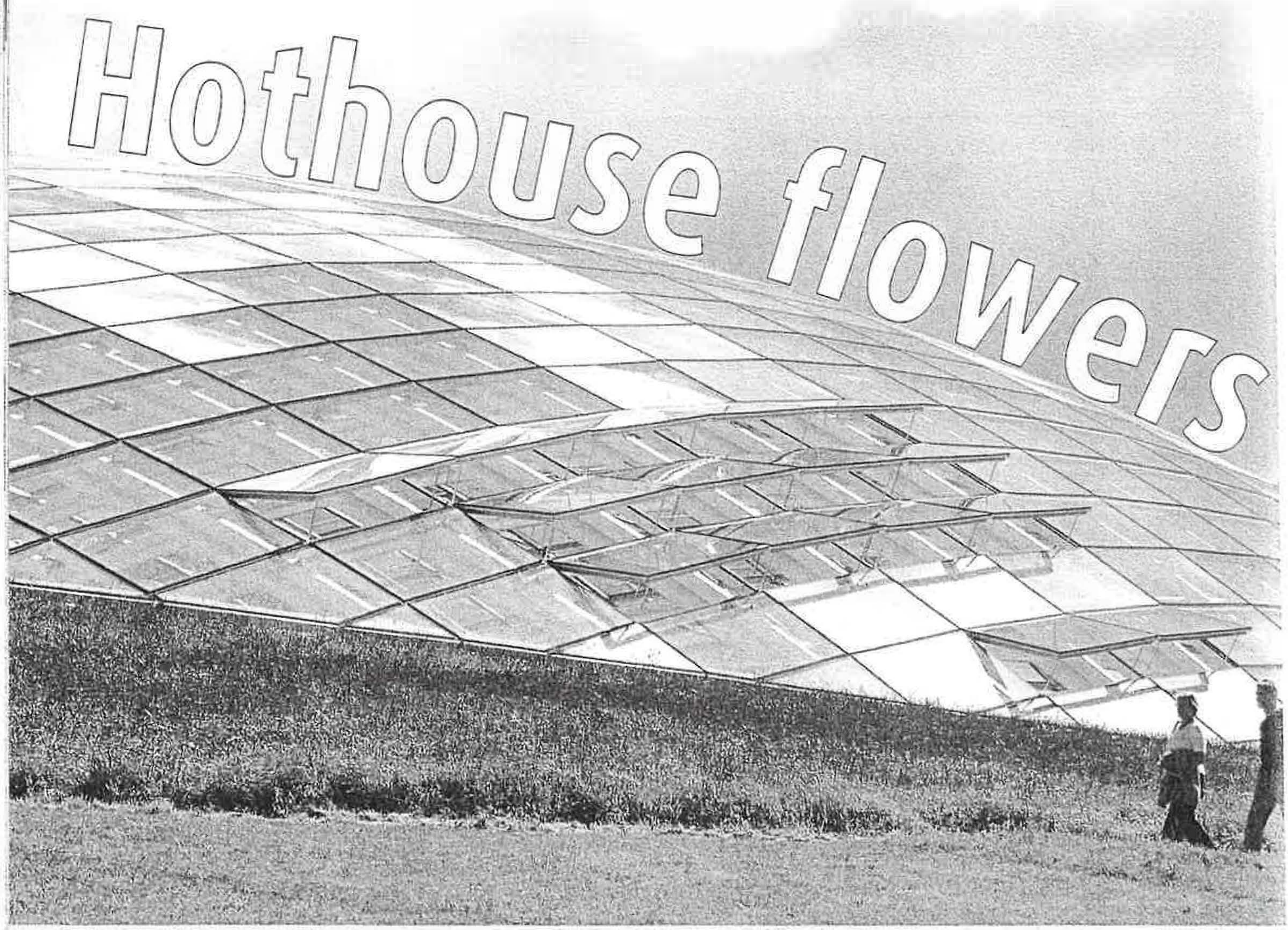
Hothouse flowers



Even when the hills have soaked up the rain and the lush green grass is bent flat in the wind, the Great Glasshouse in Wales can still offer a Mediterranean haven. But how do you create and service such an environment?

BY STEPHEN KENNETT

The plants in the Edvard Anderson Conservatory in Stockholm gave the clue, they weren't at their best. A trip by building services engineers to the Swedish city to see how others had tackled the challenge of creating the perfect environment for botanical specimens gave a revealing insight. An insight into what to avoid.

The Great Glasshouse in Llanarthne, Wales is the centrepiece of the first botanical gardens to be established in the UK for over 200 years. The initial plan was to create a greenhouse enveloping a broad range of climates, but following the all too familiar saga of trying to build too much with too little the scheme underwent a major cost-cutting exercise. This resulted in the decision to concentrate on a single Mediterranean climate zone.

The question that faced the services engineers, Max Fordham and Partners, was defining exactly what was meant by a Mediterranean climate and translating this into a building. "If you talk to glasshouse manufacturers and glasshouse controls manufacturers they can tell you a lot about growing tomatoes," said Fordham's David Lindsey. But that wasn't quite what was needed.

The trip to Stockholm highlighted two major issues. One was the need for plants to sway in the wind, the other was the importance of light to prevent spindly growth and weak stems. In Stockholm the lack of light was not helped by the northern latitude, but it was further impeded by the use of double glazing. Artificial lighting had been installed to try and combat this.

