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The Beaufort Court energy system

PVT and solar thermal for the preheating of ventilation air

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Introduction

In 2003, the new office complex of RES (Renewable Energy Services) in the UK has been completed. This building complex has been created by renovating a former egg farm built around 1930. The renovated complex has been designed with an integral energy concept in which renewable energy is used for electricity, heating and cooling. Information on the energy concept and first results of the monitoring are presented.

The RES complex

Originally, the building complex was housing the 'Ovaltine Egg Farm'. After a period of ten years in which the buildings were derelict, in 2000 RES bought the grounds and the contract was signed for the EU project, with the aim of converting and extending the site to provide 2665 m2 of headquarters office accommodation for Renewable Energy Systems. The design incorporated many renewable energy techniques, with the aim of providing zero nett emission of CO2. Project leader was Studio E architects. The installation engineering was carried out by MaxFordham and the structural engineering by Dewhurst Macfarlane & Partners. The project was completed in December 2003. In November 2003, the building occupants moved in.

Figure 1: The Ovaltine egg farm (a) in the '30 s, (b) before renovation, (c) during renovation, (d) after renovation.

The renewable energy system design

The thermal needs of the building are covered by a collector array, combined with the burning of biomass (5 hectares of Miscanthus have been planted at the complex grounds) and a backup gas fired heater. The collector array consists of 116 m2 of solar thermal collectors and 54 m2 of PV-Thermal collectors, that produce both heat and electricity. The PVT collectors were designed and manufactured as part of the project and contain 70 PVT laminates, divided over 7 collector boxes. The array has been installed on an outbuilding of the RES complex, which also serves as biomass storage. The heat produced by the PVT panels and the thermal collectors is used for preheating of ventilation air during the winter. In the summer, the heat is stored in an underground seasonal storage containing 1100 m3 of water. Summer cooling of the building is realised by water extraction from a drilled borehole that is 70 m deep. Also the electrical needs of the building are covered by means of a wind turbine and the electricity generated by the PVT panels. Surplus electricity is exported to the public grid.

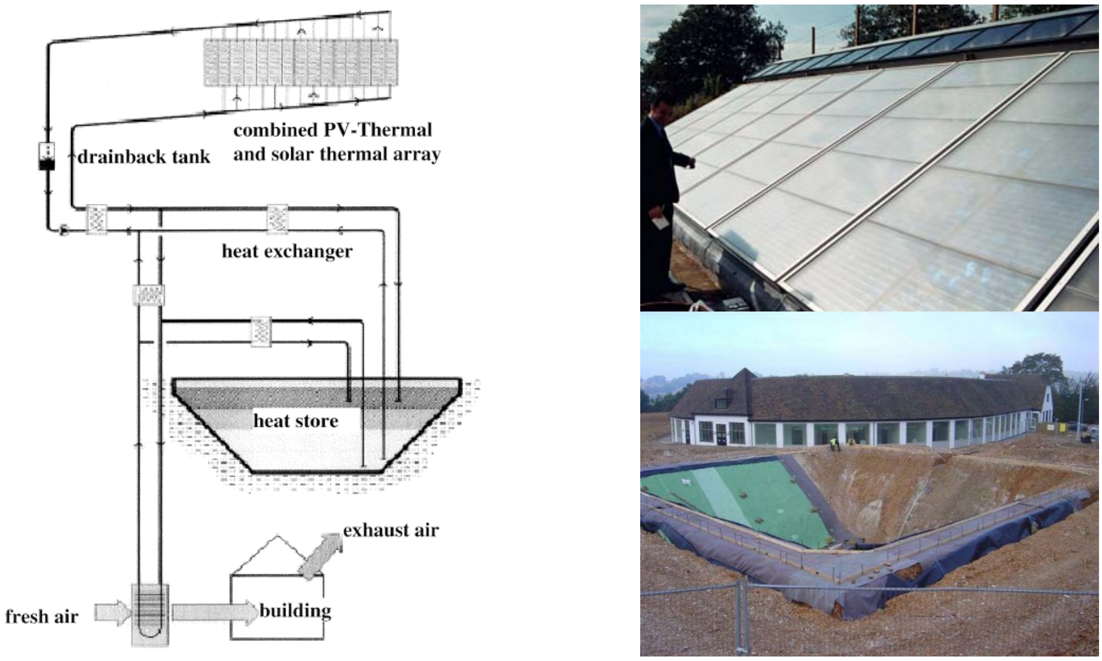

Figure 2: Left: schematic representation of the collector system, Upper right: PVT array, Lower right: seasonal storage under construction.

The solar thermal system installation

The PVT modules were developed within the project by ECN, Shell Solar and ZEN. The prototypes of the PVT panels have been tested at ECN. In addition, ECN, Shell Solar and ZEN have developed an integrated production technology, that allows for an effective assembly and that was used in the manufacturing of the final laminates. After a quality check at ECN, these laminates were transported to ZEN, where the laminates were integrated into the collector boxes. The integration did not give problems despite the fact that a large amount of electrical wiring had to be integrated in the collector boxes and the fact that the PVT laminates displayed a slight curve, due to the manufacturing process. Next, the collectors were transported to the UK. At RES, ZEN supervised the handling and installation of the collectors. Next, the PVT collectors were connected to the grid. Initially, the inverters turned out to give problems, resulting in very frequent disconnection from the grid, but this problem was solved when the inverters were replaced.

