

## Paper No: 443. NAVAN CREDIT UNION - ECO OFFICES:

### Post Occupancy Evaluation and Reflections.

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**Keywords: post occupancy evaluation, multi storey timber structure, venturi, natural ventilation deciduous shading , active solar, clay products, eco cement.**

The full power-point oral paper will document, with detailed quantitative and graphic results, the design summary and detailed outputs from several years of assessment, and iterative fine tuning, of a completed five storey eco office building, Navan Credit Union (2005), with many passive and low energy design features – see below.



#### 1. Introduction

1.1 Architects, design teams , don't much like post occupation evaluation by others, including us ! Conferences tend to tell 'good news' but this can be false and misleading. In sustainable design there is often delusional thinking, but the verified outcome is what really matters , often quite different from the design predictions. We try to 'learn by doing' in collaborative forward cycles, and so wish to openly share in this paper positive and negative lessons learned, rolling forward into later work.

1.2 The design was presented in a paper to the SB05 World conference in Tokyo 2005 <sup>[1]</sup> and this will not be repeated here. This paper documents, with detailed quantitative and graphics, and outputs from **several years of assessment**, and iterative fine tuning, of the building, with many passive and low energy design features. A quick summary of the design includes:

1.3 Five floors + roof office building completely of engineered timber structure and fabric; Swiss / German engineering and technology (Pirmin Jung; Projekt Holzbau Merkle) within an overall ecological design philosophy ; Brettstapel;Kerto .(

Displacing concrete and steel while meeting many stringent criteria of Eurocode 5 , fire safety issues etc .): Combined Primary-energy use target = 150 kw hrs / sq m per annum (revised) . Natural ventilation using a double wall of glazing; (engineered composite timber window systems with trickle ventilation devices). Passive solar chimney and a roof-light ventilator on the Venturi principle to assist natural ventilation via an atrium: Passive solar space heating; carefully oriented space planning : Passive cooling by deciduous shading , night purging; undercroft plenum: Very strategic, limited, targeted auxiliary heating and cooling; gas heat pump source: Thin-shell clay rain screen cladding on timber battens; very careful application of embodied energy for long life / durability : *Baubiologie* principles adopted: clay plaster interior finishes : integral blind systems: cellulose insulation; vapour check 'breathing wall': Eco elevator - 5 stops - No Machine room - in shaft low energy electro mechanics: Transport -Modal split away from the private car : restricted parking: generous, secure bicycle parking facilities for both members and staff : showers ,changing facilities and lockers: Owner –occupier client : Life Cycle analysis: Community ownership of a financial institution: Participative group process with members, board and staff: Sustainable urbanism contribution in macro scale: All

externally sourced electricity from renewable sources; natural gas fired heat pumps: Photovoltaics, powering servos for intelligent BEMS system and for water pumping of harvested rainwater: Solar Thermal panels for hot water supply: Green roofs for oxygenation, insulation and amenity: Green terraces for respite and stress relief: Peace Garden dedicated to global respect, solidarity and understanding.

1.3 Independent evaluation by the Useable Buildings Trust <sup>[2]</sup> will be shown (As certain remediation and monitoring is still current at the time of this deadline the paper has reached the penultimate stage and the final oral power-point paper will include results of monitoring after completion of remediation) <sup>[3]</sup>

1.4 Lessons learned are frankly described drawing conclusions from the parallax between design intentions and experienced outcomes with a view to continuing design development in this field.

1.5 'Budging BAU' (Building as Usual) how a catalytic project can affect mainstream building practice, where entrenched vested interests otherwise lead to widespread repetition of unsustainable settled practices, frustrating the necessary paradigm shift required to avert gross environmental degradation of human habitat. Ireland is emerging from an overheated "tiger" economy – the majority world of China, India, Africa, Latin America, look to Europe and elsewhere for paradigms of development in prosperity; the duty of care to show that it is possible to have prosperity and ecological design is hugely important, as global warming and ever increasing pollution continues very rapidly, as these economies emerge from poverty. Ireland has not been doing well overall with a per capita carbon foot print double that of Sweden. This exemplar addresses these issues of global degradation of human habitat, now threatening us human beings, even with very extinction.

