#5949

Lessons in low energy

by Ken Spiers

Low energy buildings are back on top of the construction agenda. Ken Spiers looks at the latest work undertaken by architect Rick Mather at the University of East Anglia, where very low energy student accommodation is currently under construction.

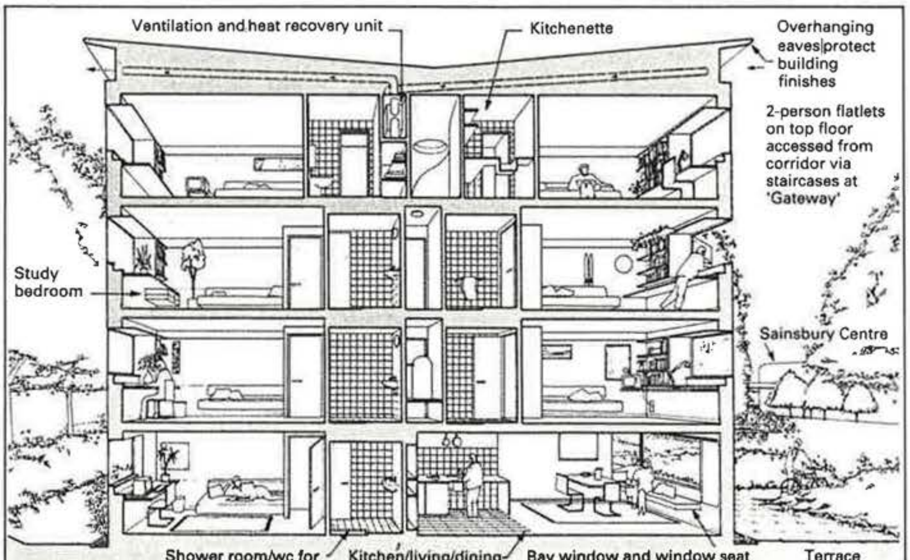
Deluxe detached house, located in quiet, prestigious residential area, four sizable bedrooms, two reception rooms, surprisingly spacious lounge, luxury fitted kitchen, superinsulated - no heating necessary.

In a classified property advertisement of the future, estate agents will list 'no central heating' as a big plus point, along with the energy rating of that home. Market forces and government pressure will eventually dictate that low energy building becomes the norm, rather than the exception.

However, all the necessary technology is available now – modern super-insulated dwellings do not require heating systems. All the necessary heat input comes from the occupants, lighting, etc.

Admittedly, building to a higher specification with greater levels of insulation in the fabric increases costs. But the net cost for a new building remains the same because such a structure does not require a substantial heating system. The addition of a mechanical ventilation and heat recovery system is often the only investment required.

Any additional heat, probably only needed at times of extreme winter temperatures, can be provided by very low wattage panel heaters. The drop in winter running costs is consequently dramatic.



Above: Schematic showing cross-section of the student accommodation at the UEA.

"Low energy building is simple, e
tive, very reliable and well-proven; it is
the way building practice has to mo
claims Andy Ford, partner at consu
Fulcrum Engineering, who is working
architect Rick Mather on a project a
University of East Anglia (UEA).

At the UEA, Rick Mather has desi
student accommodation which relie
gains from occupancy to provide the ne
sary heat input.

Practising low-energy architectur

An American based in London, Math
one of the UK pioneers of energy effi
building design. The student resid
project, now under construction at
UEA campus near Norwich, will be
largest low energy residential buildi
the UK.

Mather's practice was the ideal ch
for such a project, as he says: "It has al
been the policy of this practice to pro
energy efficient building. If you care fo
future of the planet, it is the only resp
ble way to build. Any other type of
struction is just antiquated design pract

"At the start of a project we explai
environmental and economic benefit
the low energy concept to our clients.
also outline additional benefits like
proved comfort and better air qu
which are not as easily measured a
energy bill, but are still very importa
says Mather. "Once they are aware o
overwhelming evidence in favour of
technique, people are willing to try it."

The initial computer modelling on
UEA project was carried out by Halc
Gilbert Associates. "The stand
achieved at the East Anglian student
dences are roughly on a par with Scand
vian building practice, apart from the g
ing," said Halcrow Gilbert consultant
Ruyssevelt.

