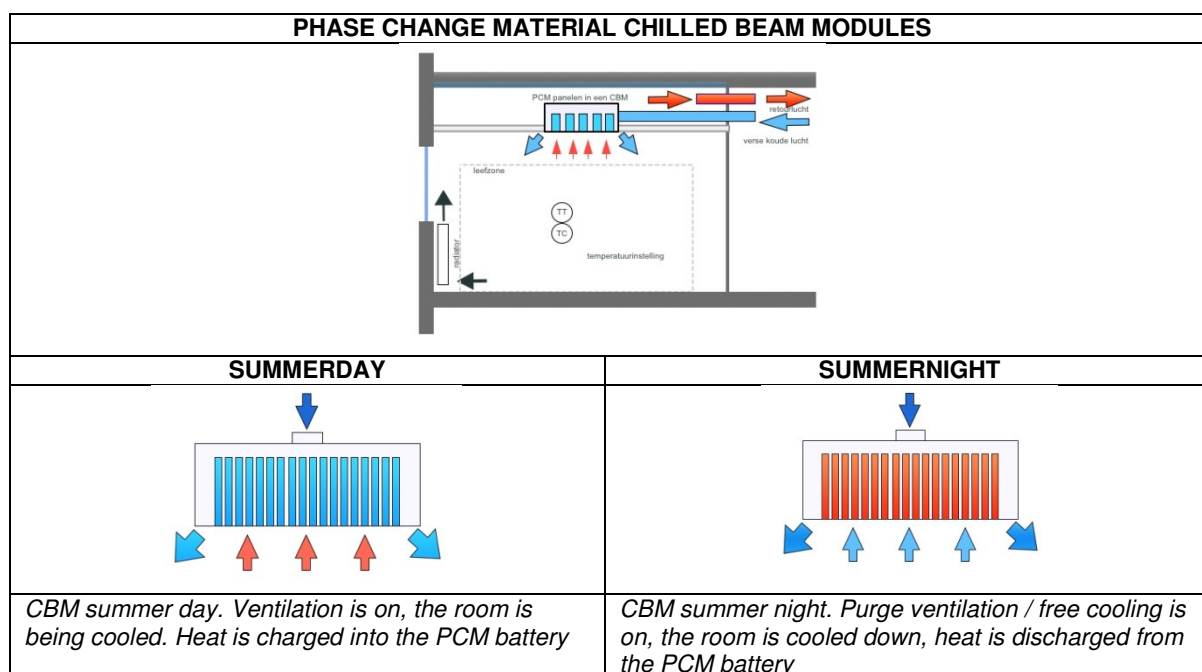


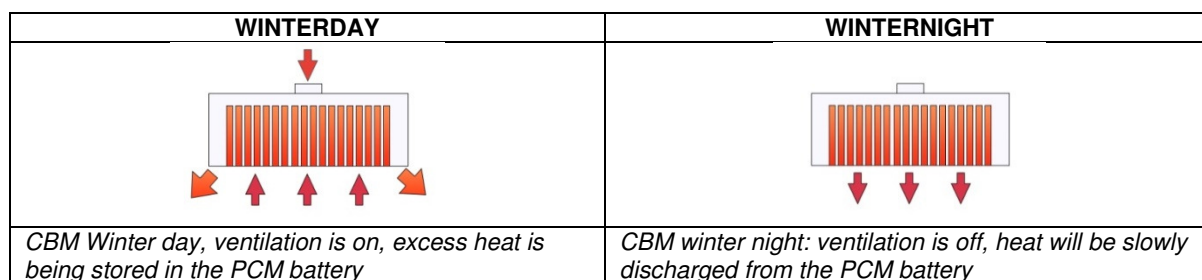
Working principle of a CBM Phase Change Material (PCM) chilled beam module

The most commonly known phase change material is water. Water has a phase change at 0 degrees Celsius, turning from liquid to solid and vice versa. Technical phase change materials can turn from solid to liquid at an engineered phase change temperature for example: 23 degrees Celsius.

The thermal battery in the CBM can store heat. As a result, a building can be cooled (storing heat into the PCM) and heated (discharging heat from the PCM). The driving force behind the operation of the CBM is the (de)central ventilation system. The total sum of cooling is the pre-cooled air and the heat stored in the phase change material, distributed with the Coanda effect. With CBM there is a difference in operation mode between day and night (as is with normal buildings. Schematically it will function as below:

