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# Sunamp High Density PCM Distributed Heat Storage based District Heating & Cooling Scheme

## – A Generic concept

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## 1. Introduction

This document describes the generic concept of a district heating scheme with distributed high capacity heat stores and supplementary heat source (if required) at main heat load nodes. The overall objective is to significantly reduce the energy use and carbon emissions and project delivery time by implementing an intelligent site wide district heating network served by a central plant consisting of for example, gas fired CHP systems, traditional gas boilers and heat pumps.

This document describes the key benefits of incorporating the Sunamp PCM distributed heat storage in district heating schemes to achieve the following main objectives of the planned scheme and also to speed up the delivery of the project using modular implementation: -

a) Reduce the peak demands both from the plant and the distribution network by interposing stores between the plant and the distribution network and also between the network and the heat load nodes (e.g. Apartment block, street of houses).
b) Optimise balancing of both heat and electricity networks at both the central plant and individual heat customers e.g. commercial buildings.
c) Optimise integration of different heat sources operating at different temperatures by using PCM with appropriate melting point in heat stores.
d) Use heat stores in the building for local heat recovery from processes etc.
e) Speed up implementation using portable temporary heating plants at the main heating load nodes.

## 2. Sunamp high energy density heat stores

Sunamp heat stores consist of heat batteries which contain inorganic, non-toxic, salt-based Phase Change Materials (PCM), which absorb and release heat during the process of melting and freezing. When the PCM freezes, it releases large amount of latent heat energy at selected constant temperature. The innovation comes from using our own special formulation of PCM developed in collaboration with the University of Edinburgh School of Chemistry resulting in combination of low cost materials which have exceptional long life, recyclability, safety and high density.

The nominal storage capacity of the heat store module is about 2MWh and its overall dimensions (L x W x H) are 6.058m x 2.438m x 1.3m i.e. half height ISO 20' container. The number of storage modules required will depend upon the design storage capacity. The budget cost is estimated at £40,000 per MWh of storage capacity. The Sunamp PCM heat storage technology offer the following key advantages compared to the traditional hot water thermal stores:

### 2.1. Compactness

Therefore, the space required for installation will reduce by a factor of up to 3. This is important because large district heating hot water stores have impact on landscape e.g. visual, shadows etc.

### 2.2. Lower water content

In the PCM heat store, bulk of the heat is stored in the PCM and this heat is transferred to the heating system by means of heat exchangers embedded in the PCM store, therefore the addition of storage to the heating system does not significantly increase the water content of the system. For example, a 1 MWh hot water store will increase the water content of the system by about 20,000 litres compared to 350 litres for the Sunamp heat store of similar capacity. Therefore, installation cost will be lower because size of the expansion vessels/system and the quantity of water treatment required will be smaller.

## 2.3. High storage efficiency

The storage efficiency is function of stratification inside the heat store. For large district heating hot water stores, this is difficult to achieve without using either very tall stores, or multiple stores and/or complex and expensive internal baffles and partitions. The stratification inside the Sunamp heat store is achieved by using PCM with deferent melting temperatures and the design of heat exchanger hydraulics (depending upon the application). In addition to this, the Sunamp heat stores have very low heat losses in standby mode.

## 2.4. Modular design

Therefore, easy to configure to suit the requirements of the plant and the building for efficient operation and integration of multiple heat source.

# 3. Distributed heat storage district heating (DH) scheme

In conventional district heating scheme, shown schematically in figure 1, one or more central hot water thermal stores used to decouple the heating plant from the continuously changing heat demands from the heat customers. The central store is sized for short term storage; typically, 1 – 2 days average heat demand. The type of heating plant also influences the installed storage capacity; for example, to maximise the utilisation of MCHP plant.