## 2. POSITIVE LESSONS LEARNED

2.1 The building is successful overall and is very well liked by the staff and members of the Credit Union, by independent interviews, coming in the top 5 % of all buildings surveyed by the Usable Buildings Trust.(Fig 1) <sup>[3]</sup>

It has attracted national and international attention as setting a precedent for an office building of five stories in timber with many ecological features <sup>[4]</sup>. The holistic *gestalt* is a success being a combination of many design elements from form colour, texture, materials lighting. We would like to think that it exemplifies

the **beauty of sustainable design** or, as we call it, **ecotecture**.

The Venturi Ventilator roof light is very successful for 'heavy hitting' ventilation with velocities of 7 to 8 metres per second recorded there; it has proved very useful when enhanced ventilation is required to avoid overheating in shoulder / Summer conditions.

The Solar chimney has been equally successful, more as a fine-tuning ventilation device useful in shoulder and winter conditions, if mild weather occurs; volumes of 1 cubic metre per second are recorded, giving excellent enhanced ventilation in sunlight, naturally in phase with demand when required.

The BEMS has been refined in programming to bring these devices into play in conjunction with the double façade at ground level and the box windows, using trickle ventilation.

## 3 GENERAL LESSONS LEARNED

3.1 Initial Energy targets were set, more in hope and best endeavours, than in hard science. In practice a combination of factors has brought us to the realisation that a figure at 150 kw hrs / annum is achievable. The reasons for this include staff behaviour which stretches across a wide band of demeanours. One staff member keeps heat on, cooling on and the windows open at the same time! Contractual failures by the major M&E subcontractor have been protracted in remediation. Very basic failures to properly instal quite conventional condensing gas boilers, modulated and in tandem has led to temporarily, during last winter, heating the building using gas-driven heat pump air-conditioning units!; this has proved inefficient in terms of gas use and is currently being rectified but it has temporarily skewed the energy consumption figures. Later figures will be better, now current boiler parts replacements are complete; final results will be in the presentation in October 2008.

3.2 Electricity; first of all the whole building is connected to the Airtricity supply company, so the source is wind; moreover the electrical environmental / control systems are as much as possible connected to the photovoltaic array with five day storage in a battery set with inverter; this reduces grid use for the like of servo actuators on double façade / window systems, certain destratification fans and pumps associated with the rainwater capture and treatment systems to avoid the eco provisions themselves becoming an energy burden. The main lesson learned was that we had underestimated how much we could connect to the PV system and as we gradually increased the load on the PV we also found that we had to increase the size of the inverter; in future we are more ambitious about how much we can rely on PV especially as the new generation of much more efficient and less costly

PV comes to market. Payback is improving but the Summer of 2008 has been the worst on record ! .

As far as possible we have taken care, for emf reasons, to avoid circuit wiring around the perimeter of occupants in rooms and have used the rose system of divergent wiring from a centre. In the final paper for presentation we hope to provide some monitoring measurements in Tesla with lessons learned especially for long stay work stations .

### **3 NEGATIVE OUTCOMES: LESSONS LEARNED.**

3.1 The use of an open atrium building, for good spatial architectural and conceptual reasons, is not necessarily optimally vindicated where sedentary staff work at ground floor of the atrium ; the problem of winter conditions at start of the working day is that as staff arrive on cold mornings in a building chilled from prolonged dark and cold overnight conditions the inevitable tendency of a lofty void to stratify, makes it difficult to quickly heat the sedentary zone to comfortable temperatures ; staff are especially comfort -conscious at this time of day ; in the future we would use an atrium ground level only for circulation or concourse space (or dining at lunch time for example) or would introduce a translucent membrane / controlled horizontal glazing at soffit level of the void above the level .(See Fig 4). Careful zoning of the heating system and localised heating at foot level in the original design has helped to offset this problem.

