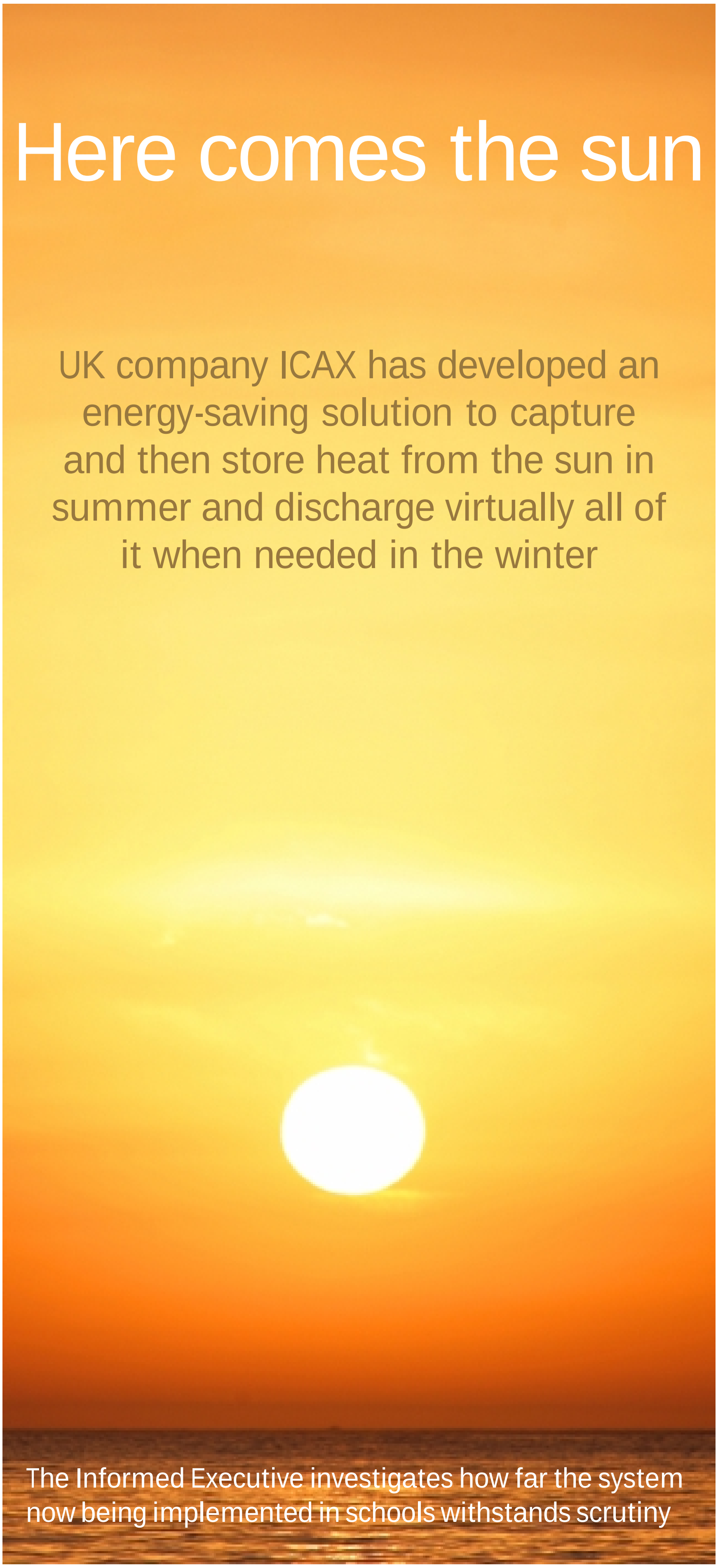

# Here comes the sun

UK company ICAX has developed an energy-saving solution to capture and then store heat from the sun in summer and discharge virtually all of it when needed in the winter

The Informed Executive investigates how far the system now being implemented in schools withstands scrutiny

Creating a chip that powers a PC is most people's idea of innovation: laying down 'cables' literally atoms apart on the surface of a semiconductor is a feat both of design and execution. Without the achievements realised in that process, there could be no laptops, no emails and certainly no mobile phones. Ignoring for the moment that processor chips can trace their lineage back a whole century to De Forest's invention of the triode valve in 1907, innovation involves pushing out the boundaries of scientific knowledge or perfecting a complex engineering process.

