TEMPORARY HEAT STORAGE BY USING COMBINED HEAT AND POWER IN SUPPLEMENTARY LIGHTED GREENHOUSES

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Abstract

Because of better utilization possibilities of the produced heat, decentrally located combined heat and power installations achieve a higher energetic efficiency than producing heat and power separately. However, efficiency depends considerably on synchronism of heat and electricity demand. Using a combined heat and power installation to feed the supplementary lighting in greenhouses leads to great differences with regard to quantity and simultaneity of the heat production and demand. This problem can be solved by storing temporary heat surpluses in a buffer. In an experimental greenhouse, cultivated with supplementary lighted roses, research has been done to study the prospects of temporary heat storage. Storage of temporary heat surpluses from the heat and power installation resulted in an energy saving of 60 kWh/m^2/yr. In case of storing heat surpluses from both combined heat and power installation and boiler (used for CO_2 production), an energy saving of 95 kWh/m^2/yr was realized.

1. Introduction

In Dutch horticulture supplementary lighting is employed especially by cultivation of young plants and flowers. About 8% of the total glasshouse area is equipped with supplementary lighting. Lighting has a great influence on energy economy of the nursery and increases electricity consumption from 6 kWh/m^2/yr up to 75 -100 kWh/m^2/yr. At present several ways of producing electricity are in practice. At first there is the possibility to buy electricity from the public grid. An increasing number of growers using supplementary lighting prefer electricity production by a combined heat and power installation. Usually combined heat and power is used just for own electricity supply. Because using combined heat and power and supplementary lighting are always synchron, in periods with a few heat demand surpluses appear. Storing temporary heat surpluses in order to use in periods of shortage decreases fuel consumption. In an experimental house, cultivated with lighted roses (Madelon) and using a simulated combined heat and power installation synchron to electricity demand of the lighting, year-round investigation into the energy saving effect of temporary heat storage has been carried out. Storage concerned heat surpluses caused by the combined heat and power installation and using the boiler just for CO_2 production.

2. Material and methods

The research accommodation consisted a modern Venlo-greenhouse with compartment surfaces of 192 m^2 each (9.60 x 20.0 m). In the house roses (Madelon) were cultivated in rockwool blocks upon movable benches. A pipe-rail network for primary heat distribution was situated below the benches and a secondary heating network about 2.0 m above

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surface. The scheme of the heating system of the research accommodation is shown (figure 1). In the heating system the heat exchanger (HE) had a central position. Here heat from combined heat and power and/or heat from boiler for CO_2-gift was liberated. If heat demand of the greenhouse was greater or equal to the heat supply of the heat exchanger water flows from the exchanger at once in and out the storage tank. Heat from exchanger as well as buffer could be transported to both heating networks.

For heat storage a water-buffer of 4 m^3 (200 m^3/ha) was available.

Lighting consisted SON-T-Agro lamps in SGR luminaires was installed 4.5 m above surface. Illumination of the lighting was 9 Watt PAR per m^2.

Lighting strategy was as follows:

In the period 20 April - 10 August plants were not lighted. During night no lighting during 6 hours.

By day lighting was dependent on outside radiation. If global radiation was greater than 75 W/m^2 light was turned off. If radiation was lower lamps were burning.

Research was concentrated on energy saving by using temporary heat storage. Investigated systems:

I. Use of temporary heat storage for heat surpluses both from the combined heat and power installation and the boiler (if in use just for CO_2 production).

II. Use of temporary heat storage for heat surpluses from combined heat and power installation (pure CO_2-gift).

III. No heat storage (pure CO_2-gift).

3. Results

Yearround illumination time was 3270 hours. During lighting period the number of lighting hours per 24 hours period varied from about 10 h in spring and autumn to 16 h in winter (figure 2).

Investigated systems presented great differences between temporary heat demand and Supply

Daily temporary storage of heat surpluses from the combined heat and power installation and the boiler (CO_2-gift) formed a substantial part of the total heat supply to the greenhouse (figure 3).

Analyses of the heat fluxes proved that an important part of the total heat was produced by the combined heat and power installation (62%). From total heat produced by the combined heat and power installation 25% was temporary stored. From heat production for CO_2-gift by boiler even over 40% storage was reached (figure 4).

For investigated systems also efficiency of the heat storage facility was fixed (figure 5). Size of the facility (200 m3/ha) proved to be not large enough to store all surpluses.

Using the storing facility for heat surpluses both from the combined heat and power installation and the boiler (CO_2-gift) about 95 kWh/m^2/yr could be stored useful, 21 kWh/m^2/yr could not be stored because shortage of facility size, while estimated losses through facility wall were 6 kWh/m^2/yr.

In case of just storing heat surpluses from the combined heat and power installation 60 kWh/m^2/yr was stored useful, 6 kWh/m^2/yr could not be stored because shortage of facility size and estimated losses through facility wall were 3 kWh/m^2/yr.

