Skins of power - buildings as energy collectors

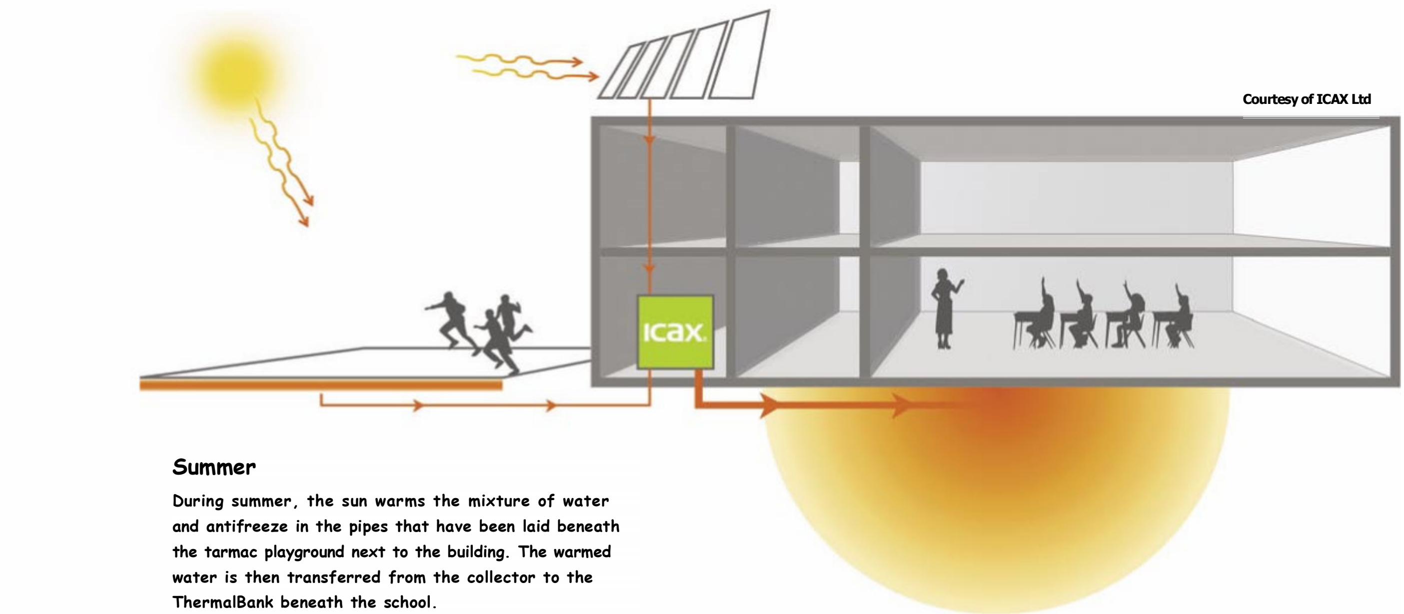
Seeking ways and means to collect and store heat across the seasons has occupied designers' minds for many generations. The search is still on for ways to make buildings into energy collectors in their own right using the power of the sun, energy from the earth, water and wind. The critical factor has been the ability to store any energy gained across the variable climatic seasons. Bill Holdsworth outlines one of the most recent attempts ...

School playgrounds, shopping centres, the forecourts of houses, town squares, airport tarmacs, parking places and roads are not inherently seen as mass producers of renewable energy. But they are, and such surfaces are being harnessed by London based design company ICAX Ltd whose patented technology provides a sustainable on-site system that was given a Royal accolade last March when the Duke of Gloucester officially opened the primary Howe Dell School and community centre in Hatfield on a site where the Comet, the first passenger jet aircraft was built in 1949. Fifty-nine years later the site has another British first, a school where the major source of energy is provided by the sun with the school playground becoming a very large solar collector which all the children can play on. John Sorrell, chair of The Commission for Architecture and the Built Environment (CABE) has been batting off 'googlies' and bouncers from the chattering classes as to whether the current school building programme could become a failure when only 13 of 3,599 schools have so far been opened.

John Sorrell declares that schools are being built that provides a better environment and in the case of Howe Dell the children were engaged in the design of the school and its community centre from the start. The head teacher, Mrs Debra Massey, has made sustainability a key part of the curriculum in teaching children ways to husband natural resources. She has created a school eco-squad who are proud that environmental principles, including school furniture sourced from locally produced or re-cycled materials, are also used to harness the power of the sun.