3.2 The undercroft space, below ground floor intended for tempered air (either cooling in summer or warm in winter), is a good generic solution but that space should have been built absolutely watertight, easier to access and keep clean ; several episodes of flooding due to a failure of the municipal services nearby (several incidents of a burst water asbestos cement water main – now replaced -and later a failed foul sewer coupled with construction flaws in water proofing services penetrations of the structure) caused great upset and concern and has discoloured the staff view of air from the undercroft , despite cleanup and through sterilisation. In future we would tend to use this device in the form of a large diameter air culvert dedicated to that purpose only ; lined with cleanable material inside and fully accessible to a standing male for cleaning; laid to falls to a sump and water tight .This would perhaps be a very large diameter low cost precast concrete pipe or culvert section, sealed and lined .

3.3 We had troubles with a draught lobby opening straight into the Banking Hall ; (see fig 3) there is a conflict between wanting universal access requiring the use of automatic doors . At times of high foot traffic the cold air intake on each door action caused staff discomfort, especially when

the winter wind was from that quarter, the North East ; we have solved the problem by making a large draught lobby inside the outer doors and refining the timing on the automatic controls on the outer and inner doors and orienting the inner set of doors so that any draughts are directed away from reception / counter staff to avoid direct discomfort conditions; the lesson learned is to balance regulations and extreme concerns about health and safety with common sense in the placing and timing of automatic doors.

3.4 Auxiliary Cooling . In the original 'light green ' building which we designed here in the mid 1980s, and to which this building is an addition, we went for a high thermal mass solution with some passive solar elements ; this worked well except in very high summer when the staff experienced discomfort as the thermal mass could not quickly be purged of unwanted gains; there was no auxiliary cooling . Night purging was rejected because of extreme concerns about security in what is effectively a bank. When these same staff were moving to the new low-thermal- mass building extension, they carried the impression with them that auxiliary cooling was essential and demanded its inclusion ; this was not really objectively necessary because the devices elsewhere noted addressed the issue, as part of the evolution of office design ; eg the deciduous shading ; the use of only one stairwell (with apex purging) as a passive gain space , the undercroft for tempered cooled air , the enhanced passive ventilation via Venturi rooflight and solar chimney. The staff are psychologically attached to the individual unit coolers and tend to overuse them, skewing the energy figures. If repeating the exercise we would not use auxiliary cooling at all in the Irish climate but in this case the staff's psychological predisposition was too strong and it was our own fault. We are still working with management to 'wean' them off this comfort cooling and by setting an overall threshold veto temperature while working to get a team spirit going for energy use reduction and to use the passive cooling systems optimally.

## **4 Monitoring Outputs**

Standard Controls Ltd have installed a BEMS which , through their Declan McDonnell , allows us to remotely, by modem, keep track of what is going on, and change parameters remotely if need be ; web-based meetings have allowed us to review at interim stages how the building is performing and iteratively optimise results. This process is ongoing, but will have settled down by the time this paper is presented orally in October 2008, with final results of this monitoring period available.

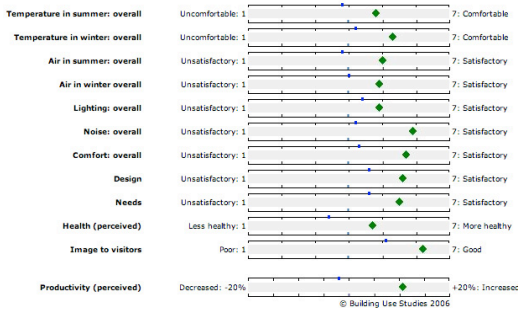


Fig 1. Summary results from Usable Buildings Trust; Blue Mark is normative; all green, above norm, on 'traffic light' scale (see Fig 2 below for more detailed assessment for some reds and ambers)