In describing their own developments in the field of energy conservation as being innovative, the founders of the UK company ICAX Ltd are laying themselves open to challenges from areas where leading edge principles of science and engineering are being applied.

What ICAX has developed is an energy-saving solution that captures and then stores heat from the sun in summer and discharges virtually all of it when needed in the winter. The patented process is known as Interseasonal Heat Transfer (IHT).

Some of the physical principles involved in IHT are to be found in any second-form school science text book, and the developers are not trying to claim, for example, that they can extract more energy from their heat vault than they put into it. What is this novel process that the company has exploited and, more to the point, what advantages can it bring to bear in an organisation's pursuit of sustainability?

## Installation at Howe Dell School

ICAX attracted significant press coverage – much of it from the specialist architectural and building media, however - when Howe Dell school in Hatfield, Hertfordshire, opened its doors for the first time in September 2007. How that junior school has become the first 'eco-school' in the UK is discussed at length elsewhere in this edition. One of the tenets on

# Using the lowest-cost source of energy to provide heating of school buildings is a novel but technically valid method

which the school's claim has been based, and probably justified, is the novel method being used to heat the building in the wintertime and cool it in summer. It is the first building in the world to employ the IHT process.

In a nutshell, sunlight heats up the playground surface. The heat energy is transferred through pipes underneath that surface, into the ground immediately below the school building. The energy is drawn off through the pipes which had delivered it there months earlier, and is put to good effect in the underfloor heating system of the school.

The same surface that captures heat in summer will also be chilled in the cold winter months and reduce by several degrees the temperature of another subterranean energy store to which the cold 'stream' is diverted. The ground there stays cold long enough to provide a chilling effect when 'pumped' back into the building several months later.

In terms of the possible applications for the technology, there is nothing which restricts its use to schools. So long as there is a suitable surface which can act as a collection point for the sun's heat, the principle can be turned to good effect in buildings with large car parks or even access roads.

Indeed, as the developers were able to demonstrate, the 'building' could itself be a section of road which has to be kept ice-free for operational reasons.

Heat captured from the road during summer and autumn can be stored and fed back into the surface layer in the winter. And while ice-free conditions are one benefit, there is no damage to the road from ice being formed within its surface and causing cracks. The lifetime maintenance cost of the surface is dramatically reduced. In theory at least, therefore, the applications in building and construction are limitless.

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As the lawyers are always keen to remind clients when justifying their fees, the devil is in the detail. What is to prevent the heat draining away into the earth and never being recovered?

How expensive is the special material which would (obviously) be needed to hold the heat beneath the building? And surely the cost of pumping heat down into the ground and then back again must outweigh the potential benefits? What might sound like a good idea on paper could well turn out to be less than that in practice.

## Harnessing energy flows

It was a question which had concerned Mark Hewitt, one of the ICAX directors, and the inventor of the system now installed at Howe Dell School. Hewitt, an architect by profession, had spent much of his career considering the heating and cooling of buildings; all the time seeking out natural ways of relating to the environment rather than consuming large quantities of energy fighting it.

His interest in harnessing energy flows had preceded by several years the sharp increases in energy costs, so this was no knee-jerk reaction to rising prices or, indeed, to the mounting pressure on establishments of all description to react to climate change.

Faced with considerable challenges, decisions have to be made now by the education sector which will enable it to implement the most sustainable solutions for heating

# The heat vault which stores is simply the earth and rock below the construction being heated

Lecturing at the University of North London on heating, cooling and sustainability in architecture had helped focus Mr Hewitt's mind on the problems. Meanwhile, Andrew Ford of Fulcrum Consulting – now also a director of ICAX Ltd – had been thinking along similar lines and it was that confluence of ideas in the mid-90s which generated theories about storing heat in one season for use at another point in the year.