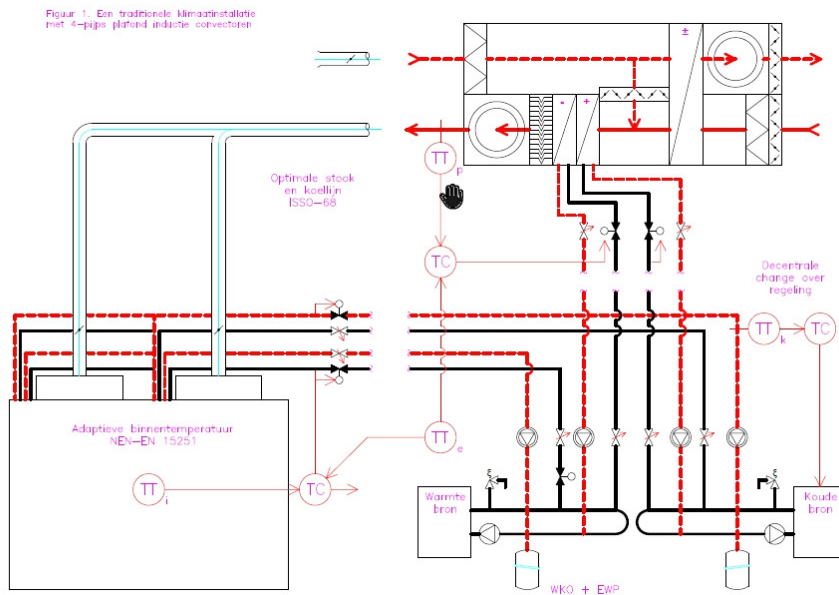


Due to the continues ventilation during the daytime, heat can be charged into the thermal PCM battery, therefore cooling the office room. This stored heat must be discharged in the night with free-cooling (also known as night purge ventilation), during the “nightly purge” all heat will we discharged from the PCM battery. If this is done in a rhythm of day and night, the free cooling during the night will be able to charge the PCM battery. If night temperatures are too warm to properly discharge the PCM a chiller can be used to cool down to an acceptable air temperature. Even in these warmer nights the chiller will perform at a much better COP / EER and thus saving energy. In winter, there are other control strategies that can be followed for optimal utilization of the stored heat in the thermal PCM. We will give an example of the most common situation :



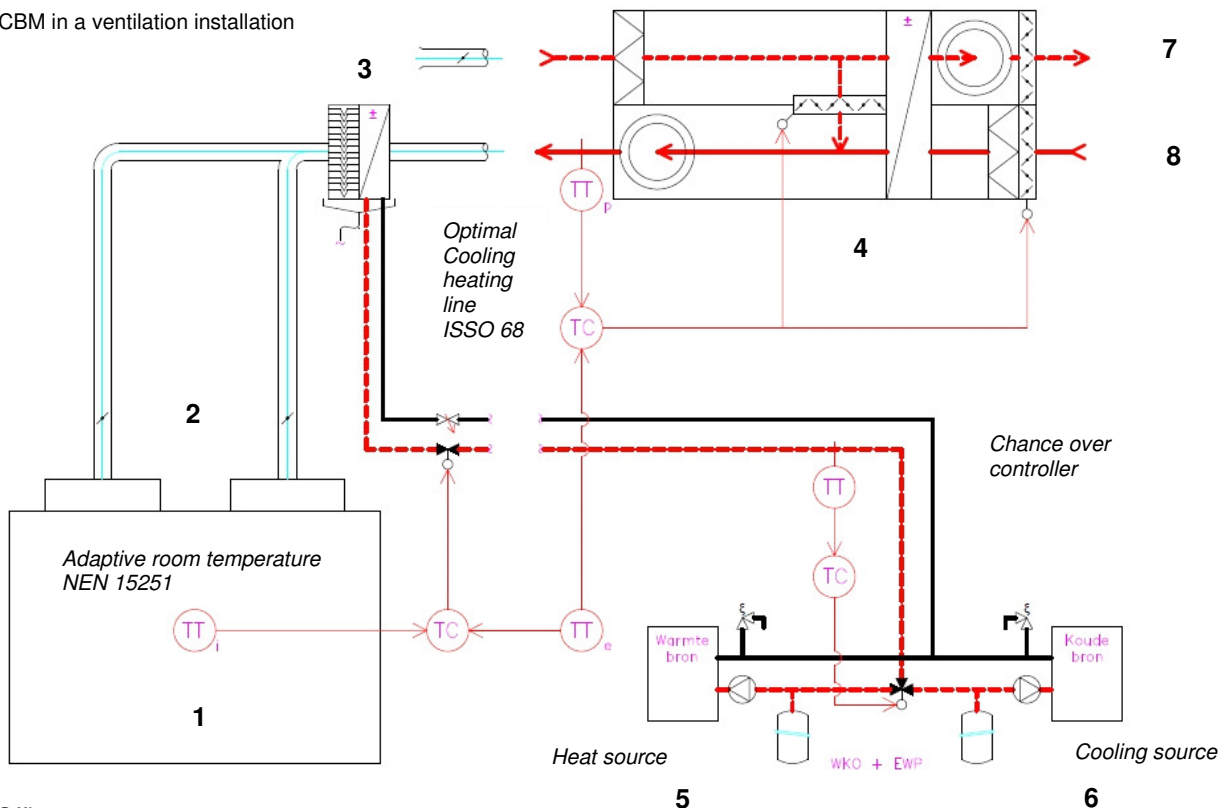
In winter the thermal PCM battery will store excess building heat from the heating system, people, lights and devices. With no active discharge strategy this heat will be discharged during the night time to the room. Rule of thumb 1 kilogram PCM can store the heat of ≈ 20 Kilogram of concrete.

The picture below is an example of a **classic chilled beam** installation:



The figure below shows the position of a CBM Phase change material in a standard ventilation and climate control installation

CBM in a ventilation installation



1. Office room
2. CBM PCM chilled beam modules
3. optional cooling heat exchanger (can be positioned inside an air handler)
4. Air handler with heat recovery (heat wheel)
5. Heating source, i.e. gas powered, geothermal powered heat pump
6. Cooling source, Chiller, heat pump
7. Discharged air from the building
8. Fresh supply air tot the building (a PCM energy source)

The pictures below show CBM units in a straight line in an office, and the thermal PCM battery



CBM in a straight line in a Dutch office building



The thermal PCM battery made from HDPE panels filled with a phase change material