



Buffer Vessels

March 2025



INTRODUCTION //

Buffer vessels and thermal stores are a topic that Engineers can discuss for hours!

In this guide we set out our recommendations for the sizing and design of systems. Every building is different and the way in which the heat pump is used may also need to be different and therefore the buffer size will be different. For example, to make best use of low electricity prices over night the buffer will need to be larger.

There are 3 golden rules:

1. Clade heat pumps do not require a buffer as they use hot gas defrost and will vary output according to demand.
2. We do recommend a buffer volume to smooth the start up and anti-cycling of a heat pump as a precaution, we provide a minimum volume for this.
3. The building and heating system will require a buffer volume to operate as designed, the system designer must size this volume.





MINIMUM BUFFER SIZING FOR HEAT PUMP OPERATION //

Clade's minimum buffer recommendations are given in the table. These represent the minimum storage requirements necessary to protect the heat pump and allow for a maximum of six starts per hour.

CO2 heat pumps

A wider TD means a lower volume of buffer required to store the energy at min turn down and during start up.

R290 heat pumps

Propane modular heat pumps start one module at a time so only require buffer volume for that module.

Where more than one heat pump is used the minimum volume is multiplied by the number of heat pumps.

Model name	Min L of buffer
Acer 65/50	303
Acer 95/75	443
Acer 130/100	606
Maple SN 260/200	1213
Maple SN 390/300	1819
Maple SN 520/400	2426
Maple SN 650/500	3032
Elm 75/60	1400
Elm 105/70	1679
Rowan all capacities	2239
Birch 85/53	1586
Birch 20/80	2239
Yew all capacities	2612



BUFFER VESSEL SIZING FACTORS FOR SYSTEM SIDE //

Any heat pump system may require additional buffer volume to operate correctly and efficiently providing optimal comfort for the building users.

The following recommendations provide guidance on selecting a suitable buffer capacity to maximise energy efficiency and maintain consistent heating output encompassing the following:

Defrost Cycle Management

Clade air source heat pumps undergo periodic defrost cycles depending on the ambient conditions. During defrost the heat pump uses hot gas to clear ice from the evaporator, this does not pull heat from the buffer but it does reduce heat capacity to the building. The buffer vessel provides stored thermal energy to maintain heating supply to the building. The buffer can be sized to cover the full, or part of the heat demand. Clade recommends a minimum of 30 minutes storage to cover this.

Peak Load Consideration

Heat pumps can be sized smaller than the peak demand of the building. In which case the buffer volume should accommodate the total peak kWh heating demand of the building in both duration and capacity. CIBSE Guide A shows how to perform detailed analysis of building heating load profiles. Factors such as occupancy patterns, thermal mass, and intermittent heating requirements should be evaluated to determine the total time the peak load is required and the necessary storage capacity.

Low demand conditions

Clade heat pumps are inverter driven variable output but in some circumstances the building demand is even lower than the maximum turn down ratio of the heat pump. Buffer volumes should be sized to prevent excessive cycling of the heat pump to no more than 6 starts an hour, less cycling means greater efficiency.

Grid flexibility and time of use tariffs

Flexibility is a key part of our energy future (Ref. NESO report on future energy system to achieve net zero), additionally significant energy cost reduction can be achieved by shifting the heat generation time. Designers should allow for up to 6 hours time shift in the buffer volume.

Further guidance can be found in industry publications such as CIBSE CP1.

EFFECTIVE BUFFER DESIGN //

To ensure optimal performance and efficiency in heat pump systems, proper buffer vessel design is crucial. A well-designed buffer enhances stratification, maximises usable volume, and provides precise control for charging and discharging cycles. Key aspects of an effective buffer design include:

Height-to-Width Ratio

A buffer vessel should have a height-to-width ratio of 2.5:1. This geometry promotes better thermal stratification by reducing the potential for mixing between layers, ensuring a stable temperature gradient within the vessel.

Sparge Pipes

Increases the useable volume of the vessel.

External Combined Headers

One in one out header based on CIBSE CP1. Prevents mixing and maintains stratification and sized to achieve less than 0.3 m/s velocity into the vessel. The header helps maintain stable pressure conditions across both the primary and secondary circuits. This is essential for variable flow systems and avoids issues with fluctuating demand.

Perforated Baffle Plate

Positioned inside the vessel, the baffle plate ensures an even spread of stratification and helps maintain the cold section at the bottom of the buffer critical for return temperatures.