## Computational modelling

ICAX itself was formed in 1999, when time was being spent studying the migration of heat through the ground using computational fluid dynamic modelling. It was the company's detailed predictions after this modelling that prompted the Highways Agency to award a contract for a pilot project. It was on a stretch of access road adjacent to the Toddington Services on the M1 near Dunstable in Bedfordshire that the effectiveness of IHT was first evaluated.

The independent Transport Research Laboratory (TRL) conducted exhaustive tests on an ICAX installation designed to keep ice from forming in a slip road. In a detailed report, TRL determined that the solution had performed almost exactly as predicted in the mathematical modelling of the site. The principles on which Interseasonal Heat Transfer is based had clearly been verified in practice.

## Fundamental principles

ICAX director Edward Thompson identified the single most important principle on which the company's developments are based. "It is that heat moves very slowly in the ground, about one metre a month in typical conditions.

"Another phenomenon which can be checked out – albeit with some difficulty in most instances – is that at a depth of around six metres, the temperature is consistently close to 10°C, whatever time in the year it is checked and wherever in the UK it is tested, except at high altitude."

That fact alone would suggest that heat energy put into the earth is not going to be used just to heat up sub-zero rocks in the earth's crust.

There is one more, wholly elementary principle which underpins the ICAX solution. It is that dark, matt surfaces heat up more rapidly than light coloured or shiny surfaces, as anyone wearing dark clothes on a sunny day will have experienced. Surfaces covered in Tarmacadam – school playgrounds, car parks and road surfaces – are therefore efficient collectors of heat from the sun.

## Collecting radiant heat

Whatever the application, those principles are the same, relying on radiant energy to heat up a thermal bank over time and then release the energy as heat when required. The sun is

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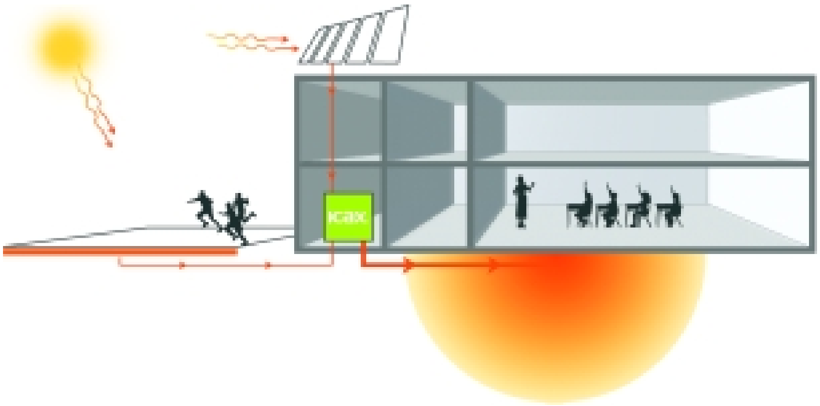
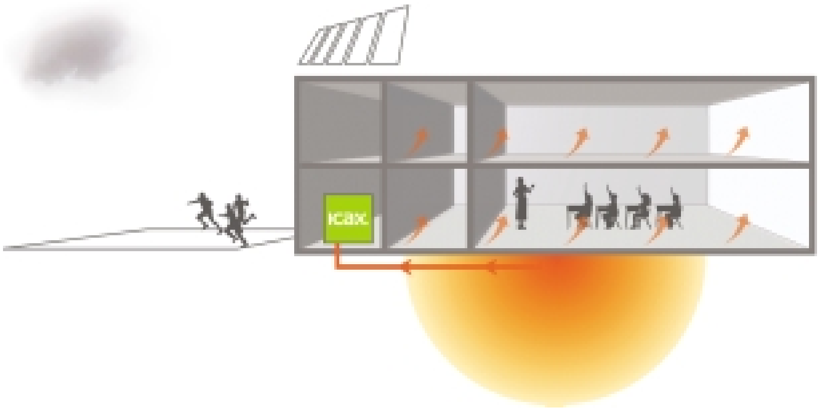


The same system was designed to keep the building cool in Summer (above) and warm in Winter (below)



sufficiently powerful in the UK from May to September (and at other times in the year when the collection process can continue) for heat to be harvested over a period of months rather than a few days. The criterion is that there exists a temperature difference between the heat capture surface (the playground in the case of a school) and that in the heat vault.