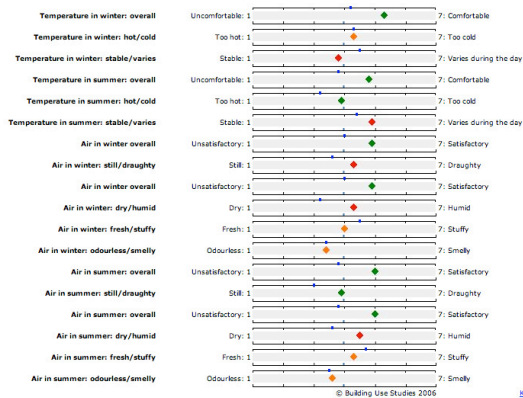


Fig 2. More detailed Useable Building Trust Assessment Blue Mark is again normative :some reds and ambers show lessons to be learned and corrected during monitoring / remediation.

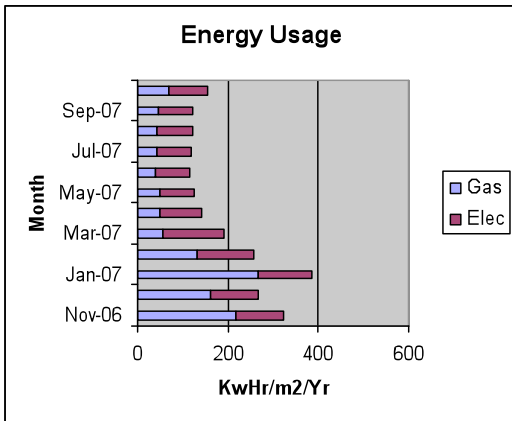


Fig 3(a). Overall energy monitoring results to Oct 2007 from Nov 2006 expressed as KwHrs / sq M /annum and not normalised: early anomalous results during commission and test phase are notable

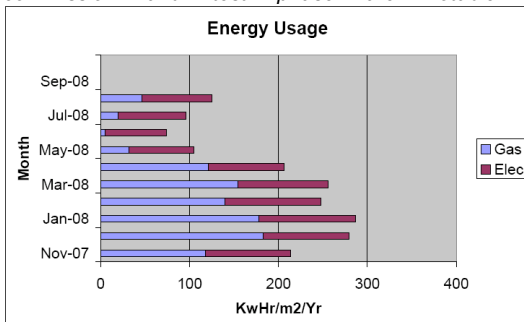


Fig 3 (b) Results from Nov 07 to Aug 2008 show we are converging on 150 KwHrs / sq m /annum , a realistic

de facto target for best practice office buildings. We hope and expect to improve on these figures.

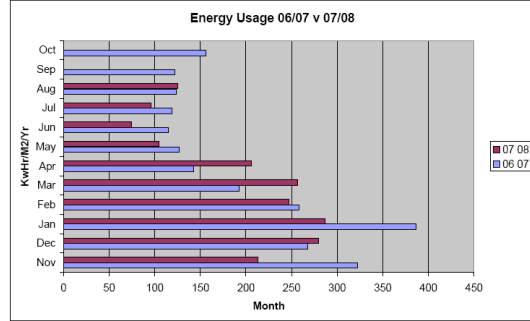


Fig 3 C Comparison of gross primary energy 06/07 and 07/08.

Although the Winter 07/08 are badly skewed upward by boiler problems (for reasons noted in the text) where 'air-con' was used for auxiliary heating purposes, the winter peak was much less than the previous year (to be updated Oct 2008 before presentation of the paper ).The boilers have just been fixed at the time of writing.

