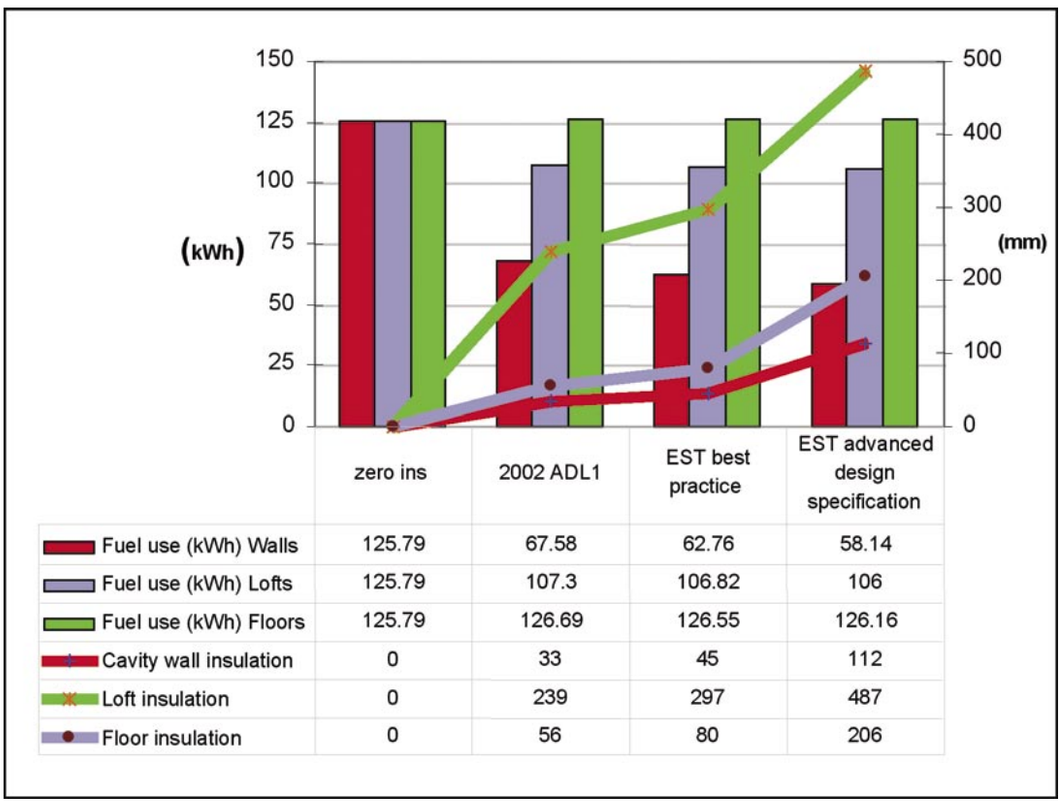
# Beware the blanket approach!

In 2003 at the University of Glamorgan, a pilot research project commenced to investigate methods for achieving savings in carbon dioxide ($CO_2$) attributable to space heating in dwellings. This research has raised a number of questions, illustrating as it does, the relative benefits of heating system efficiency and insulation thickness within the building envelope. **Mike George, Andrew Geens and John Littlewood** explain ...

Chart 1: The effect of insulation measures on daily energy use for a SEDBUK Category B gas boiler (worst case scenario)




| | zero ins | 2002 ADL1 | EST best practice | EST advanced design specification |
|---|---|---|---|---|
| Fuel use (kWh) Walls | 125.79 | 67.58 | 62.76 | 58.14 |
| Fuel use (kWh) Lofts | 125.79 | 107.3 | 106.82 | 106 |
| Fuel use (kWh) Floors | 125.79 | 126.69 | 126.55 | 126.16 |
| Cavity wall insulation | 0 | 33 | 45 | 112 |
| Loft insulation | 0 | 239 | 297 | 487 |
| Floor insulation | 0 | 56 | 80 | 206 |

PUBLICATIONS to date have demonstrated that increases in gas boiler efficiency produce savings comparable to those generated by insulation upgrades, [2,3]. It is also illustrated here (and elsewhere that the insertion of any floor insulation to a solid floor contributes little (and in some cases nothing) to energy / $CO_2$ savings.