Rick Mather's interest in low en
building goes back to the first house
designed for his sister in Canada.
building is about 480 km north of Edm
ton, Alberta where the winters are sev
The design temperature is −40°C, and
occasions monitoring has shown that
inside house temperature, when uno
pied in these conditions, only drops
+13°C.

Despite the winter ambient temp
ature, the house was designed without

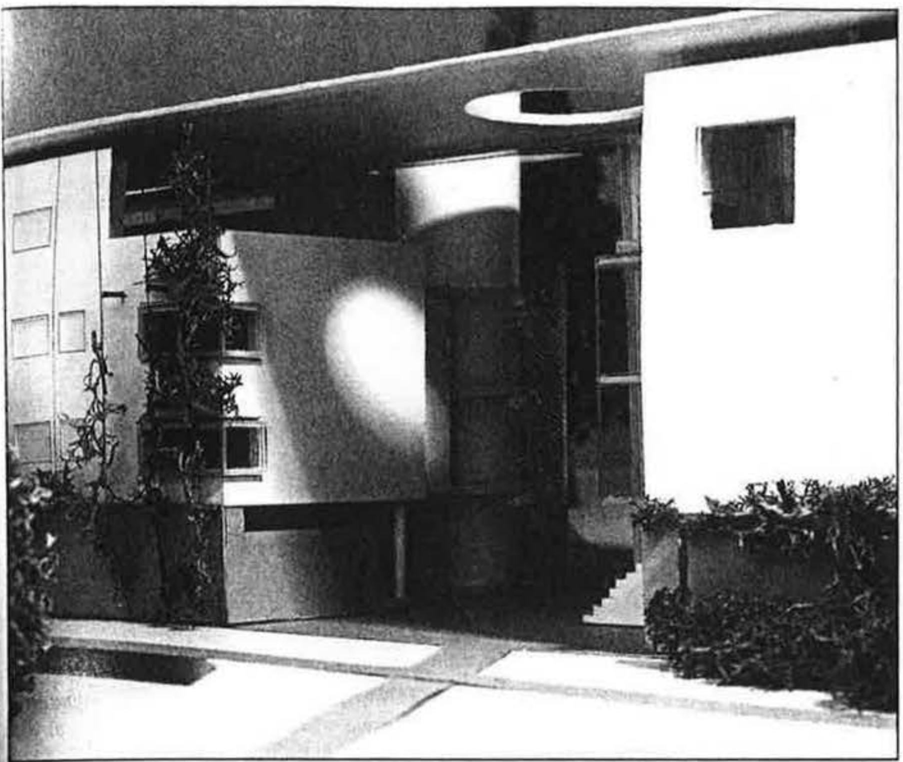


Figure 1: Architectural model of the student accommodation. Note heavy use of solar shading.

need for a heating system. The detail of the structure and application of insulation was based on research work carried out by the University of Saskatchewan.

The building was manufactured using two timber wall structures made of 50 × 100 mm timber studs with a 200 mm interstitial gap in between. The internal frame is filled with 100 mm of rockwool, and sealed with a plastic membrane. Care was taken in construction to ensure this was not damaged or penetrated by the services installation.

The 200 mm gap is also filled with insulation, as is the outer framework which is faced in timber. All the windows are double glazed. Heat input is provided by heat recovered from the mechanical supply and extract ventilation system. There is also incidental heat from the sealed wood cookstove, which has its own external air supply.

By far the majority of the heat comes from occupants and equipment such as the electric lights. It is either transmitted directly by convection in the room or indirectly by recovery from the exhaust air.

Water collected from the roof is saved in tanks in the basement which act as a thermal store.

The UEA project

At the new student accommodation on the campus of the UEA, dynamic computer modelling showed the effect of similar energy efficiency measures. This allowed Mather to optimise the effectiveness of his design, particularly the energy consumption.

The UEA accommodation is effectively a series of terraced houses. According to Mather, this gave an instant advantage. "By reducing the external walls to only front and back you are always going to be better off than with detached dwellings. And, similarly, putting the rectangular study bedrooms with their short side outwards reduces the external wall area to a minimum.