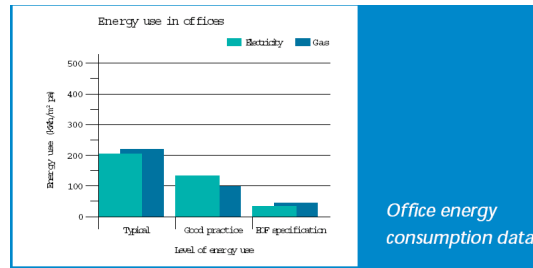


Fig 3 D Typical Good / Best / Excellent Practice Reference (BRECSU)~ 400 to ~100 KwHrs / sq m / annum

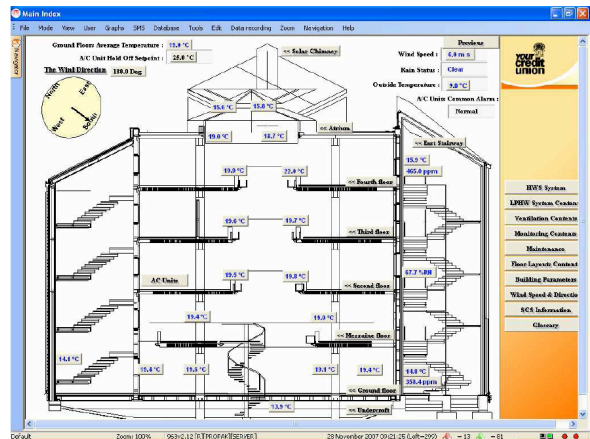


Fig 4. Whole Building Image with temperatures and CO2 levels Overall monitoring is by review of this whole building image :this can then be interrogated, live, to give specific results, such as those in the figures ; this allows for targeted responses and interventions to synergise at the elements and optimise results overall .

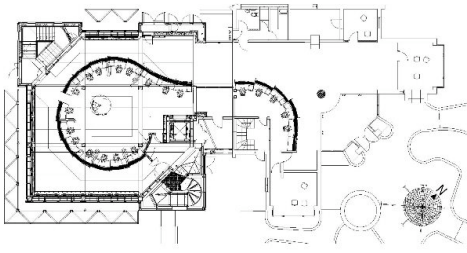


Fig 5. This schematic plan shows the old (rhs) and new (lhs) illustrating the difficulty in open plan of joining two open plan buildings together; one high thermal mass passive solar and the other, low. Problematic lobby on rhs; Atrium above centre of circular service counter.

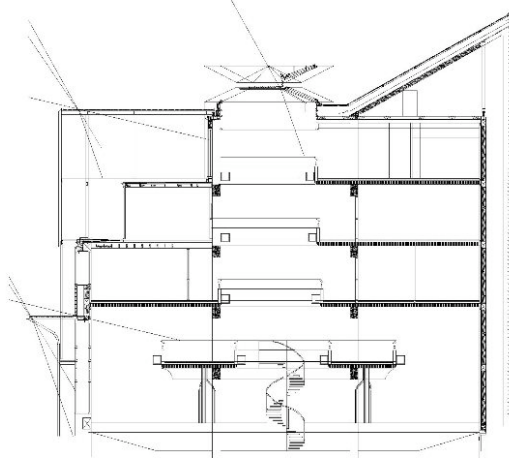


Fig 6. This schematic North (rhs)- South (lhs) section shows the undercroft; deciduous trellis at ground level banking hall double façade; atrium above centre of circular service counter; mezzanine, a combination of open plan and cellular offices at intermediate floors, south terraces for community room, canteen, manager, at top floors; the Venturi Ventilator and solar chimney on the plant room roof

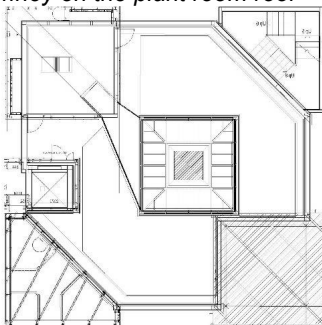


Fig 7. This schematic ROOF PLAN North-South (on diagonal; south vertex is bottom right) shows the Venturi roof light above atrium in centre; solar chimney over North plant room top left, Glazed stair facing East and opaque stair facing West and shading spaces from unwanted late gains, and shaded external southern loggia to bottom right.