Mr Thompson outlined how these nuggets of school physics were brought together into what has demonstrably become a workable solution. “Once it was realised just how slowly heat moves in the ground, and a mechanism was found for taking it under the surface and extracting it again, there was the framework of a wholly viable application.”

Fortunately, the transfer medium is inexpensive. Piped water is near-perfect for transferring the heat. It is a good store of heat in transit and an outstanding conductor and receiver. All of these properties make it ideal for taking the heat energy from beneath the hot surface where it is collected and transferring it to the heat bank.

## Mass of earth forms heat vault

Perhaps the most surprising aspect of the ICAX solution is that the heat vault is simply the earth and rock below the construction being heated. Not only is there no expenditure on a storage medium, but it does not require a special retaining tank or insulating wall to contain it.

Building Regulations require that a layer of insulation is included in the foundations of every new building. This has the additional effect of preventing heat that is stored beneath it from permeating upwards and being lost to the atmosphere. It means that the only possible escape route for heat from the ground has been blocked off as the result of regulations put in place for an entirely different reason.

The effectiveness of the Interseasonal Heat Transfer system which ICAX developed, and for which it has secured patents on the thermal vault (the heart of the invention) and the mechanism for shallow storage of heat, would depend marginally on the nature of the soil and rocks beneath the insulating membrane.

According to Edward Thompson, wet clay soils hold the heat better than dry sandy material, but the difference is not sufficient to make the process unworkable. “It would mean that the vault area in which the network of water pipes is buried may need to be a few percent larger if the ground cannot hold as much heat energy per cubic metre. Detailed modelling is required for the different parameters

Opposite: The playground area at Howe Dell School: to the casual visitor there is nothing different about it from a conventional school playground.

# Specification for Interseasonal Heat Transfer indicates that there should be no undue limitations on its application

encountered at each location as it is vital to achieve the right size balance to match the thermal needs of each building. Would it not, perhaps, be more thermally efficient to replace the soil heat vault entirely with a water tank or a few hundred cubic metres of high quality wet clay acquired for the purpose? Thompson discounted the first option on grounds of cost: "It would require the removal of a substantial amount of earth and a leak-proof tank would have to be fabricated and installed on site.

"The cost would increase, and there would be an unacceptable risk of destabilising the building, all for a relatively small increase in heat capacity. Perhaps more to the point, it would be inconsistent with the principles of sustainability inherent in our line of thought."

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Introducing wet clay would save the cost of a water tank and provide suitable foundations for the building, but the costs involved would still outweigh any benefits, and raise valid questions about the carbon cost of excavating and transporting the material. It would suggest that the most effective solution overall is the one lying beneath the builders' feet.

## Variations in size of capture zone

The size of the heat capture zone might be expected to have a bearing on the amount of energy that could be harnessed. Clearly, a school yard thirty metres square would be able to access rather less sunshine than one thirty times its size, but within the range of dimensions encountered in the real world of education, variations in playground size have an imperceptible effect on the heat being collected.

Factors such as the direction in which the playground faces have a greater impact, however, with south-facing plots being more efficient. Finding that parts of the playground are in permanent shadow has a greater bearing than if the school is of single or double storey construction.

It is only when local property assumes near-skyscraper proportions that the efficiency of the collection area falls off to an unacceptable level, according to Edward Thompson.

The colour of the area being used for heat capture has its own impact on efficiency: traditional black Tarmacadam is clearly the best surface, but a number of such sites are found to have red surfaces. Anything much lighter than dark red reduces the viability to an unacceptable level.

