CORNISH PASTICHE?

BUILDING SERVICES JOURNAL, SEPTEMBER 1999

The planned Gaia Trust headquarters in Cornwall will bring together a pot-pourri of innovative renewable energy sources. Can Fulcrum successfully balance several different technologies in a single building?
By Roderic Bunn

Promoters of sustainable construction owe their thanks to Cornish farmer John Edwards. Through his sponsorship of wind power, Edwards has helped to cultivate the image of Delabole from a grim slate-quarrying town into a beacon of renewable energy.
Such has been the success of his Renewable Energy Centre that the Gaia Trust - chaired by environmental patriarch James Lovelock - has chosen isolated moorland outside Delabole for a new zero-energy headquarters. With funds from the UK Government and the EC's Thermie scheme, the Collaborative Research in the Economics of the Environment and Development1 (CREED) project is currently under detailed design by Edward Cullinan Architects and environmental engineer Fulcrum Consulting.

Both architect and engineer are striving to reduce the building's environmental impact: cutting the embodied energy content and limiting reliance on fossil fuels. It helps that there is a 4 MW wind farm in the next field, although there won't be a direct link. Instead, the building will generate power from roof-mounted photovoltaics, and hot water will be generated by novel solar collectors.

Water from the solar collectors will be stored in two thermal stores, nominally known as the 'hot' store and 'cold' store. Output from these will be used to prime a heat pump. As a possible contingency measure for the future, water from an open circuit borehole may be run through the heat pump to cope with extreme conditions.

Mechanical ventilation will be provided with very low fan power, the tempered air supplied through a floor slab composed of the hollow-core concrete system, Termodeck. This will help to stabilise the building's thermal conditions while providing both radiant and convective cooling to occupants (figure 1).

The site

The site is very exposed, so the architect has designed a low, narrow-plan,
60 m-long building running east to west. It has a curved roof designed specifically to optimise solar power.

To the north a circular earth bank will cover a narrow strip of classrooms, offices and service rooms. To the south, the deeper and more exposed portion of the building will house an exhibition area, a 250-seat lecture theatre and an audio-visual display.

The building will be simply constructed with an emphasis on sustainable building materials. The timber for the roof, slate for the columns and lime for the mortar will all be sourced locally. A small amount of concrete is used in the Termodeck slabs.

High levels of thermal insulation and a tight fabric will be major objectives, with 200 mm of insulation beneath the roof and under the Termodeck.

The vaulted roof has been designed to accommodate solar collectors while limiting the amount of timber. The cross-hatched timber roof (see figure 2) is skewed to the north to provide the solar panels with an optimum angle of incidence to the sun: 30°.

A row of greenhouses will be added in due course, to provide another heat collector and grow organic produce.

Power generation

Fulcrum is attempting to get as close as possible to a energy-autonomous building. Services designer Will Potter recognises this won't be easy, particularly given the building's role as a visitor centre and the need for a commercial kitchen and flexible exhibition area.

Fulcrum has ring-fenced what it considers to be the constant and predictable loads in the building. The annual energy target has been set at 72 000 kWh, which equates to an electrical demand of around 30 kWh/m2/y. There is no gas supply to the site.

The designers considered using the wind farm, but concluded that the sun is a better match for energy needs than the wind. They therefore opted for solar power, with a grid connection as a fail-safe when solar energy is insufficient to meet demand.

The lion's share of the electrical load will be taken by lighting. While compact fluorescent sources will be used where possible, the lighting for public areas will need to balance the low energy requirement while satisfying the need for visual appeal. Thus Fulcrum has opted for metal halide uplighters in the exhibition area, but at a low illuminance of 50 lux.

Power will be generated by two types of photovoltaics - one integrated into sealed double-glazed panels, the other based on opaque, large area Tedlar laminates. Translucent pvs are intended to permit lots of daylight through the double glazing (figure 2).

There will be a total of 120 Optisol glazed units and 176 Tedlar laminates. The clear-glass photovoltaics are BP Saturn units which have been shipped to Pilkington Solar in Germany for assembling with Optisol glazing.

The solar arrays will be separately connected to two central inverters. Once power has been converted from dc to ac, the two outputs will be combined to produce electricity for input to the main building distribution system.

The unusual solar collectors will be installed above the photovoltaics on the roof. These will generate hot water for the building's background heating system comprising a heater battery in the single air handling unit.

The absorber consists of two stainless steel plates, stamped and welded in such a way that they are offset from each other. The resulting cavities cause the water to divide into thin jets to ensure a thorough irrigation of the absorber. The panels contain 2·6 litres/m2 of water with a contact area between the fluid and the exposed surface of 97%, leading the French manufacturer, Energie Solaire, to claim a heat transfer co-efficient of 0·94 W/m2K.

The designers are hoping to create symbiotic relationship between the pvs and the solar collectors by creating an air gap between them and the roof. This will, they hope, create a solar chimney, drawing cool air over the pvs (so increasing their efficiency) while warmed air helps warm the solar collectors from beneath.

The pv panels have been designed to provide a peak output of 63 kW. Using historical weather data, the designers anticipate that the array will generate around 74 600 kWh/y.

Heating and ventilation
The Gaia building will be largely self-heating. It features 200 mm of insulation in the roof and under the Termodeck slabs, and a high efficiency air handling unit capable of recovering around 90% of waste heat. The ahu is likely to be a Menerga unit which contains motorised dampers that flip back and forth every 60 seconds, switching the air streams between the exhaust and supply accumulators.

The tempered supply air will be pumped into a builders' work duct beneath the building and injected into the Termodeck slabs. Fan efficiency will be close to the magical 1 W/litre/s: 0·58 W/litre/s for the supply fan and 0·60 W/litres/s for the exhaust.

The building's hot store (held at 40°C) will be charged during the day, and the cold store (15°C) during the night and winter. During periods of low demand the ahu heater batteries will take energy directly from the thermal stores, with extreme conditions or peak occupancy dealt with by the heat pump (figure 1).

Elsewhere, the building bristles with sustainable techniques, like rainwater recovery for toilet flushing, and a separating septic tank to store urine for irrigating biomass in the form of coppice willow.

With the building now out to tender, only a few unanswered questions remain. Will CREED, for example, succeed in striking a balance between growing the coppice willow to its full height of around 10 m without compromising the efficiency of the wind farm next door? Will the pot-pourri of different technologies hold together and deliver a sustainable development? Building Services Journal will investigate further when the project is complete next year.

References

1Collaborative Research in the Economics of the Environment and Development (CREED) aims to widen the debate on sustainable development through research into environmental economics and policy analysis in developing countries. This is achieved primarily through collaboration on research projects involving the International Institute for Environment and Development (www.iied.org) and the Institute for Environmental Studies.

Related Websites

BP Solar http://constructionresources.com/
Construction Resources http://constructionresources.com/