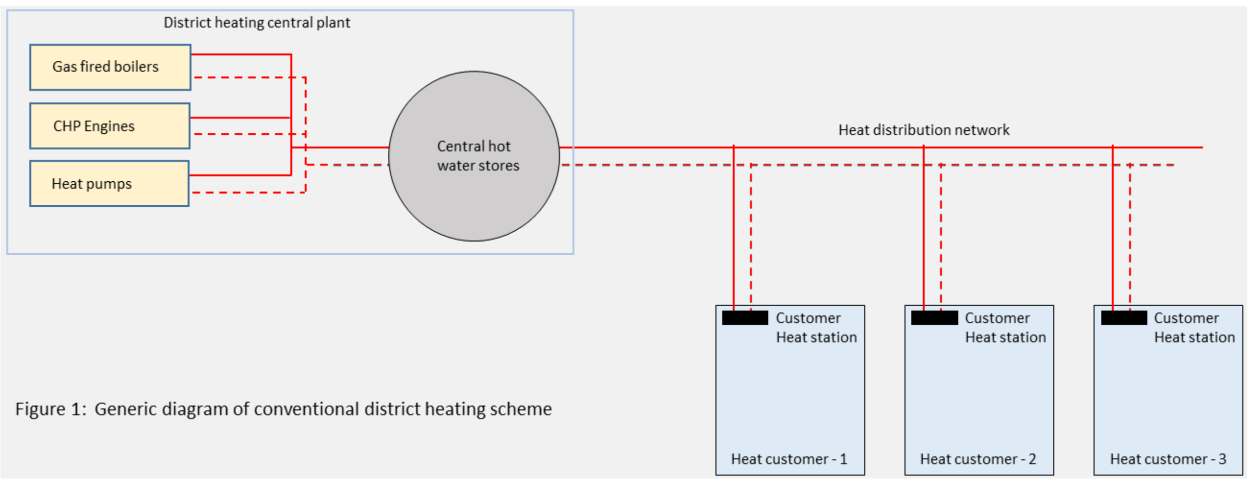



Figure 1: Generic diagram of conventional district heating scheme

The Sunamp propose to use intelligent distributed heat storage district heating scheme as shown schematically in figure 2. There is a communication link between the central heat store controller, heat store controllers in the buildings and the plant to efficiently and dynamically mange the operation of the DH system. The Energy-hub study (Seventh framework programme Grant Agreement No: NMP2-SL-2010-260165 Call identifier: FP7-2010-NMP-ENVENERGY-ICT-EEB) has shown that this arrangement increases the operational flexibility and higher profits in running the CHP scheme compared with central buffer store.

The district cooling is generally costlier and less efficient than district heating because district cooling circuit will have lower temperature difference (About 10ºC) resulting in larger diameter pipes and hence more losses. Therefore, the Sunamp proposal is to generate cooling at building level if required and integrate the cooling plant with heat store in that building as discussed below.

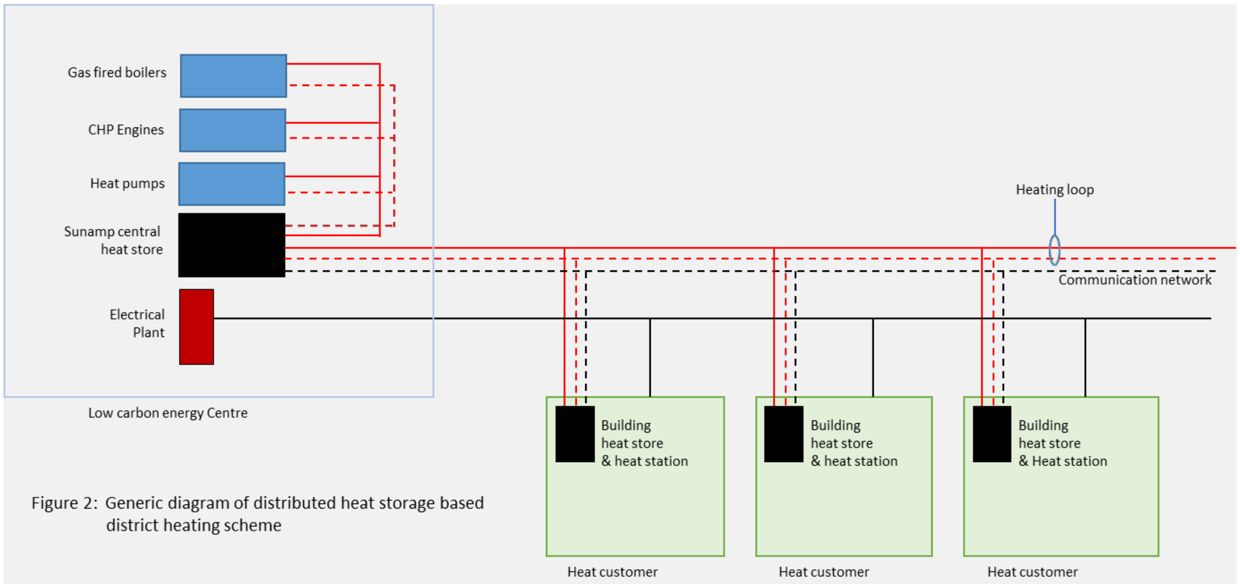



Figure 2: Generic diagram of distributed heat storage based district heating scheme