Does rain water affect the viability of IHT when heat is being collected in a playground? Not in practice, according to Thompson. "On a hot day when it rains and then turns windy, evaporation will reduce some of the potential heat gains. But a computer-controlled pump switches off and avoids taking cool water down to the vault. If a day is really cloudy, we might

IHT is best suited to applications where buildings are being extended or taken down to their foundations, as the vault can be located beneath the new structure. That is the case with the schools in the Building Schools for the Future (BSF) programme, where many schools will be re-built. That is an ideal opportunity for installing energy-saving technologies

not collect much heat energy at all, and the pumps do not switch on. That really is not a problem, however as so much heat comes from the sun that we do not have to catch all of it."

If the ICAX concept has one limitation, it is that Interseasonal Heat Transfer (IHT) systems are best installed when a building is being constructed, or at the very least undergoing refurbishment which exposes the foundations. While the thermal bank does not have to be positioned under a building, other locations incur the cost of an insulation capping, which is free when there is a building above them.

It is clear from the technical specification of the IHT technology that there is plenty of latitude in the conditions encountered before performance drops off unacceptably. Compromises, such as solar thermal heat capture on the roof of a building rather than from a playground or car park, achieve acceptable levels of heat capture and storage, but at a greater net cost.

It would follow that Howe Dell school was a near perfect site for installing IHT as it was a new building on a former runway. It involved a two-storey building, had a suitable playground surface and was south-facing.

Not all of the projects for which ICAX might be considered are as sharply defined as Howe Dell: there are relatively few schools being built right now from the ground up, requiring compromises and a proportionate loss of efficiency.

Mr Thompson saw more important issues than the construction alone: "The building should be viewed in its totality. Any development with a low carbon footprint should be well designed, well built and well managed. In the case of a school, there are inevitably issues with teachers who leave windows open, for example."

## Practical application of IHT

The IHT technology had been proved to work in the near-laboratory conditions of a roadway, and Howe Dell provided a chance to roll it out in a building project. The design was subjected to computer modelling to check that the scale of the proposed installation was appropriate to the task. The implications of the proposed ICAX solution were sufficiently great for the Carbon Trust to fund the IHT at Howe Dell.

The ICAX technology has been licensed by Misawa in Japan for this experimental site at Hiroshima, where the area to the front of the picture is being kept free from ice and snow using heat captured during the Summer.

While the cost of adapting IHT to the needs of the school, and then implementing it on the site were borne in this instance by the Carbon Trust, it does not follow that every subsequent school seeking to 'turn green' should be lining up seeking a contribution. Having established that the principles can be turned very rapidly into practice on a 'live' site, ICAX is now in the marketplace offering a solution that is wholly credible, and a cost-effective alternative to gas or oil-fired central heating in public buildings.

Where does ICAX go from here? Clearly, there is the public sector, with its greater emphasis on carbon reduction techniques than most private sector organisations: ICAX has installed a solar collector system at HM Prison Garth in Lancashire. In addition to new buildings, transport undertakings provide a natural target, given the early success of IHT with the UK's Highways Agency. There is a real demand that transport can operate under adverse weather conditions: the fact that the technology reduces long-term maintenance costs increases its attractiveness to the sector.

One potential target is the aviation industry, where airports can be closed down at short notice due to icy conditions on the runways. As Edward Thompson noted, there could be a few logistical problems on that front: "The economic pressure on airports means that runways are re-surfaced overnight, so that would not give us much of a chance to install the network of pipes. But the case for IHT in such circumstances is a strong one: it would extend the life of runways by ten to fifteen years in practice."

ICAX Ltd is a British company whose time has come. Its installations are the result of painstaking research and modelling where the predictions are being borne out. It is not a panacæa for the energy ills of public buildings. But it does provide a solution that is classic in its simplicity; novel in its application. §

Further information about Interseasonal Heat Transfer can be found on the ICAX Ltd web site at www.icax.co.uk