13th November 2013

Implementation of the Energy Efficiency Directive in Ireland Public Consultation

Name of Organisation/Individual Providing Feedback: Féile Butler, MRIAI
Mud and Wood
Grange Beg
Skreen
Co. Sligo

These are general comments.

Can Energy Efficiency Be Considered without Reference to the Embodied Energy of Building Materials?

p. 3 *"The Directive translates elements of the European Efficiency Plan into binding measures on Member States, including …. an obligation on public bodies to procure products, services and buildings with highly energy efficient performance."* (article 6)

p.22 *"Current Policy Context – There is no binding obligation on public procurers to consider environmental characteristics."*

p.43 *"Article 16 of the 2009 Renewable Energy Directive states that priority is to be given to electricity generated from renewable sources."*

The 20-20-20 EU Policy calls for a 20% reduction in greenhouse gas levels, a 20% reduction in energy consumption and a 20% increase in renewable energy. This is good and proper. There is recognition that energy generated from renewable sources is preferable to energy generated from non-renewable resources. However, it makes no sense to try to achieve this without looking at the embodied energy hidden within the building materials themselves.

There have been numerous studies done estimating the amount of embodied energy associated with different dwelling types. In "*Architecture Ireland, V.247, 2010, p.70 -71*" N. O' Loughlin estimated that the embodied carbon associated with an A2-rated semi-d house (floor area 105m²) over 60 years was equivalent to 35.2 years of the operational CO_2. For a 75m² A2-rated apartment over the same time scale, the embodied carbon was equivalent to 28 years of the operational CO_2. Armstrong and Goggins (2012) have measured embodied carbon accounting for 23 – 34% of the total carbon footprint depending on dwelling type.

What is becoming clear is that as the operational energy reduces, the embodied energy is becoming increasingly significant. In work done by Jim Carfrae and Pieter de Wilde on "*The Leechwell Garden House: A Passive Solar Dwelling Built from Renewable Materials*", the embodied energy as a percentage of the total energy attributed to a Passivhaus dwelling is 40%. In the study, he compared the Passivhaus dwelling with a similar straw bale house, with matching annual heat energy values. The embodied energy of the straw bale house was only 5% of the total.

In Life Cycle Assessment, each of these phases are important – raw material extraction, transportation, manufacture of building materials, transportation, construction, operation, maintenance/refurbishment and end of life disposal/recycling. The Energy Efficiency Directive only deals with the operational aspect, which is not adequate if truly sustainable solutions are to be found.

Many of the natural building materials have tiny embodied energy. In fact, many of them can sequester carbon such as straw bales, timber and hemp-lime. Dwellings may achieve an A1 rating, but be built with every remotely accessed, toxic, highly-processed, disposable (i.e. incapable of being refurbished or repaired) material available.

Looking at cob (an earth and straw composite) as a building material, it is sourced on site; it does not get more local than that. It requires virtually no processing to turn it into a building material. Building a 130m² cob house by digger mixing required 120 litres of diesel. There was no other processing involved. It is low maintenance in that if it needs to be repaired, the material is right there on site. It is eternally recyclable. We have successfully repaired historic cob walls using the original material. When it comes to final disposal, there is no issue. If unmaintained, particularly if the roof is badly compromised or missing altogether, after a few decades the cob walls will simply vanish back into the earth.

Should there be a requirement to build using a certain percentage of renewable materials and/or low-embodied energy materials, just as there is requirement to use a minimum amount of renewable technologies?

<u>The BER System is Fundamentally Flawed.</u>

p.54 *"A BER is a rating based on the* ***building fabric*** *and building services in a building for typical occupancy patterns."*

It is my observation that BER does little to reflect the performance of building fabric and that some materials suffer more than others in this regard. Unfortunately, it strikes me that it is the low-embodied, low impact materials that suffer the most.

<u>The Problem with U-Values as a Measurement of Thermal Comfort Provision</u>

In "*Natural Building: A Guide to Materials and Techniques*", Tom Woolley states, "*the experience of living in a cob building is that it will have a good level of thermal comfort and perform better than might be predicted from simply assessing the crude U-value*".

Regarding hempcrete (hemp and lime composite), another monolithic form of building, the same book quotes, "*it has been argued by Ralph Carpenter, of Modece Architects, and others, that the U-value is not a good way to assess the thermal performance of this type of material"*, i.e. monolithic construction.

With a relatively high thermal conductivity of approximately 0.393W/mK, cob does not score well with U-values. Yet as Tom Woolley alluded to, there is a prevailing perception that cob buildings are warm and dry to live in without insulating the walls. This is borne out by experience, such as Paul Barclay's house built in Totnes, Devon in 2008 and our own cob house in Co. Sligo, which we moved into in 2010.

Paul Barclay super-insulated everything but the cob, which he left completely uninsulated. They have never turned on their underfloor heating. We super-insulated some elements, insulated other elements and left our cob walls uninsulated except for a 30mm hemp-lime render. We do heat the house, but our fuel bills are small.

U-values are calculated under laboratory conditions. They assume a steady state for the temperature on either side of the wall (inside and outside). They also assume a steady, uniform state for the heat transfer through the material in question. The reality is that a steady state does not exist in the real world. Temperatures fluctuate through the day and U-values do not take these changes into account.

Capacitive insulation refers to the ability of thermal mass to slow down or delay the flow of heat. It has virtually no effect when the surrounding environment is in a steady state, i.e. in laboratory conditions. However, once temperatures start to fluctuate, the benefit of capacitive insulation becomes important. In monolithic, massive structures this becomes very important.

