'Open' and 'closed' buffer systems for heat storage

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Modern glasshouse enterprises, especially the larger companies, increasingly use a heat storage tank (or buffer). They are most useful on properties where natural gas is the fuel, and the flue gases are used for CO2 enrichment, especially in areas with low night temperature. In the Netherlands about 50% of all greenhouses is equipped with a heat storage tank. Originally the only purpose of a buffer was to store heat from the day to the night to enable CO2 enrichment. Nowadays in the Netherlands buffers are also used for energy management. This requires a different set-up of connection pipes, valves and pumps. The new set-up is called 'open' buffer system. In contrast the traditional set-up is now called 'closed' buffer system. In the Netherlands all new buffers are built as open buffers. However, in NZ the opinion is that the advantages of an open buffer are uncertain. This article describes the two systems and discusses pros and cons.

Buffer

A buffer is an insulated steel tank filled with water. It is part of a closed loop with the boiler, transport ducts and heating spirals. Smaller tanks can lay horizontal or stand upright. The larger storage tanks are upright tanks with a height of 10 m maximum, and up to 8 m diameter (this gives 500 m^3 volume). Even bigger is possible. The top of the tank is filled with nitrogen to allow expansion of the water.

The terminology about buffers may need some clarification. Growers will say that the buffer is 'full' or 'empty'. This has nothing to do with the amount of water in the buffer, as the buffer is always full of water. But 'empty' means that the water in the buffer is at its minimum temperature, which is the temperature of the return water. This is 40 °C in summer and 55 °C in winter. 'Full' means that it has reached it maximum temperature, which is usually 95 °C.

Capacity of buffer

The first buffers in the 1980s were around 25 m^3 volume per 1 ha greenhouse area, but in recent years most new buffers in the Netherlands are 100 - 150 or even 200 m^3 per ha. The average buffer size was 94 m^3 per ha in 2001. Obviously the size of the buffer determines the amount of heat stored for the night. In regions with very cold nights it is useful to have a large buffer, whereas in areas with mild night temperatures a large buffer leads to energy waste. Since the temperatures in NZ are not very low, the buffers should be of a much smaller size than in the Netherlands. The size should be calculated on the basis of heat and CO2 demand patterns. The amount of heat that can be stored, and the amount of CO2 that can be produced, were calculated in the previous article.

Conventional 'closed' buffer system

Growers using a gas-fired boiler can use the flue gases from their boiler for CO2 enrichment. (But check the flue gas quality before using it for CO2 enrichment!). Obviously the boiler produces both CO2 and heat at the same time, whereas CO2 and heat are not required at the same time. CO2 is needed during the day, especially when it is sunny, and it is useless at night. Heat is virtually unwanted when it is sunny, and is needed most at night. To overcome this problem, the heat storage tank (buffer) was developed in the Netherlands in the 1980s.

At day, gas is burned and the CO_2 is injected into the greenhouse, while the hot water is sent to the buffer. At night there is no need for CO_2, as the plants are not active in darkness. Hence the boiler is on stand-by. The hot water that is required at night for greenhouse heating is taken from the buffer. The hot water from the buffer runs through the transport ducts, manifold and/or header set, heating spirals and back to the buffer (see Figure 1a & b). If the buffer gets 'empty' during a cold night, the boiler kicks in.

Set-up of 'closed buffer' system

A closed buffer system, designed to assist CO_2 enrichment, is set up as follows. The valves in the transport pipes are set either for loading the buffer (storing heat) or for unloading the buffer (retrieving heat). It is not possible to load and unload the buffer at the same time. It is possible, thought, to send a part of the heat produced by the boiler to the buffer and another part to the greenhouse. It is also possible that the greenhouse receives heat from both the boiler and the buffer at the same time. If the water temperature in the buffer is not high enough to achieve the required pipe temperature in the greenhouse, additional heat is supplied by the boiler. The trigger for attracting additional heat from the boiler is the measured water temperature in the heating pipes (or manifold or header set).

In a closed buffer system the gas valve position of the boiler is controlled by the computer. On warm days it is controlled on the basis of CO_2 demand, while taking into account the size of the buffer. On cold days it is controlled on the basis of required temperature of the heating system. In practice the boiler and buffer control is a bit more complicated but that goes too far for this article.

The new 'open' buffer system

Using an open buffer system is often called 'heating with the buffer'. In an open buffer system there is an open connection between boiler, buffer and manifold (or header set). The boiler produces water of a fixed temperature, e.g. 95 °C. The boiler feeds the buffer with this hot water, and subsequently the buffer supplies hot water to the manifold and this goes through the heating spirals and back to the buffer. One point of difference with a closed buffer is that an open buffer can always forward the heat to the manifold, without changes of valves. Another difference is that in an open buffer system the gas valve position of the boiler is controlled not on the basis temperature (as this is fixed), but on the basis of required amount of energy storage. This is determined by the computer, in the Netherlands by using a weather prediction that the computer receives automatically. If a very cold night is expected, more heat must be stored. In very cold nights the buffer plus the boiler together provide the required heat. In NZ however, it will be harder to accurately predict how much heat will be needed in the following night.