## 3.1. Sunamp central heat store

The capacity and configuration of the central heat store (figure 2) will depend upon the heating plant design, but would be significantly lower (4 – 10MWh) than the traditional DH scheme. Its main purpose would be to integrate the heating sources and accumulate waste heat recovered from the central heating plant and equipment. In the generic configuration shown in figure 3, the low and high waste heat (e.g. exhaust, flues) recovered from the central plant is accumulated in the heat store and heat pump is used to upgrade the low-grade heat to high grade heat.

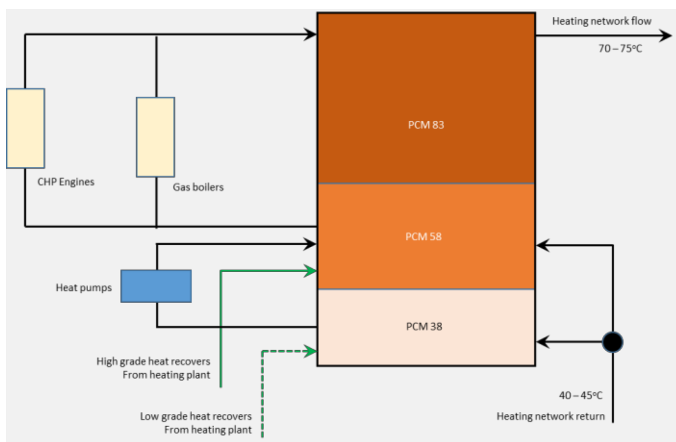



Figure 3: Generic configuration of Central District Heating Store

## 3.2. Sunamp building heat stores

The capacity and the configuration of the building level heat store will depend upon the utilisation and heating and hot water loads in that building. Typical example configurations are discussed below.

### 3.2.1. Residential building

The generic configuration example of a heat storage system for a residential building is shown in figure 4. The building heat distribution circuit is designed for 50-55°C flow temperature and 25 – 40°C return temperature and a Heat Transfer Station (HTS) is interposed between the building heat network and the apartment heating and hot water system.

The hot water is heated instantaneously by means of plate heat exchanger in the HTS and therefore no domestic hot water is stored either in the building or the apartment. The heating circuit in the apartment is designed for 50°C flow and 40°C return.

***Note:** If the building has PV or solar thermal panels, then the output from these can also be stored in the building heat store. The excess output can be directed to the heat station; PV output via electricity network and thermal output from solar thermal via return pipe of the heat distribution network.*

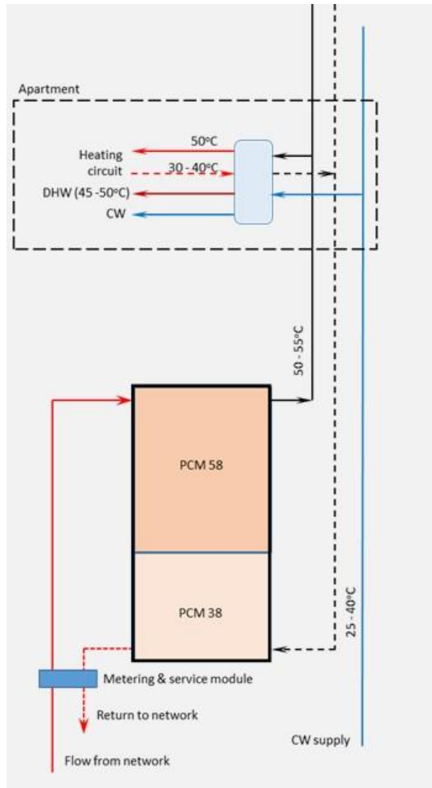



Figure 4
Generic configuration of Residential Building Heat Store

### 3.2.2. Commercial buildings

The generic configuration examples of a building heat store in commercial buildings are shown in figures 5 and 6. In figure 4, the waste heat from the cooling plant is recovered and accumulated in the heat store for use in the building. The waste heat from other processes in the building (e.g. data centre) can also be recovered and accumulated in the building heat store (figure 6).