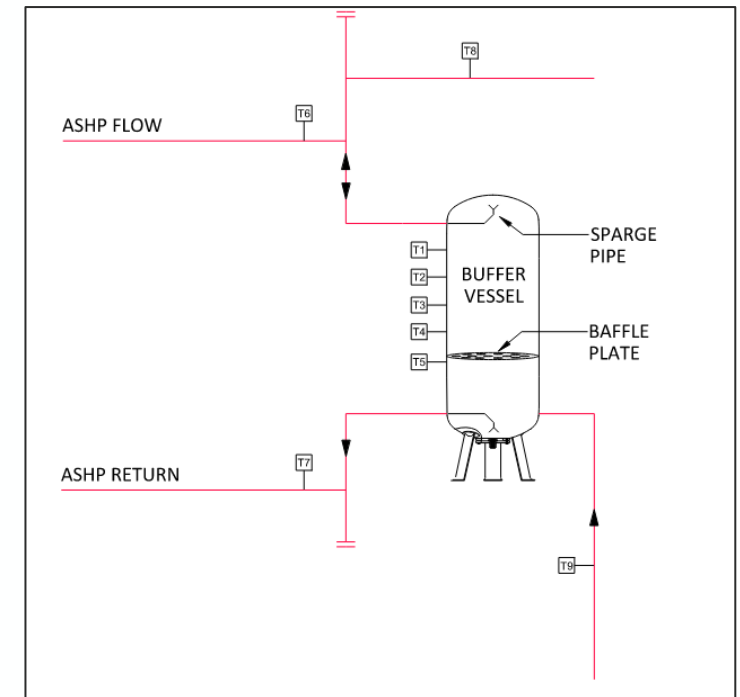
Temperature sensors

Five temperature sensors distributed vertically within the buffer need to be distributed properly for precise monitoring and adjustments to maintain optimal conditions. When there are multiple buffers, these need to be spread across the vessels evenly.

Integration with Heat Pumps

The master controller plays a central role in managing the buffer vessel: **0-10V Signals:** Charging and depleting the buffer triggers 0-10V signals that dynamically adjust the operation of air source heat pumps.

By incorporating these design elements, the buffer vessel can effectively support the operation of heat pumps, ensuring efficiency and manage return temperatures.

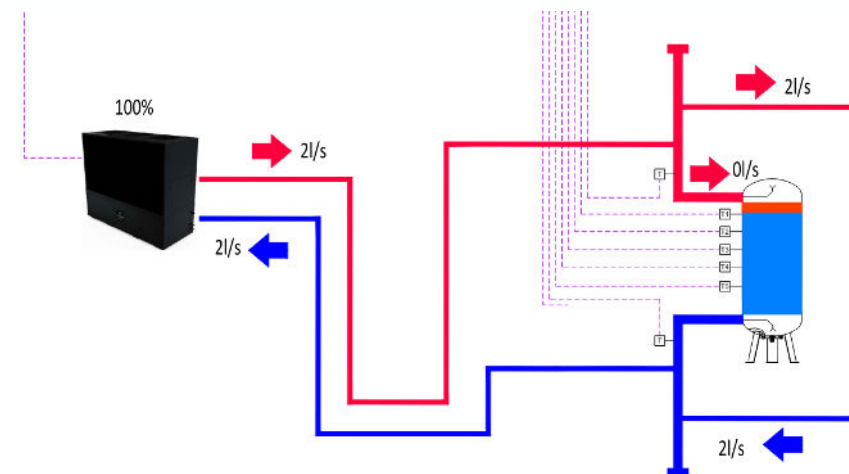


EFFECTIVE BUFFER DESIGN IN ACTION //

1

Here the secondary system is at full demand and the buffer is fully depleted.

The heat pump runs at 100% capacity to meet the demand of the building, bypassing the buffer.

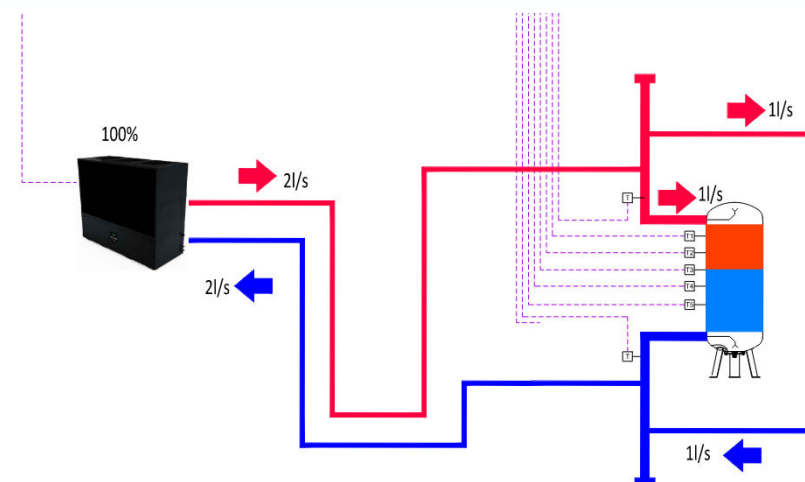


2

Here the demand from the building ramps down from 2 l/s to 1 l/s.

The heat pump continues to run at 100% capacity to meet demand from the building while also satisfying the buffer.