Set up of 'open' buffer system

There are at least two ways of installing an open buffer system (see Figure 2a & b). For the smaller systems usually a mixing valve is used, which carries part of the supply water from the boiler back to the return pipe. This mixing valve is used to ensure that the buffer is fed with water of a fixed supply temperature (this is the buffer loading temperature). A pump takes care of the flow. This can be a pump with fixed revolutions, but ideally a frequency-controlled pump is used. The pump speed is controlled depending on the required heat supply by the boiler. This set-up leads to a steady burner control and costs least electricity.

Very large open buffer systems are installed in another way, simply because there are no large-size mixing valves available. In this case a frequency-controlled pump is installed to achieve the constant supply temperature into the buffer. An extra pump with fixed revolutions is used to carry a part of the supply water of the boiler back to the return pipe in order to prevent a too low return temperature.

Advantages and disadvantages

The advantage of an open buffer is that the boiler can run most of the time at its most efficient gas valve position. It will burn very calmly at a constant speed during a large part of the day. Only when the heat content in the buffer starts to deviate too much from the desired amount the gas valve position is adjusted. Also the open buffer requires a bit less pipes and valves, and can therefore be a bit cheaper.

One disadvantage of an open buffer system is that the boiler always produces water of 95 °C. So the boiler, transport ducts and a part of the buffer are always very hot (95 °C), and therefore suffer a bit more heat loss than a normal system. Sometime the boiler can be activated, while there is no CO_2 demand and no heat demand. This happens when a cold night is expected, so that a lot of heat is produced for the coming night. This is not a disadvantage, but people have to get used to it.

The Dutch say that open buffers have great advantages, but the installers of buffers in NZ (Frank and Richard Hectors) say that the open buffer system is only worthwhile for those situations for which it was designed. That is for growers who have a contract with the gas company for a fixed gas intake. In such contracts, a peak in gas intake is extremely expensive, and peaks must be avoided at all time. The use of an open buffer assists to make such a gas contract feasible.

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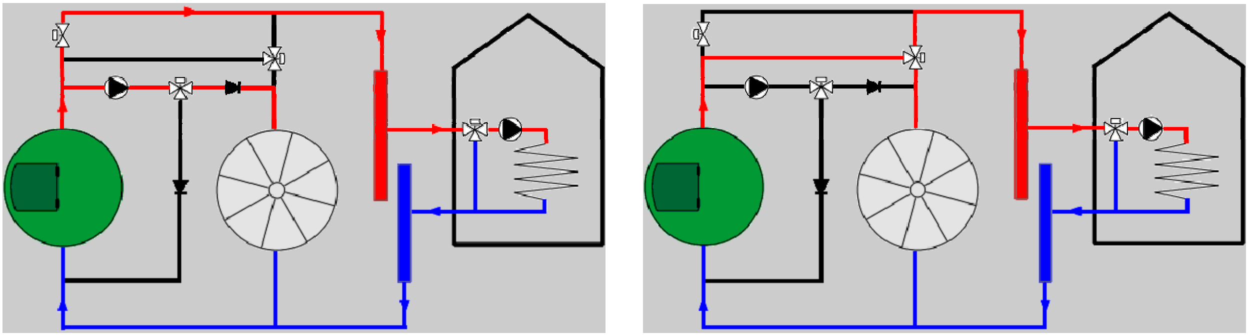
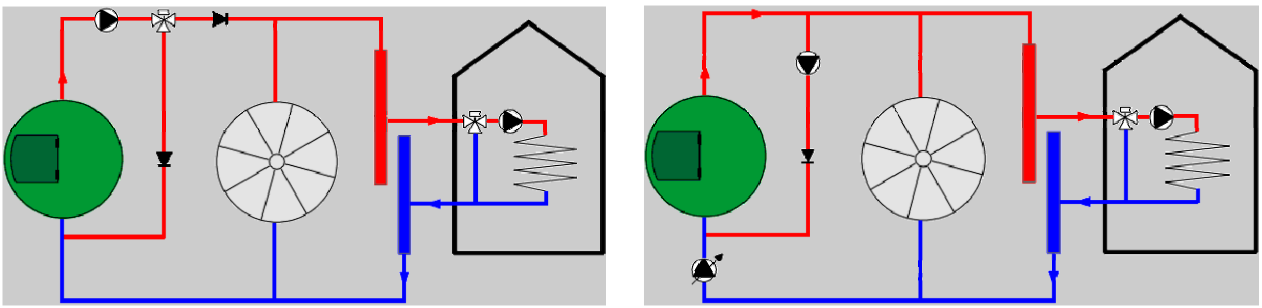
Fig 1a & b. *Schematic presentation of a 'closed' buffer system,*
(1a) loading, (1b) unloading
Source: Ton Rijsdijk, www.cli-mate.net.



Conventional buffer: loading   Conventional buffer: unloading

Fig 2a & b. *Schematic presentation of an 'open' buffer system.*
(2a) with a mixing valve, (2b) without a mixing valve
Source: Ton Rijsdijk, www.cli-mate.net.



Open buffer with mixing valve   Open buffer with frequency pump