***Notes:***

*a) If the building has PV or solar thermal panels, then the output from these can also be stored in the building heat store.*

*b) If the there is no spare storage capacity for waste heat recovered or from solar systems, then the excess can be directed to the heat station; PV output via electricity network and thermal output from solar thermal via return pipe of the heat distribution network.*

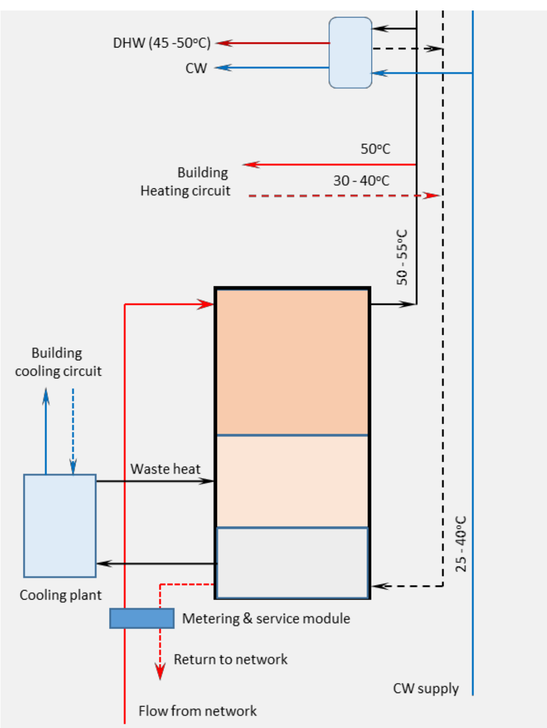



Figure 5
Generic configuration of Commercial Building Heat Store - 1

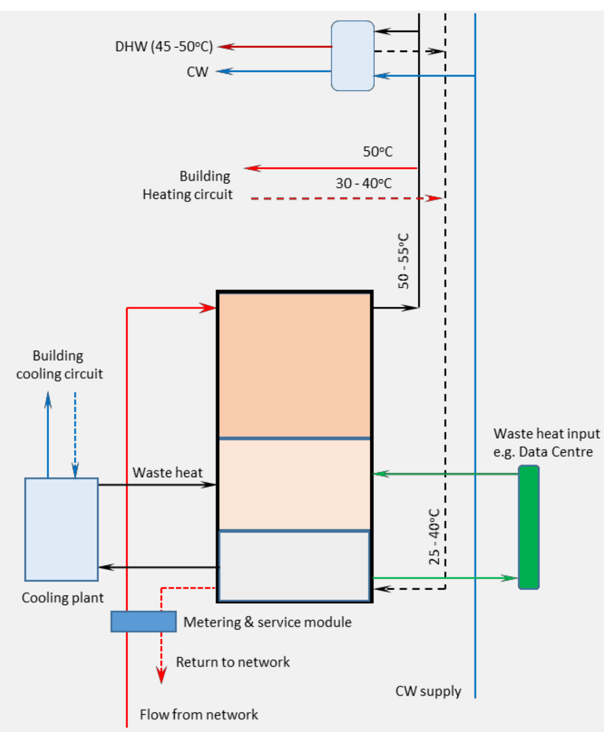



Figure 6
Generic configuration of Commercial Building Heat Store - 2

### 3.3. Advantages of distributed storage district heating scheme

The central buffer store allows the heating plant to size to be reduced because the store will supply the short term peak demands. However, the distribution network would still have to be sized for peak demand. However, with distributed storage system, the building peak demands are shaved by the local heat stores and therefore there is scope for reducing the distribution network pipe sizes. [*Note: A recent study has shown that for a 18kW load, in UK service pipes were sized for 70kW compared with 32kW in Denmark*].

In UK typical losses from distribution network are 11% for in bulk scheme and 43% in non-bulk scheme district heating schemes. Therefore, it is proposed to run the network at 75ºC in winter and 70ºC in summer and use the benefit of distributed stores to critically size the network to minimise the distribution losses.