Fuel consumption of the investigated systems proved also great differences (figure 6).

Efficiency of the boiler was estimated at nth 0.9 and of the combined heat and power installation at nth 0.6 and nelec 0.3. The energy consumption of combined heat and power installation amounted to 44.5 m^3 natural gas/m^2/yr, which was, depending on the system, 65% till 74% of the total fuel consumption. Total natural gas consumption for the investigated systems came to 62.3 m^3 gas/m^2/yr in case of temporary storage of heat surpluses both from the combined heat and power installation and the boiler (CO_2-gift), 60.4 m^3 gas/m^2/yr in case of storing heat surpluses just from the combined heat and power installation (pure CO_2-gift), while the system without heat storage and pure CO_2-gift came to 68.3 m^3 gas/m^2/yr.

4. Discussion

Yearround research in a supplementary lighted experimental greenhouse has proved that temporary storage of heat surpluses from the combined heat and power installation and the boiler (CO^2-gift) can provide a substantial energy saving of over 10 m^3 natural gas/m^2/yr.

Further attention should be paid to energetic and economic feasibility of combined heat and power and temporary storage of heat surpluses for lighted as well as unlighted greenhouses if electricity surpluses can be delivered to the electricity grid.

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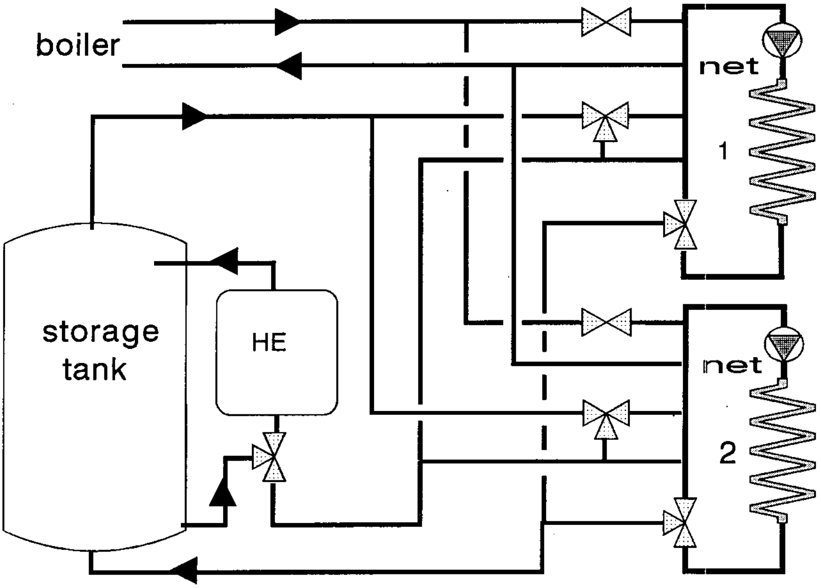

Figure 1 Scheme heating system of the research accomodation

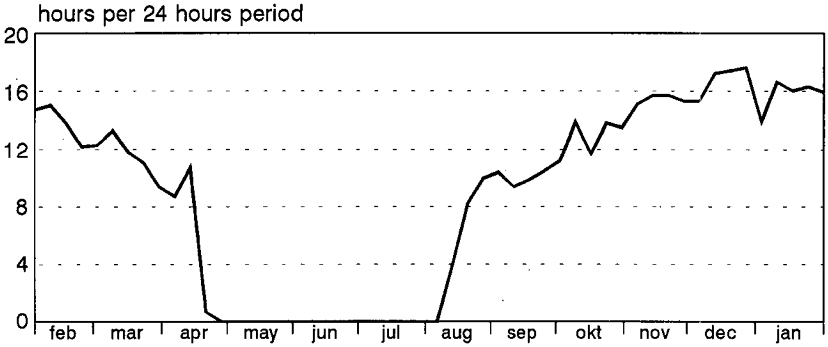

Figure 2 Average number of lighting hours per 24 hours period

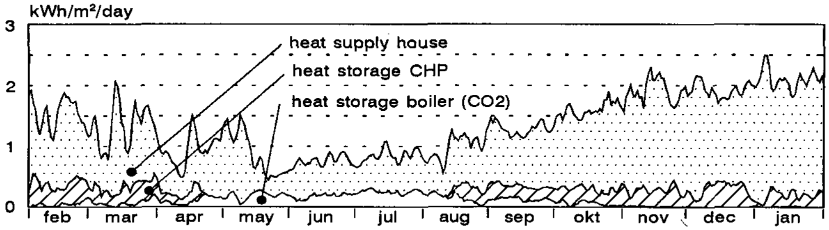

Figure 3 Yearround heat supply glasshouse and temporary heat storage combined heat and power (CHP) and boiler (CO_2-gift)