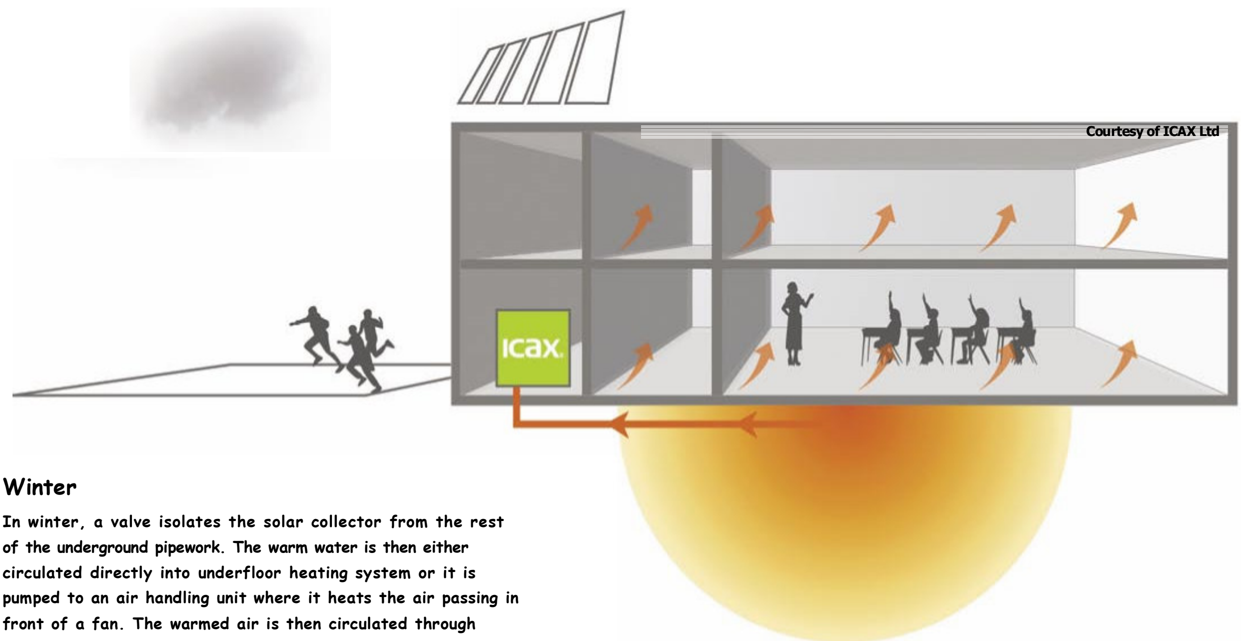
This innovative school and community centre was designed by the London architectural practice of Capita Architects, and is unique with its ecological construction methods interacting with the ground breaking solar energy system where the thermodynamic principle of direct heat transfer of solar energy is absorbed by

Howe Dell School and community centre designed by Capita Architects, with unique ecological construction methods interacting with the ground breaking solar energy and interseasonal heat storage system.



Summer

During summer, the sun warms the mixture of water and antifreeze in the pipes that have been laid beneath the tarmac playground next to the building. The warmed water is then transferred from the collector to the ThermalBank beneath the school.



Winter

In winter, a valve isolates the solar collector from the rest of the underground pipework. The warm water is then either circulated directly into underfloor heating system or it is pumped to an air handling unit where it heats the air passing in front of a fan. The warmed air is then circulated through hollow core Termodeck slabs at floor and ceiling level which passes the warmed air into the classrooms.

the surface of a 600 metre square asphalted playground. Embedded below the surface is a heat collector in the form of an array of reinforced plastic pipes circulating a liquid which, as it warms up, is transferred to two heat stores beneath the school. Here the trick has been to store the collected energy with minimal losses across the seasons to suit fluctuating demands. What has been found important is for buildings that have multiple uses during daytime and evening throughout the year's cycle of climate changes.

Over a number of years various single and hybrid systems using rock beds, natural and chemical salts and water in storage bunds have been used but without a satisfactory performance across the seasons. British architect Mark Hewitt and energy engineer Andy Ford have studied in depth the phenomena of heat migration and have developed a new and radical innovation. The technology has been made pragmatically possible since the arrival of computational fluid dynamics software that can model the heat migration in the ground over a ten year period. With such a capability the system can be installed for a whole range of buildings and urban infra-structures.

The phrase Interseasonal Heat Transfer (IHT) is used to describe this invention which is complementary to both solar and other ground source heat pump engineering systems that are reasonably well known. The difference is that IHT provides a method for the storage of heat energy in Thermal-Banks across the seasons for long beneficial periods of time. This means that excess heat generated by solar panels, chillers, asphalted roads or any waste heat sources during summer can be safely stored until it is needed.

The 20 kW wind turbine at Howe Dell School
Courtesy of Gazelle Wind Turbines Ltd

The system also has the ability to collect cold energy during winters and then store it in the ground prior to release to cool buildings in the summer. The need for summer cooling will increase dramatically as climate change raises summer temperatures especially in the examination season.