With this in mind the design of the glasshouse evolved to maximise light penetration and low-level air movement. The resulting structure, designed by Foster and Partners, is a single glazed dome, elliptical in plan and measuring 125 m by 55 m. The superstructure is canted at 7° to the south, creating a solid northern boundary to allow protection from harsh winter conditions. Twenty-four steel arches span the width of the building, the longest, in the centre, stretch across 55 m, while the remainder diminish symmetrically down to 25 m spans at each end. Sited on top of a low hill with only the glazed structure apparent the building is visually stunning, while at the same time blending into the surrounding landscape.

Heating the glasshouse

The client wanted a minimum temperature of 7°C to be maintained in the glasshouse. In the situation of a three day spell in an exceptionally cold winter this could represent a load of around 1 MW. However modelling the heating requirements for the whole site found that the glasshouse needed relatively little heating.

For the majority of the time the glasshouse doesn't require heating during the day because, with the ventilation inlets shut and normal diffuse light, there's more heat energy coming in than there is going out. By keeping the vents shut and allowing the temperature inside to rise to 11°C heat starts to be stored in the ground. When night-time comes and the temperature begins to fall this heat is re-emitted.

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The site therefore required a top-up heat source for the Great Glasshouse as well as heating for the other buildings. The designers looked at what sustainable forms of heating might be appropriate. Originally the site in the parkland of the Middleton Hall estate had been a formal garden which included five artificial lakes. These became overgrown with trees when the gardens fell into disrepair and, following the decision to restore the site, provided a ready-made source of fuel, but only a three-year supply.

This meant the garden's management were keen that there should be a long-term business plan. Other local wood sources were investigated, particularly the possibility of using offcuts from fence and post manufacturing. Potential sources were located and the case was strengthened by a change in the landfill tax which meant businesses needing to dispose of off-cuts were keen to participate. Even taking into account transportation and labour costs, the plan for burning wood proved financially more attractive than using, for example, oil.

A 150 KW Nordic biomass boiler was installed and is capable of producing 70% – 80% of the heat for the site. Two additional 600 kW oil boilers were also installed for use in very cold weather.

Traditionally greenhouses for growing tomatoes use a network of finned tubes, placed every 10 m, to provide an even heat distribution. This approach was initially considered for the Great Glasshouse but it would create implications for the landscaping. The use of a single finned tube in a perimeter trench was investigated to see what the effect on temperature distribution would be.

The biggest concern was that the cold surface temperature of the glass would create excessively strong downward plumes of cold air. A cfd model of a 24-hour overcast cycle showed that this wouldn't be the case. Although cold air builds up at the roof's centre, the building's height and the strength of the plumes meant enough mixing took place resulting in a predicted temperature distribution of ±2°C throughout.

Condensation is a problem, particularly if there is a cold night sky and during certain winter conditions. However during daytime conditions it is possible to vent the moisture, and for the majority of the year there is little risk of condensation after 10.00 h, meaning dripping is unlikely during occupied hours.

Avoiding solar gain

With such a massive glazed structure excessive solar gain was a major concern. Weather station data from Haverfordwest and Golden Grove was examined to investigate the correlation of high solar radiation and wind speed. This enabled the designers to predict that there would be sufficient wind for cross ventilation for the majority of hot sunny days.

Numerous openable vents would seem the logical answer but the cost, about £2000 more than a fixed pane, prohibited this. The vents also needed to provide good plant-level air movement so the task of optimising their arrangement was important. As the glasshouse looks down the valley in the line of prevailing south-westerly winds, the vents were situated low down at either end as well as at the top to maximise stack ventilation on a still day. Models, set up to look at the distribution of the wind pressure, found that the dome's shape provided an additional driving force by creating an area of negative pressure on the upwind side.

Overall it was found that internal temperatures would be about 4°C above outside temperatures. The only time that it may be uncomfortably hot would be on a very still day. However the plants also add to the cooling of the space through evapotranspiration, which can be quite significant as well as the effects of heat absorption into the ground and reflection.

Water source

Rainwater is collected from the dome roof and used for toilet flushing and glasshouse irrigation. There are two main back-up sources, a mains connection and a borehole. Other sources were also investigated including grey water recycling and extracting water from the lakes. The latter was ruled out because of the need to maintain a minimum compensation flow for the river supplying it and to make sure the water level of the lakes isn't adversely effected during a prolonged dry spell.

The client was convinced that there was water under the site. A hydrological study showed the existence of water but it was hard to predict exactly where. So, what do you do? A water diviner was called in, a borehole sunk and water was struck. Any doubts about the diviner's credentials were dismissed when a second borehole, sunk 3 m from the first, managed just half the yield of the original. The borehole supplies site-wide irrigation.

Sewage is treated on-site using a living machine (for more details on this type of system see *BSJ, February 2000*). The grey water from the system is discharged into the lakes and helps maintain the through-flow in times of drought. There is scope in the future to develop the concept and plant willow to clean the effluent and in turn coppice it to fuel the biomass boiler.

The Great Glasshouse aims to minimise its environmental impact and, in keeping with the building's 80 year design life, areas of potential improvement have been earmarked. Plants have never had it so good.