Where practical, local heat stores would be used to recover and store waste heat from the processes in the building and reuse this either in the same building or distribute to other buildings via distribution network.

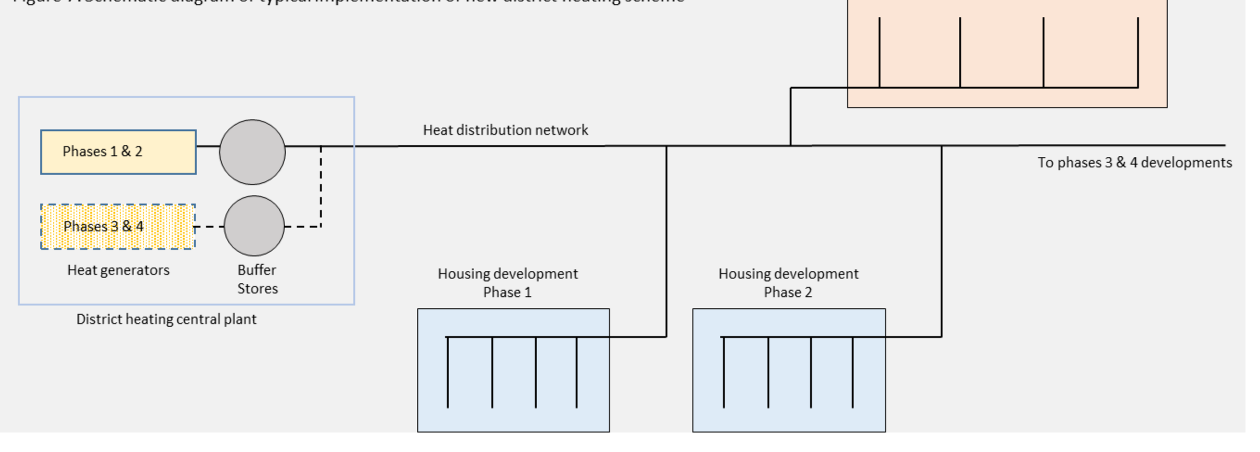
## 4. Implementation of district heating scheme

### 4.1. District heating scheme for new developments

The most common approach is to plan the new housing and commercial developments and the district heating for these developments at the same time. However, the scheme may be completed in several phases (Figure 7). This approach carries minimum risks for the developer because: -

a) The heating loads are known and virtually guarantied and therefore the both the central plant and the distribution networks can be sized, planned, and installed in the most cost effective and efficient way.
b) The end user heat transfer stations and the heating systems can be designed with very little risk, because all the parameters of the heat supply networks will be known.
c) The load profiles of the heat users would be known and therefore the central district heating plant can be designed to meet these demands and operated efficiently.
d) Income streams and project time lines would be defined and therefore financing of the project would in general be less risky.

Figure 7: Schematic diagram of typical implementation of new district heating scheme



## 4.2. Modular distributed storage district heating scheme for existing end users

The approach used for new schemes described in section 4.1. may not be suitable for new district heating schemes designed to connect to existing buildings which already have heating systems because risks for the risks for district heating developers would be higher. The main reasons are: -

a) Connections to loads (e.g. buildings) cannot be guaranteed because the end user already has heating system connected to other network e.g. gas.
b) The heating system in the target buildings may not be suitable for connecting to district heating network.
c) Installing the network to target building may not be cost effective because of their location.

Some of the risks discussed above can be minimised by adapting a modular approach and starting from the end user side. However, this does not eliminate the need to plan, design and agree the route of the distribution network and the location of the central plant. Typical examples of the modular approach based on distributed heat storage are illustrated in figure 8.

1) A mini district heating system is designed and installed to suit the heating systems in the dwellings in the scheme. The heat is initially supplied from a temporary local plant, 1, until the district heating network connection becomes alive.
2) Same as 1) but if waste heat from local heat source is available, then the local heating plant can make use of it. When the main network becomes alive, the heat source can either be moved to next min district heating scheme or put into standby mode.
3) Same as 1) but hut heat to the local plant is by transport from nearby location until the main network becomes alive.

Figure 8: Schematic diagram of constructing modular district heating scheme