The Carbon Trust was instrumental in part funding the installation of the IHT system. Fulcrum Consulting were the British building services consultants who, along with the architects, integrated other alternative energy systems using a TermoDeck pre-cast concrete ventilation system for delivering thermal comfort conditions as well as the installation of solar panels and a photovoltaic array to supply hot water services and electrical power. Roof top solar panels are used to pre-heat water for use in kitchens together with washing and shower facilities. Surplus heat from this source is also stored during school holidays especially for winter use. 0n the electrical side there is the further addition on a corner of the school site of a 20 kW Gazelle Horizontal Axis Urban Wind Turbine to make use of the energy from the prevailing south-westerly wind; a fitting epitaph to the aerofoil propellers that took the de Havilland aircraft into the winds of change. The whole idea of the Howe Dell School is that it becomes an exemplar for the creation of schools with a zero-carbon footprint. The school was commissioned by the forward thinking Hertfordshire County Council, having taken on board the government's desire to reduce overall emissions of carbon dioxide and other climate changing pollutants by requesting the designers to incorporate a number of green technologies.

Whilst the children of Howe Dell School play on their solar collector playground, not far away and close to the M1 Toddington Service Station, the UK Highways Agency in conjunction with the Transport Research Laboratory Ltd have completed a two year trial of the IHT system on two long stretches of an access road. Last summer your correspondent visited the test station with Lord Robin Corbett of Castle Vale and Alan Simpson, a Nottingham MP. We were told that monitored results showed that the system was working beautifully. Now the full report has been made public. The results show a confidence in its future success, but to-date there has been no major announcement of this British endeavour from 10 Downing Street. Rolled out in a substantial way that in tandem with wind, wave and solar energy we could put worries associated with nuclear power to rest, but other factors are at work.

New recommendations for schools (DCSF Building Bulletin 101) require that the internal temperature should never exceed 32°C and that there should be a maximum of only 120 hours a year where the temperature exceeds 28°C. This forces architects to consider carbon intensive air conditioning in spite of budgetary constraints and the adverse implications for running costs. These parameters came from the DCSF Building Bulletin 101. They are unhealthy and uneconomical. In the early 1960's a radical school in England was built using a solar passive trombe wall with only the lighting and children's body heat to provide the warmth. I do wonder if the arbiters of these values actually understood the Laws of Thermodynamics!

To overcome this unhelpful edict there is an alternative approach which can help with winter heating and summer cooling. It involves the use of what has become known as 'Thermal Banks' to store heat from the time it is plentiful ie: summer. The reverse is true in winter. Thermal-Banks are an integral part of the IHT system. It has been found that the technology is able to "Go with the Flow" and perform a delicate balancing act over the year, instead of seeking separate solutions that are often in conflict. This lateral approach saves money and saves carbon emissions. According to director Mark Hewitt the IHT system can save over 50% on carbon emissions compared to using a gas boiler and an 80% saving of carbon emissions compared to using standard air conditioning and chillers for cooling.

The concept of using thermal banks can also be extended to buildings that have large refrigeration capacities such as technical schools or supermarkets. Using a collection array as the Howe Dell School playground or a more expensive borehole, the costly energy from refrigerators for example instead of being wasted can be stored and then used at a later date through an heat exchanger to provide warming and cooling, thus helping to reduce the overall load. With a thermal bank beneath a supermarket store of 8,000 m^2 IHT have calculated that 36,600 $kgC0_2$ would be saved against conventional gas heating, with an annual cost saving of £6,000 plus additional annual cost saving of £3,000, greater than if a conventional ground source heat pump installation were used.

Confidence in the IHT system is spreading worldwide. In Hiroshima City, Japan an IHT system is working successfully installed under license by Misawa Environmental Technology Company. Misawa are undertaking developments that are in balance with their own local climatic and geological situations. Hewitt said. "We can deliver because we really understand how heat energy migrates in the ground. We are able to calculate precisely where heat will be when you need it, what happens to it and how much is left." These are brave words for a very brave system. It is essential that Councils and other stakeholders across the British Isles take him at his word. If not then trip along to Howe Dell School in Hatfield and ask the children what they think.

As the skins of structures are being further developed to make the maximum use of natural forces, other surfaces such as window glass can now with the aid of a transparent dye concentrate and redirect light on normal window glass to photovoltaic cells in the frame which converts the light into electricity (there is an article on this later in this issue). The breakthrough means a tenfold increase in power compared to the use of the PV cell alone. Elsewhere in Europe the same innovative thinking is being used for the design of schools and the United Kingdom is no exception.