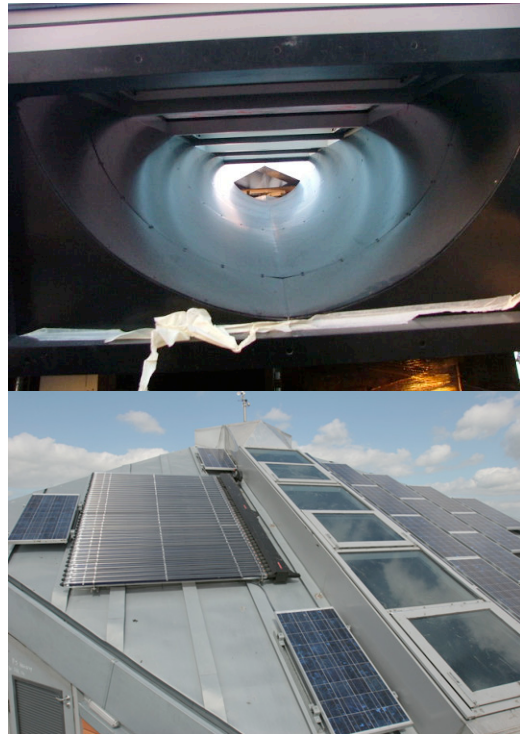


Fig 8. Solar Chimney: Internal sectional / External view (with PV and Solar Thermal); attached via motorised damper to top of atrium; controlled for fine tuning by BEMS

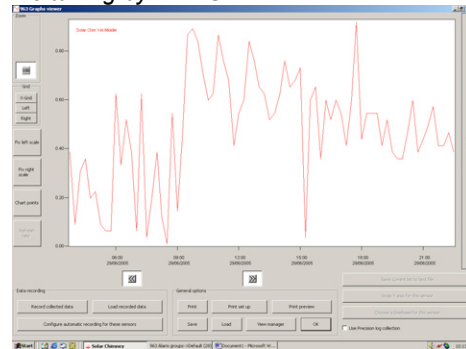


Fig 9 Solar chimney performance showing a maximum velocity of ~ 1 M / sec

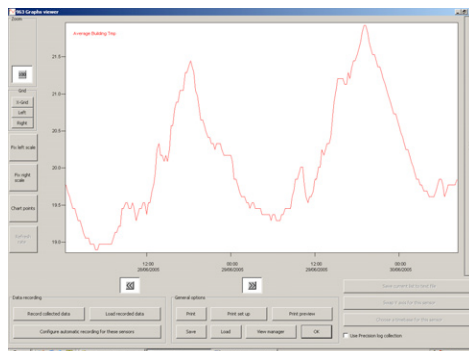


Fig 10 Average Building Temperature over two successive Summer Days; the afternoon 'spike' is the issue.

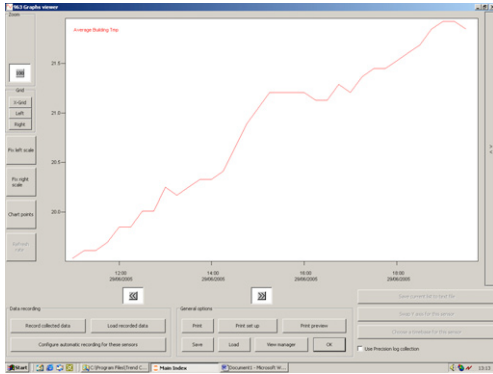


Fig 11 Average Building Temperature more closely monitored over one Summer afternoon showing interventions resulting in a delay in the afternoon 'spike' in temperature until after working hours: night purging is used to reduce the overall fabric temperature overnight.