As a result of the above findings [1,2,3] the authors made a contribution to the Office of the Deputy Prime Minister (ODPM) consultation process into the new Part L [4]. This stated concerns that insulation levels have reached (and in some cases) exceeded their optimum level for dwellings that are new-built or renovated, and are not designed for zero heating.

Last month the ODPM released the draft of the new Approved Document Part L. The document is divided into four parts and comprises ADL1A [5] for new dwellings and extensions; ADL1B [6] for work in existing dwellings; ADL2A [7] for new non-domestic buildings and ADL2B [8] for alterations to existing non-domestic buildings. There is of course a degree of commonality within these documents for 'the conservation of fuel and power' in buildings. This article will test the validity of two assertions that have been made, to reduce $CO_2$ emissions attributable to buildings. The first assertion is that increasing insulation thickness in these approved documents will continue to produce considerable savings in energy use and $CO_2$ emissions. The second assertion is that localised wind turbines may make an effective contribution to space heating.

Indeed the insulation philosophy

**Table 1: Model details**

| Model details | number | Cavity wall | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | plaster (mm) | render (mm) | block (mm)* | insulation (mm)** | Cavity (mm) | brick (mm) | Total breadth (mm) | U-value ($W/m^2C$) |
| Zero insulation | control | 3 | 13 | 100 | 0 | 50 | 105 | 271 | 0.62 |
| Part L1 2002 | 2 | 3 | 13 | 100 | 33 | 50 | 105 | 304 | 0.35 |
| EST best practice | 3 | 3 | 13 | 150 | 45 | 50 | 105 | 366 | 0.25 |
| EST advanced | 4 | 3 | 13 | 112 | 124 | 50 | 105 | 407 | 0.15 |

| Model details | number | Cold roof | | | | |
|---|---|---|---|---|---|---|
| | | plaster (mm) | p/board (mm) | insulation (mm)*** | Total breadth (mm) | U-value ($W/m^2C$) |
| Zero insulation | control | 3 | 12.5 | 0 | 15.5 | 3 |
| Part L1 2002 | 5 | 3 | 12.5 | 239 | 254.5 | 0.16 |
| EST best practice | 6 | 3 | 12.5 | 297 | 312.5 | 0.13 |
| EST advanced | 7 | 3 | 12.5 | 487 | 502.5 | 0.08 |

| Model details | | Solid floor | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | carpet (mm) | screed (mm) | insulation (mm)** | concrete (mm) | membrane (mm) | aggregate (mm) | Total breadth (mm) | U-value ($W/m^2C$) |
| Zero insulation | control | 5 | 50 | 0 | 100 | 3 | 75 | 233 | 0.56 |
| Part L1 2002 | 8 | 5 | 50 | 56 | 100 | 3 | 75 | 289 | 0.25 |
| EST best practice | 9 | 5 | 50 | 80 | 100 | 3 | 75 | 313 | 0.2 |
| EST advanced | 10 | 5 | 50 | 206 | 100 | 3 | 75 | 439 | 0.1 |

* blocks simulated have a density of 400Kg/$M^3$ and a conductivity of 0.08 W/m C