Bill Holdsworth

Footnote from Mark Hewitt of ICAX Ltd (July 2008):

The total gas spend for any school is governed by many factors: the severity of the winter, the price of gas, and the design and construction level of the building. Lets say, for instance, that a school has a peak heating demand of 200KW, and requires around 350,000 kWh (or 35 mWh) per year for heating. If IHT (which could comfortably provide this capacity) were used instead of gas to provide the heating, the annual cast saving would be around £6680, and the carbon saving around 9980 kg/Co2.

In the specific case of Howe Dell School, Interseasonal storage provides an 18 Kw base load. This will save at least £560 per year on gas. This will increase as gas costs rise by 30 to 40% a year in excess of the annual carbon saving of a gas boiler installation of some 3,400 kg/Co_2.

Insight

Dave Elliot

MICRO POWER IS NOT ENOUGH

The UK Green Building Council's (GBC) new report, 'The Definition of Zero Carbon', says that Zero Carbon Houses should generate all their own energy - and not be allowed to top up with imported power from remote renewable energy generators. However, there could be some near-site generation, as long as that was 'additional' to the national renewable programme. But basically, like the Renewable Advisory Board, and it seems the government, they want no imports.

A new report on Microgeneration from Element Energy, backed by BERR and, amongst others, the Microgeneration Council, says the same thing, although it seems to compromise on heat pumps. It comments 'the level of support for micro-generation depends on the degree to which developers are allowed to offset their consumption using off-site electricity generation and suggest a policy which 'prohibits off-site electricity, but perhaps allows electricity import for heat pumps` which it says 'should stimulate all microgeneration technologies`.

Meanwhile green energy retailer Good Energy has been arguing that houses should not be able to earn from exporting power. In a submission calling for a feed in tariff (FIT) for microgeneration they say that 'the most efficient use of micro-generation is for it to be used on site. If a customer maximises on-site usage, then they reduce their need for imported energy. When energy leaves the site, a percentage (approximately 10%) is lost as it travels on the network. Any FIT based on export will encourage microgenerators to export their energy, rather than use it on site. Encouraging export encourages inefficiency`.

However surely it's vital, in order to make micropower economic, to pay properly for any excess exported power and indeed to actually stimulate and enable the balancing, locally and if necessary nationally, of the supply and demand variations associated with each individual house? And if there is a shortfall, what's wrong with importing power from large efficient wind turbines in windy areas? Or wave farms, or tidal farms?

Of course to keep it 100% green would mean building a direct wire link to the remote site - as has been suggested for local off site power. More realistically normal grid links could be used as a common carrier, as happens with green tariff services. After all the regulations simple say that the houses must be net zero carbon over the year, which presumably means they will have grid links and would be allowed to import when they can't generate enough themselves and export when they have excess, with the net balance being zero. Surely Good Energy can't object to that?

Obviously, if they were to import more than this, i.e. more than they produce over the year, then there would have to be tight regulations to ensure that developers set up firm contracts for matching electricity used by consumers with renewable power supplied by generators, with no backsliding or changes e.g. when new homeowners took over. And it will have to avoid double counting with the ROC`s system.

This only applies to electricity. Hopefully the Zero Carbon Houses will be built so well they wont need much extra heating apart from, say, solar collectors and perhaps biomass, along possibly with a heat pump. But as Element Energy realized, they will need electricity for the later, and of course, for all the other domestic gadgets. Trying to get it all 100% 24/7 from on-site micropower seems hard, perhaps foolish and maybe even impossible.

Micro-wind seems unlikely to be up to it in most urban areas. PV solar has come a long way - there is now nearly 10GW installed around the world. But it is still expensive, and anyway it's used best in day-time occupancy buildings. If you really are insistent on 100% autonomy, that leaves biomass-fired micro CHP- as yet, an undeveloped option.

The belief is that by banning imports, these micropower technologies will improve. Let's hope so. But seeking to get 100% self-sufficiency for each house seems an odd target. Heat yes, electricity no. At the very least some contribution from near site generation will be needed, but that may not always be viable, depending on location and access to local renewable source. So a compromise on wider imports is required.

The Element Energy report is entitled 'The Growth Potential for Microgeneration in England, Wales and Scotland`. It can be found at www.berr.gov.uk/energy/micro-generationresearch

In parallel, EST and the Open University have produced a study of microgeneration heating options and their consumer uptake, entitled nicely: YIMBY Generation - yes in my back yard! It covers solar heat collectors, biomass/ wood and geothermal- all of which, as noted above, can make a lot of sense as part of the move to partial self-sufficiency.

It can be downloaded from : HTTP://DESIGN.OPEN.AC.UK/RESEARCH/RESEARCH_DIG.HTM