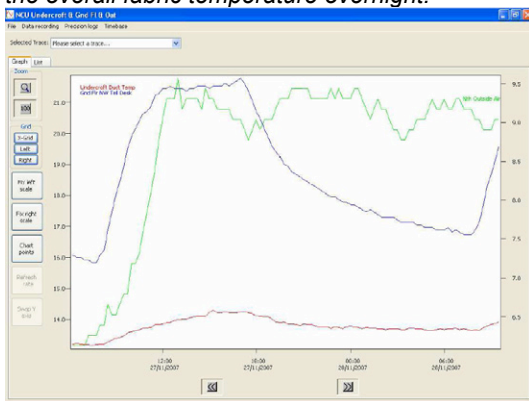


Fig 12 Undercroft tempered air (lhs scale) plotted with interior temperatures (lhs scale) outside air (rhs scale) showing a significant beneficial delta T for incoming ventilation from undercroft.

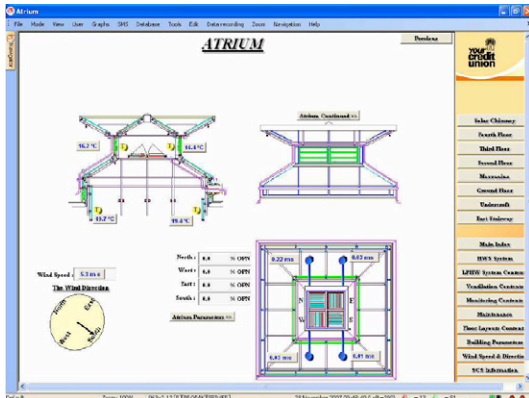


Fig 13 Venturi ventilator performance

## 6. Acknowledgements

This project is the result of an extraordinary team effort between client, design team and consultants, many specialist subcontractors and a most cooperative main contractor who proved vital to the process; these have been fully listed and acknowledged in a detailed article on the building [5]. The modest financial subsidy by SEI (Sustainable Energy Ireland) for monitoring is acknowledged and the assiduous monitoring work of Declan McDonnell, Standard Controls, Dublin, Ireland

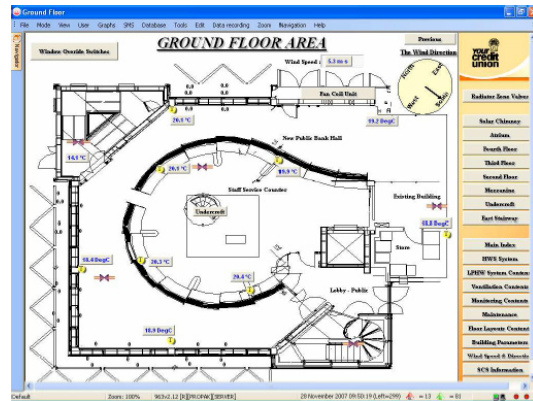


Fig 14 Targeted monitoring of sedentary comfort at ground floor level below the atrium

## 5. Conclusion: Moving Forward

The main conclusion is that an ecological design team needs to stay with a project for two to three years after handover / defects period to assist in optimising the actual results obtained and be open to independent audit and peer review and publication. This has a potential benefit of halving energy use, in practice. As a result of lessons learned here we have been able to roll forward into later work, these new design insights; an example is a crèche for a third level campus ready to go on site as shown in Fig 15, too complex to describe in detail here.

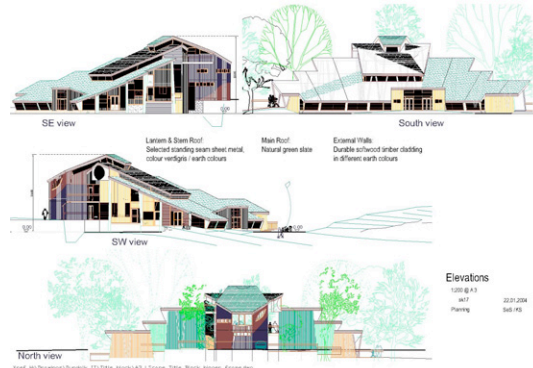


Fig 15 Crèche on Third Level Campus

## 7. References

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