** insulation simulated have a density of 30Kg/$M^3$ and a conductivity of 0.025 W/m C

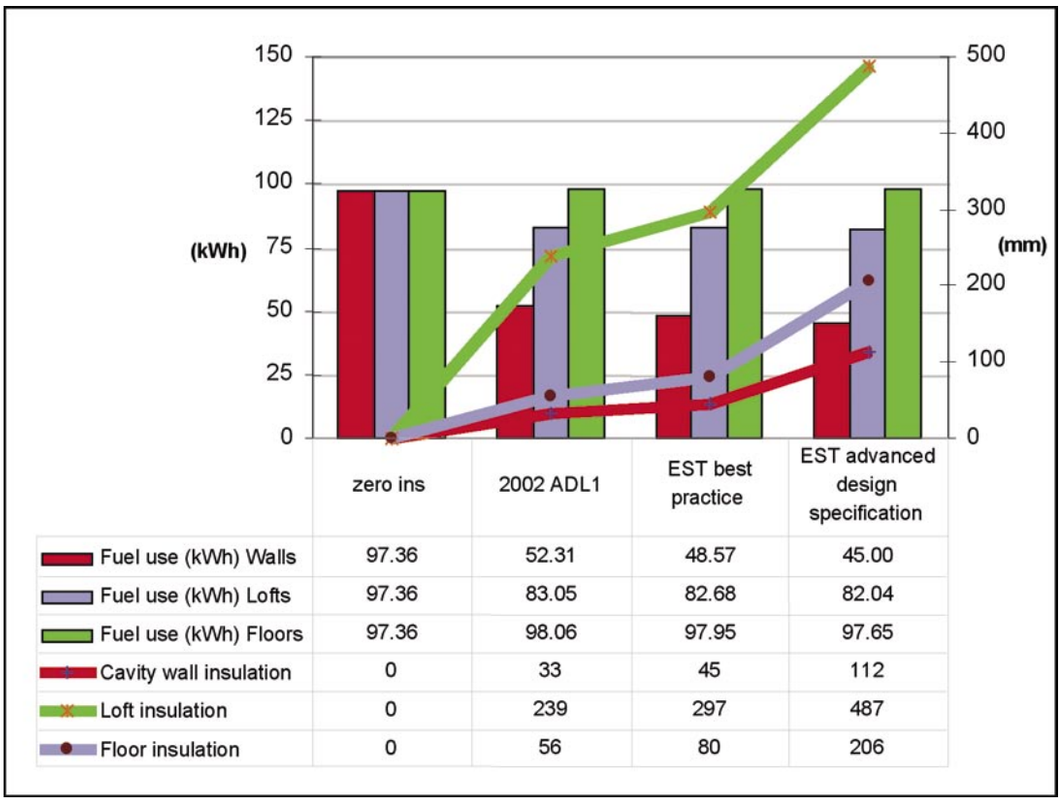
*** insulation simulated have a density of 12Kg/$M^3$ and a conductivity of 0.040 W/m C

of the ODPM [5,6,7,8] does seem to reflect the above view as increased insulation levels are used within the target u-value method as a compensatory measure for high carbon methods of space heating without recourse to the elemental method. Insulation is not however an effective compensatory measure and its usefulness as such in reducing energy use for space heating is tested here.

Charts 1 and 2 illustrate the relative benefits of increasing insulation for individual building elements by utilising recently developed computer software, namely dynamic thermal modelling software TAS, from Environmental Design Solutions Limited (EDSL). TAS was used to undertake a theoretical analysis of the energy use resulting from incremental changes to the thermal transmittance (U-value) of the chosen elements of a typical four bedroom detached dwelling in Cardiff. A CIBSE worst case external temperature scenario was used for the 24 hour simulations

Model construction details of dynamic simulations are given in Table 1. The thermal configurations are chosen to reflect the current [9] and new draft [5] Part L requirements. In addition the Energy Saving Trust has published supporting documentation for Part L advocating a 'best practice' and 'advanced standard' for new dwellings [10]. These are not mandatory for all new dwellings and their necessity will be determined by a dwellings carbon index (CI) target.

Chart 2: The effect of insulation measures on daily energy use for electric heating (worst case scenario)




The CI is determined by a number of factors including, orientation and shading, insulation levels, heating system, ventilation and the exposed surface area relative to floor area. Generally more insulation will be required as floor area and exposed surfaces increase [11].

Chart 1 illustrates the energy used by the respective models in kilowatt hours (kWh) resulting from varying the insulation thickness in millimetres (mm). The control model has zero insulation.

Table 2: Annual energy use

| Method of heating | Annual energy use |
|---|---|
| Gas | 7021 kWh |
| Electricity | 5429 kWh |

The first interesting point is that insulating a solid floor makes no contribution whatsoever to energy savings. Contrastingly, insulating cavity walls and lofts to current Approved Document L1 (ADL1) [9] requirements produces savings of 46% and 14% respectively. Savings resulting from Energy Saving Trust Best Practice initiatives are relatively small by comparison [11].

Chart 2 illustrates results for the same house with electrical space heating. Models in Chart 2 produce the same percentage savings, but do in fact require less energy in terms of kWh.

Further simulations have been undertaken to quantify the daily energy requirement for a model having ADL1 [9] combined insulation levels for cavity walls and loft. Note that floor insulation is disregarded. The energy requirement outputted directly from TAS is 45.46kWh for gas and 35.19kWh for electricity.