The heat store was made by means of an in-situ sealed lining in a 6 metre deep excavated hole in the ground, covered with an insulated floating lid. However, the finalisation of the store took far more time than was anticipated, which was due to the novelty of the design, the high

level of insulation required and the need to keep the construction cost low. This delayed the start of the monitoring.
An additional delay was the commissioning of the solar thermal mechanical transfer system - the commissioning of the 3 port valves that determined the direction of flow of the heated water took longer than anticipated. The solar thermal system was not fully commissioned until around August 2004.

First monitoring results

As of January 2004, the total energy system will be monitored for at least one year, to determine its performance. The monitoring is carried out by Esbensen Consulting Engineers. An overview of the monitoring data is given in Table 1. The borehole cooling occurs only over the period April to August 2004, whereas the backup heating focuses over the period December to March.

type	period	total yield
electrical production of wind turbine	6/3/2004 - 6/3/2005	194 MWh
thermal production PVT collectors	6/3/2004 - 6/3/2005	7 MWh
thermal production all solar collectors	6/3/2004 - 6/3/2005	34 MWh
backup gas heating	6/3/2004 - 6/3/2005	83 MWh
total heating demand	6/3/2004 - 6/3/2005	100 MWh
borehole cooling	20/5/2004 - 6/3/2005	19 MWh

Table 1: Energy flows of RES complex.

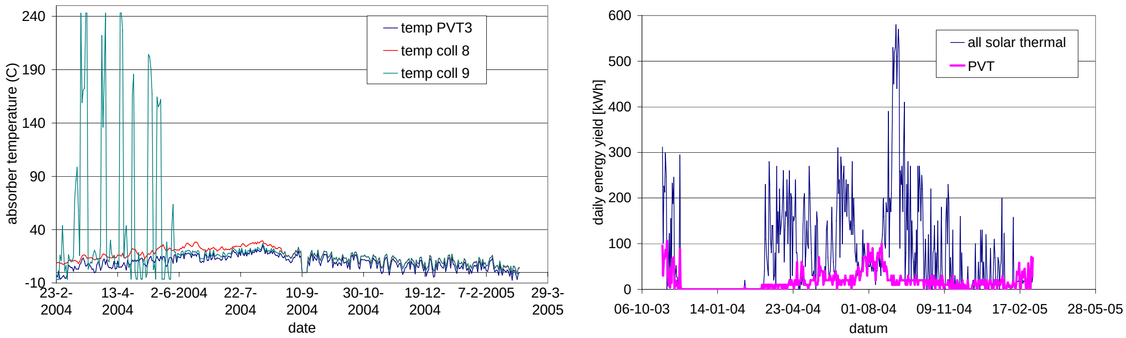

Figure 3: First monitoring results RES system

From Figure 3, it can be seen that initially, collector number 9 was under almost continuous stagnation. This was due to problems with the connection between the collectors and the energy storage. Stagnation temperatures of up to 240 °C were observed. Fortunately, these problems were solved in June 2004. After this date, it can be seen that the collector temperatures of the PVT and the two solar thermal collectors are very similar, the PVT being slightly lower than the other two. The absorber temperature remains below 30 °C, due to the very large heat capacity of the store, which corresponds to over 1300 kWh/K. In the second figure, the yield of the PVT collectors is compared to the combined yield of all solar thermal collectors. It can be seen that the yield of the PVT array is much lower than the yield of the solar thermal array, which is to be expected due to the smaller size of the PVT array and the somewhat lower thermal efficiency.
The PVT produced 7 MWh of thermal energy over the period 6-3-2004 to 6-3-2005, while the full collector array produced 34 MWh of thermal energy over this period. Assuming an annual irradiance of 1000 kWh/m2, which is representative for this area, this would give an efficiency of about 13% for the PVT collectors and 23% for the solar thermal collectors. Given the low storage temperature, a higher yield would have been expected here, but the lower yield is probably due to the fact that the thermal system was not yet fully functional before August 2004 due to the late commissioning of the valves. Also piping losses may play a role, due to the large distance between the storage and the collector array.

During the period 6-3-2004 to 6-3-2005, a total amount of 100 MWh was used for heating. Since the floor area equals 2665 m2, this amounts to 38 kWh/m2, which is a good result. The backup gas heater used 83 MWh over this period, which gives a 17 MWh contribution from renewables. This contribution is due to the collector yield (including the PVT collectors) and the biomass heater.
The potential of the biomass has not yet been fully realised. However, it is expected that the biomass crop will eventually give an annual yield of about 160 MWh, which is more than the entire heating demand of the building. It is therefore expected that the site will be able to cover its own heating demand fully and even become a nett exporter of biomass.
For the electricity use, a total amount of 174 MWh was used from 6-3-2004 to 6-3-2005. This amounts to 65 kWh/m2. The total electrical consumption is therefore 10% smaller than the total electrical production of the wind turbine over the same period, which equals 194 MWh, which makes RES a nett exporter of electrical energy. This is further augmented by the electrical yield of the PVT. Due to the problems with the inverters, insufficient data have been obtained on the electrical yield of the PVT, but it is estimated at 3.5 MWh annually under normal conditions.
All together, the first monitoring results look promising. It should be concluded that the project was on the whole a success, and a lot of experience has been gained from it.

Acknowledgement

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