"However, maximum use will be made of the light available on that outer face. The window has tapered reveals, reflecting light to the internal regions and helping to reduce the artificial lighting load. All the windows will be double glazed and fully openable for summer ventilation. Low emissivity glass will be used in all the large glazed areas."

Mather also gave particular consideration to sun shades above the large south facing windows, which were designed to admit winter sun and cut out summer sun (see figure 1).

An investigation into current best practice in Scandinavia and Northern Europe was inaugurated by Mather's practice to set new criteria for construction – in effect, much more stringent *Building Regulations* for this project. Paul Ruyssevelt of Halcrow Gilbert explains how these high standards were evaluated and decided upon.

"A model was constructed for each of the four zones in a 10 person unit, which accounted for the internal gains. As detailed data on student occupation patterns were not available, we looked at both normal and high occupancy levels."

In order to speed up the process of considering thermal insulation levels, the options examined were limited to the extremes: *Building Regulations* at one end and the superinsulated unit at the other (table 1). Additionally, two variants of superinsulated unit employing low energy lamps and low emissivity double glazing were looked at (table 2).

Furthermore, the airtightness of construction, not yet covered in the UK *Building Regulations*, was also set down. A level of one air change per hour (ac/h) when the building was pressurised to 50 Pa was chosen, equating to an infiltration rate of 0·1 – 0·2 ac/h.

Air quality will be maintained in this well-sealed structure by constant mechanical ventilation. This provides extract from the shower rooms and kitchens along with a supply of fresh air to the bedrooms and living rooms.

The system pre-heats supply air with heat recovered from the exhaust flow via a plate heat exchanger. In the shower rooms, extract provides 6 ac/h while supply flows produce 1 ac/h in bedrooms.

Table 1: Design options assessed

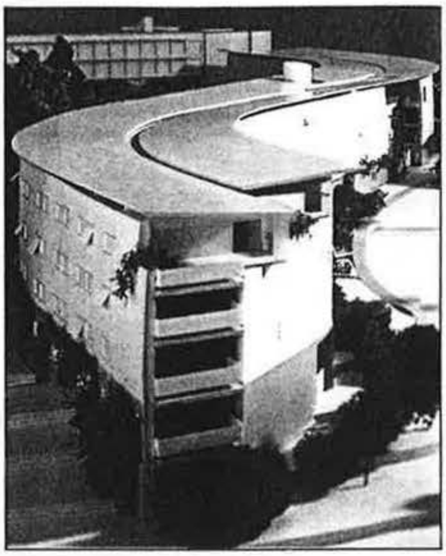
	Building Regulations 1990	Superinsulated with passive ventilation	Superinsulated with mechanical ventilation
U values (W/m²K)			
Walls	0·45	0·22	0·22
Roof	0·25	0·15	0·15
Floor	0·3	0·18	0·18
Windows	2·8	2·8	2·8
Ventilation heat loss (ac/h)			
Winter	1·0	1·0	0·5
Summer	6·0	6·0	6·0

Heat recovery in the ventilation system reduces the effective heat loss due to ventilation by over 50%
Ventilation rates will be achieved by opening windows to provide cross-flow ventilation

Table 2: Energy performance of options

Annual auxiliary heating	Building Regulations 1990	Superinsulated with passive ventilation	Superinsulated with mechanical ventilation
Energy (kWh)	12265	8196	333
Electricity cost (£)	538	360	15

Energy for running fans in option 3 (kWh): 2000
Addition for low energy lights (kWh): 500
Reduction for low emissivity double glazing (kWh): 547



"The ventilation system was designed with low duct air velocities to minimise the fan power requirement," explains Andy Ford of Fulcrum Engineering. "Because of the use of displacement ventilation in the bedrooms there will be a higher temperature difference between the extract air and supply air, which results in efficient heat recovery.

"Ventilation Jones, the manufacturer, is supplying a system whereby fresh supply air, about 1-2°C cooler than the occupied zone displaces stale air up to a height of about 1·2 m. Thus, when sleeping or working at a desk the students will always be breathing 100% fresh air," adds Ford.

The system will run continuously but in the communal areas a CO_2 sensor will reduce ventilation rates when occupation levels are low. Any resulting fluctuations in total flow rate will be catered for by a variable speed fan.