In order to quantify annual energy use, every day of a 180 day heating season for the same ADL1 [9] models have been simulated giving the results shown in Table 2.

Given these values the energy required as a compensatory measure is the difference between the former and latter which is 1592 kWh.

The associated $CO_2$ emissions are calculated using carbon conversion factors from ADL1, See table 3 [9].

However, the carbon intensity of electricity will of course depend upon the method of generation. In this case let us consider localised wind turbines as they are 'carbon free'. Since we have established an accurate figure of energy consumption we can now consider the range of outputs claimed in this context.

Depending on the point of view a 1.5kW rated roof mounted turbine located in a typical urban area will generate between 500kWh [12] and 1300kWh [13] of electricity per annum This is dramatically lower than other estimates cited at [13] of output up to 4200kWh.

Table 4 illustrates the number of 1.5kW turbines required to meet the energy use for space heating for a range of outputs.

## Conclusion

Regarding insulation levels it is clear that legislative requirements have gone as far as possible in terms of making a meaningful contribution to the energy efficient design of dwellings with space heating requirements.

Furthermore the steady state approach of fabric design is not appropriate for solid floors as insulating them is shown in our research to have a detrimental effect.

It is our view that the way forward is to keep the current ADL1

Table 3: calculating carbon emissions

| | | |
|---|---|---|
| Gas: | 7021 x 0.1943 / 1000 | = 1.364 tonnes |
| Grid electricity: | 5429 x 0.4143 /1000 | = 2.249 tonnes |
| Compensatory target is 0.885 tonnes or 885kg. | | |

**[9] requirements for all elements of the building envelope where the inside/outside temperature range is pertinent i.e. excluding solid floors.**

**This will mean that natural insulants such as flax and sheep's wool; as well as recycled newspaper will not be ruled out at the design stage because of limitations due to the thickness required. This will ensure that all insulations are judged in environmental terms within a 'level playing field'.**

**Regarding the use of electric space heating it is clear from our findings that requiring greater levels of insulation as a compensatory measure is not effective. It remains unclear as to whether localised wind turbines are a better compensatory measure due to the current debate as to their annual output. However, it must be remembered that whatever the output, it is 'carbon free'.**

**Having explored this particular 'avenue' for alternative approaches to energy efficiency in dwellings, the authors hope to expand the research programme to consider other measures to reduce $CO_2$ emissions attributable to both new and existing dwellings.**

George, MDJ; Geens, AJ and Littlewood JR

Table 4: Wind turbine data

| Annual turbine output (kWh) | Number of turbines required for carbon free heating (5429kWh) | Number of turbines required as a compensatory measure for electric heating (2136kWh)* |
|---|---|---|
| 500 | 11 (10.85) | 5 (4.272) |
| 1300 | 5 (4.18) | 2 (1.64) |
| 4200 | 1 (1.29) | 1 (0.51) |

* Carbon free kWh required to neutralise additional 885Kg of $CO_2$ from electric heating when compared with gas heating

## References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[13] Elliot, D 2005 Reply to the article: Wind Power – claims are questionable. Building for a Future Autumn 2005



Mike George has more than twenty years experience in the construction industry. He graduated as an Architectural Technologist from the School of Technology at the University of Glamorgan in 2004 and is currently lecturing part–time at the University.

Dr John R Littlewood is a Building Surveyor and has over eleven years industrial, research and lecturing experience in the field of computer aided design, visualisation and thermal modelling of residential buildings. He joined the Faculty of the Built Environment at the University of the West England in November 2005 as a Senior Lecturer. He is a member of the Innovation and Research Committee for the Chartered Institute of Architectural Technologists and also a member of the Sustainability Forum for the Royal Institution of Chartered Surveyors. He is also seconded to Building Design Partnership's Sustainability Unit, as a Sustainability Consultant for two days per week.

Dr Andrew J Geens, a Chartered Building Services Engineer has over 20 years experience in marine engineering, building services management, particularly ventilation design, and low energy building design. He is the Head of the Sustainability Unit at the University of Glamorgan and also award Leader for the newly accredited Chartered Institution of Building Services Engineers (CIBSE) BEng Building Services Degree, whose teaching team, won the National Buro Happold award in 2005. Dr Geens also serves on a number of National Committees for CIBSE and the REHVA Working Group on Ventilation and Smoking.