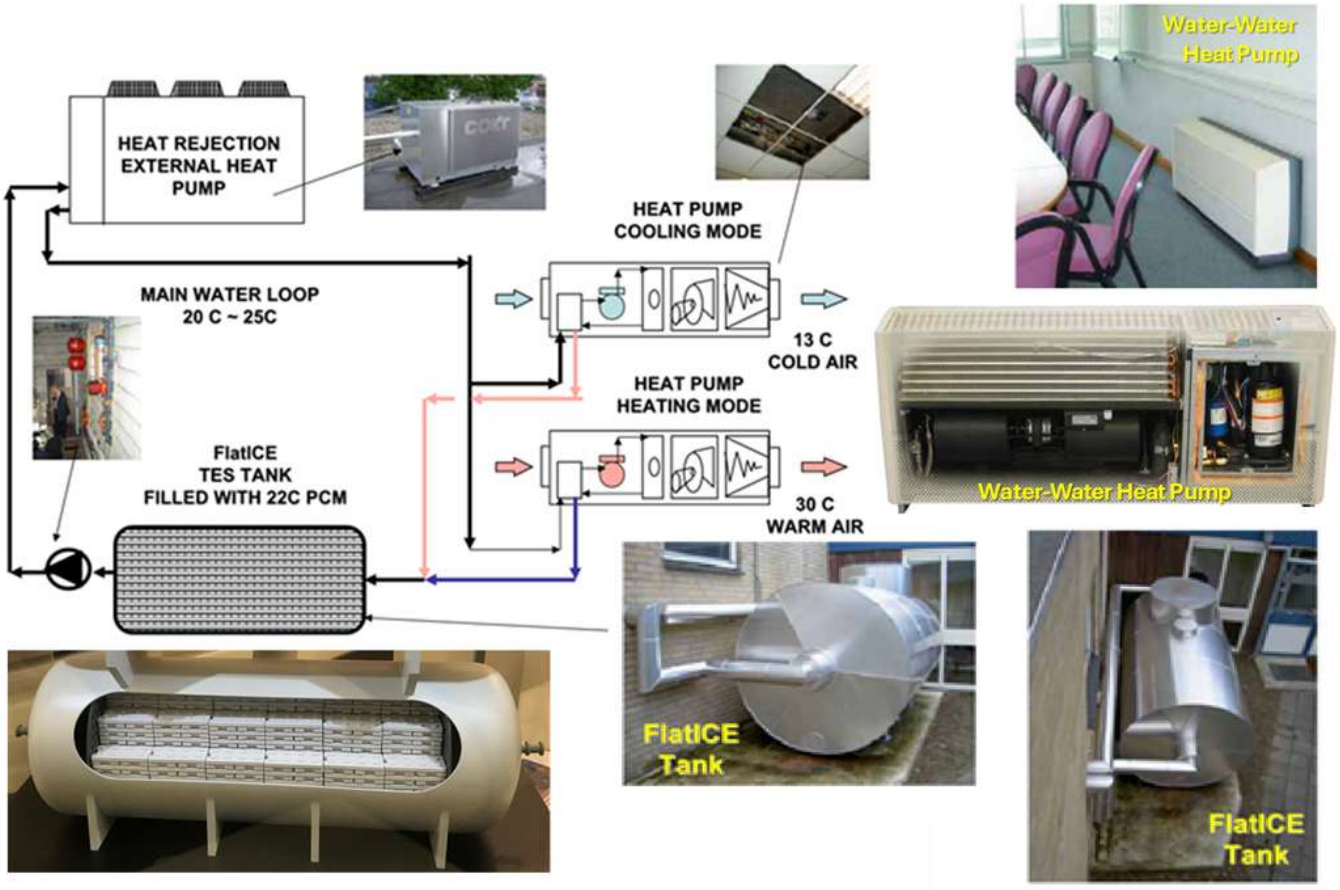
A well-balanced Run Around District Energy Concept (RADEC) could provide an optimal solution for the electrification of heating via heat pumps, a direction increasingly advocated by governments worldwide. Certain buildings—such as data centres, cold storage facilities, supermarkets, and specific industrial processes—require cooling year-round and generate waste heat as a by-product. Instead of discarding this excess heat, it can be harnessed to power heat pumps for domestic, commercial, and industrial heating. By carefully balancing the main distribution network, it may be possible to maintain the system's temperature (typically between 15–20°C or 59–68°F) without relying on external heating or cooling sources.

A typical example of this concept is as follows.



- As the main distribution pipework is kept at 15~20^{0}C (59~68^{0}F) there would be no insulation requirement as this temperature range would be closer to the ground temperature and therefore installation cost (CAPEX) can be reduced significantly.
- As bulk of the energy machinery for both heating and cooling supplied by the building owners the cost of installing a district energy network for the main investors would be minimal and therefore offers the best return on their investment due to lowest possible CAPEX as well as lowest OPEX.
- By operating water network with a large ΔT this would reduce the pump sizes and therefore considerable reduction in pump energy consumption.
- Utilising Solar as the heat source and cool / evaporative cooling units for the heat rejection would increase the overall system efficiency and offer minimum energy consumption in comparison with any conventional district heating system and therefore it offers a significant operational cost savings (OPEX).
- Not only operating costs would be reduced but also not having large mechanical cooling / heating machinery the over all maintenance cost of the district energy circuit would be far lower than conventional district energy systems.
- PCM based TES would offer to store the cooler night ambient energy in 20^{0}C (68^{0}F) PCM tanks using free energy and equally day-time solar energy in winter can be used to charge the same tanks and this way all year round excess cold and warm energy can be handled using free energy sources.
- The combination of maximum free solar and cool energy as well as reduced overall energy consumption of the network RADEC offers the lowest environmental impact for any district energy systems.

Small scale of this idea has already been commercially applied and supplied by companies like Versatemp and Colt and typical demonstration installation example is as follows.



These commercial systems designed to handle commercial buildings and rely on the orientation of the building to balance the network. South facing side of the building may require cooling but North side of the building may require heating and this would offer to balance the system so one side of the waste energy can be utilised as the energy source for opposite side and therefore the system's overall