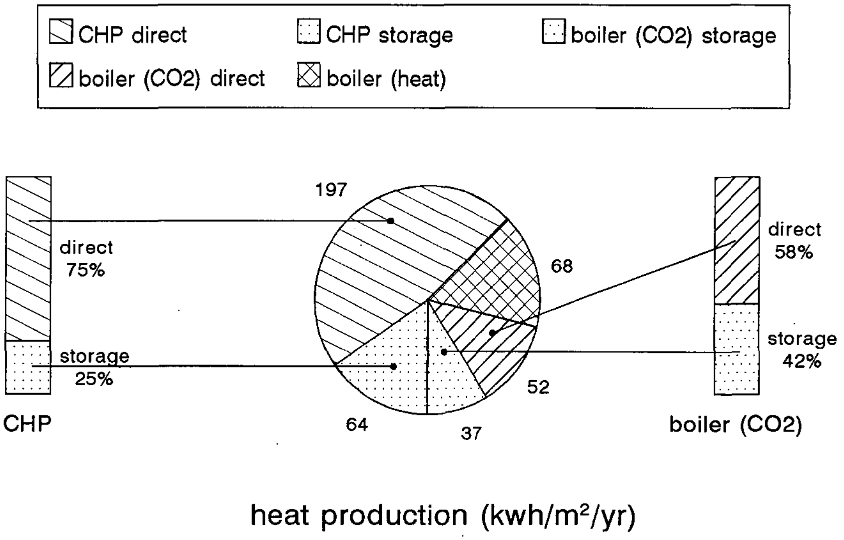

Figure 4 Storage of heat surplusses of combined heat and power (CHP) and boiler (CO_2-gift) in kWh/m²/yr

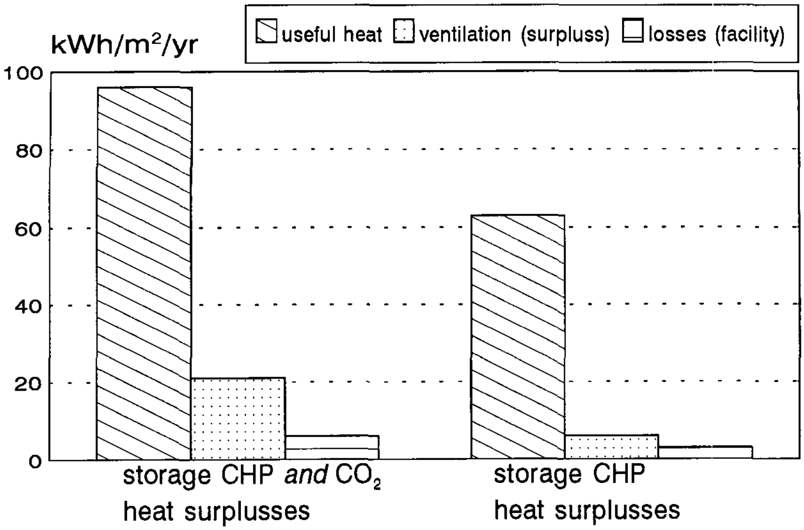

Figure 5 Efficiency of the heat storage facility

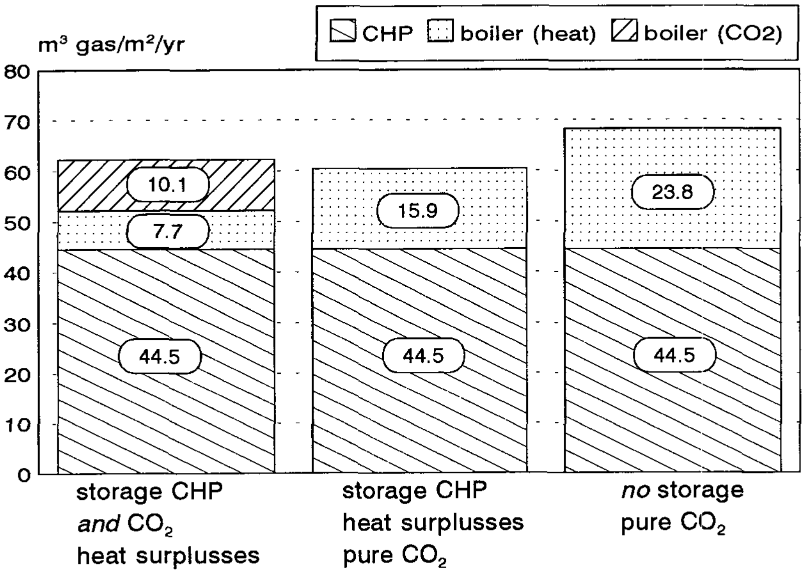

Figure 6 Influence on energy consumption by heat storage for 3 different systems