Cooler return water is pulled from the bottom of the buffer,

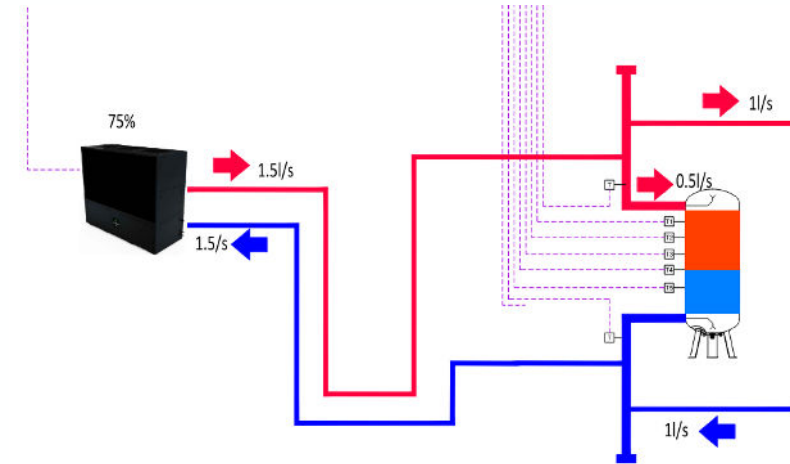


EFFECTIVE BUFFER IN ACTION //

3

As the temperature sensors in the buffer detects the increase in temperature within the vessel the heat pump starts to ramp down while still meeting building demand.

In this example the heat pump is at 75% and will continue to ramp down as temperature sensors lower down the vessel hit the set point.



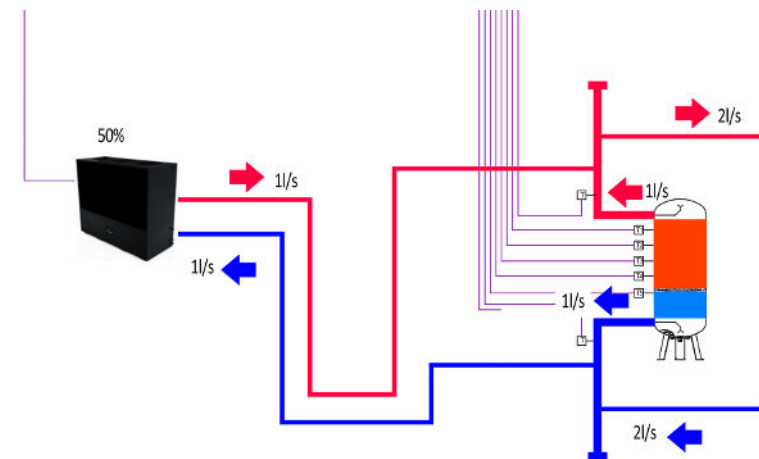
4

Here the buffer is fully satisfied with the cold layer still present at the bottom.

Demand from the building turns to full capacity and the process starts again.

As Buffer temp falls the heat pump reacts as it sees demand on the system.

Stratification is maintained in the buffer





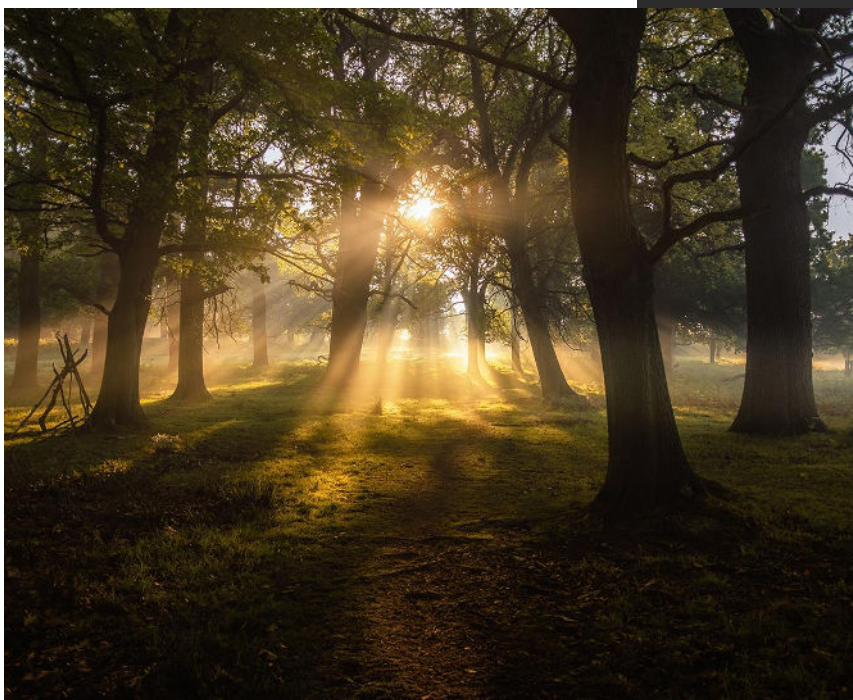
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