The results in table 2 show the significant saving in energy as a result of using superinsulation and mechanical ventilation with heat recovery. It can be seen that a large proportion of the saving will be attributable to heat recovery from the ventilation system.

Summer cooling

To investigate potential problems of summer time overheating with a superinsulated structure, computer simulations were carried out for a summer design day with high levels of solar radiation and high ambient temperatures.

These studies show that due to the thermal capacity of the structure, the internal temperature does not exceed the daily external maximum in either the superinsulated case or the current *Building Regulations* case. In fact, the temperatures experienced in the superinsulated building and in a building to today's standards are so close that our bodies would have difficulty in detecting the difference.

During the summer months, in addition to the opening of windows, the mechanical ventilation system can supply ambient temperature air for cooling. In order to do this, a bypass to the heat exchanger will be activated when the ambient air temperature rises above 19°C.

Electric panel heaters rated at 250 W will be fitted for the relatively short heating season. The modelling shows that a heating season of just six weeks will be the average. However, the main use of the heaters will be for initial warm-up from an unoccupied state. When occupied, each room will have no significant heat demand.

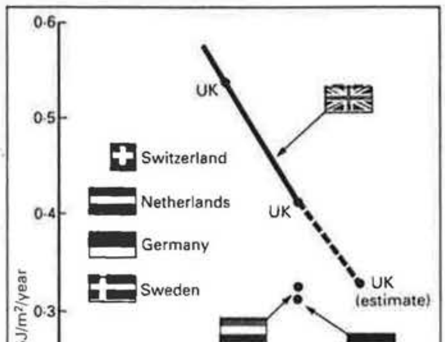


Figure 2: Graph showing the trend in European building regulations towards lower heating requirements.

All energy consuming equipment such as refrigerators and freezers is specified as high efficiency. Artificial lighting will be provided by high efficiency, high frequency fluorescents throughout.

Pushing low energy

There is no doubt that low energy construction is the method of the future for houses and other buildings, because there is no sensible alternative.

Those who already have experience of low energy buildings vouch for them: in areas like Milton Keynes, inhabitants of superinsulated houses know the benefits and will not settle for anything less. The low energy houses are viewed as very attractive properties, being both comfortable and cheap to run.

Builders, developers and everybody in the construction industry must raise their standards and start to build tight structures with high insulation levels and mechanical supply and extract ventilation.

The next round of *Building Regulations* should provide some stimulus to the industry. It seems likely that the new *Regulations* will include building air tightness specifications and may encourage the use of fan ventilation systems with heat recovery.

Conclusion

Figure 2 shows how European building practice is showing a trend towards zero heating requirement. Over the next few years we will reach a point like that at the UEA student accommodation, where a minimal system is installed for a much reduced heating season.

As heat demand falls, a much more significant proportion of the energy requirement is used for lighting, hot water and ventilation fan power. Increasing attention must be paid to all these areas to sustain progress.

A lower heat input per square metre of building means more opportunities for all-electric solutions. It becomes economic to employ small electric water heaters and space heating. In commercial and industrial buildings, as heat input is decreased, control by heat pump heat recovery and thermal storage techniques will increase in popularity.

Experience in the East Midlands bears this out – the proportion of all-electric new houses has risen to 25% and is steadily increasing. Rick Mather, for one, takes a bullish view and can see no reason why an approach such as that adopted in Switzerland cannot be applied in the UK. All households would be required to raise their standards of energy efficiency within a given time limit.

Measures to improve energy efficiency could even be subsidised with easy methods of payment or government grants to aid householders to carry out necessary work. Alternatively another approach, like inducements via tax relief on energy efficient devices or building materials, could be used. The precise method of provoking or promoting action does not matter as long as we make it happen.

This article was partly based on a presentation by Rick Mather, given as part of the East Midlands Electricity guest lecture series at Nottingham University.

Ken Spiers is head of environmental systems at East Midlands Electricity, Rick Mather is principal of Rick Mather Architects, Andy Ford is a partner of the Fulcrum Engineering Partnership, and Paul Ruyssevelt is a consultant with Halcrow Gilbert Associates.

Figure 2 courtesy David Olivier of Energy Advisory Associates