While DEAP recognises different grades of thermal mass, this is with a view to the "useful" thermal mass, i.e. that which can contribute heat back into the room. I agree that only the first 75 – 100mm of thermal mass is actually beneficial for this purpose.

However, not only is thermal mass important in affecting thermal performance, thermal inertia or diffusivity is also critical. Experiments by Lime Technology on Tradical Hemcrete show that materials with high thermal inertia are slow to change temperature and slow to reach a steady state of heat transfer. This slows heat transfer down. Concrete has high thermal mass but no thermal inertia and so does not perform as well as materials with high thermal inertia, such as hempcrete and cob.

Comparing hempcrete and mineral wool under a dynamic load, the heat flux through the hempcrete was lower than through the mineral wool, despite the mineral wool having a higher insulation value. In fact, the hempcrete transferred almost 3 times less heat than the steady state model would have estimated ("*Tradical Hemcrete: Thermal Performance Slideshow Presentation*" - Ian Pritchett). In a typical 600mm wide cob wall with a density of 1,450kg/m^3, it will take 8 to 9 hours for a unit of heat to travel through it.

In "*Historic Scotland's Technical Paper 10: U-values and traditional buildings - In situ measurements and their comparisons to calculated values*" Paul Baker studied a number of historic properties, including the 18th Century Logie Schoolhouse which has 600mm wide solid earth.mud walls. The actual U-value measurements were up to 50% better than the software U-values indicated, 0.4 W/m^{2}K on one wall instead of the software predicted 0.7 – 0.8 W/m^{2}K and 0.5 W/m^{2}K on another wall instead of the software predicted 0.8 – 1.0 W/m^{2}K.

<u>The Performance Gap</u>

There is another fundamental flaw when relying on U-values to define the thermal performance of building fabric. I accept that DEAP provides an asset rating and therefore a comparable level playing field for all. However, in reality, there are huge issues with the performance gap, i.e. the actual energy performance of buildings when measured against their calculated performance.

At the Better Building Conference 2013 a number of papers were presented on this issue. Dominic Miles-Shenton repeated the findings of *Hens et al, 2007* and *Doran, 2000*, that heat loss is highly dependent upon the design and installation of the insulation layers. For a semi-detached house at Stamford Brook the predicted total heat loss was 63.8 W/K; the actual total heat loss was 111.8 W/K, +75%. For a mid-terrace house the results were even worse; 75.2 W/K predicted versus 153.4 W/K actual.

Joseph Little quoted a study by Lecompte, 1990 which showed that if a continuous gap of 10mm exists behind insulation, a 3mm gap between insulation batts can result in a degradation of the U-value by 158%. For a 10mm gap, this increases to 193%. He also demonstrated the effect of a 9km/hour wind through 300mm attic insulation, reducing its thermal performance by 35%.

Monolithic materials, such as cob and hempcrete, are by their very nature inherently airtight. Thermal bridges are all but eliminated. There are no layers or junctions between materials to damage or detail incorrectly. Whereas most conventional building materials rarely achieve their claimed U-values in practice (the SERVE project 2010 in Co. Tipperary had an 80% call back rate in the first year), monolithic materials tend to exceed theirs.

It could be argued that a big lump of insulation should be stuck to cob walls to tick the box and achieve the required targets. However, with sustainability in mind, I do not favour using unnecessary (in my view) additional materials just because the limited computer calculation decrees it.

Also , in research done by Professor Jean-Claude Morel, "*A Better Understanding of the Hydrothermal Behaviour of the Rammed Earth to Avoid the Wrong Kind of Earth Conservation Practice in France*", the addition of insulation to the wall increased the moisture content of the wall by almost 300%, from 1.7% to 5% (earth walls will always contain a certain amount of water, this is what helps to bind the material together). So although the insulation was applied to improve the thermal performance of the wall, it also led to an increase in the moisture content of the wall itself, thus reducing the thermal performance of the wall. There may have been a net gain in thermal performance, although the professor did not have pre- and post- in-situ U-value data. However, I still contend that cob walls can be incorporated into an overall whole house approach and good levels of thermal comfort without the need to insulate them or insulate them excessively.

U-values are fundamentally embedded in the system at present and it would be all but impossible to find a quick fix. However, there should be some recognition that they are a flawed way to measure the thermal comfort a material can provide and that some materials suffer more than others. It is frustrating to have to work with U-values that (a) are probably incorrect to begin with and (b) are inadequate for reflecting the actual thermal performance of the material.

I highlighted this issue in the recent DEAP Public Consultation.

Humidity Buffering/Balancing and Thermal Comfort

For materials capable of regulating relative humidity in an indoor environment, such as cob and hempcrete, these values may not be appropriate. As Tom Woolley states in "*Natural Building: A Guide to Materials and Techniques*", "*The relative humidity of a room will be more important than its temperature and it is often humidity rather than temperature that will affect the occupants' feelings of comfort*". Cob and hempcrete can provide comparable experiences of thermal comfort at lower temperatures than some conventional building materials.

At the Mass Matters Conference in Edinburgh in 2012, Paul Tuohy commented on the inadequacy of relying on air temperatures to measure thermal comfort. He looked at a house where the wall surface as 16 - 18ºC, the window surface was 9.5ºC and the air temperature was 22ºC; the experience of thermal comfort was measured at 18.2ºC. He then looked at a house where the wall surface was 21.4ºC, the window surface was 19.2ºC and the air temperature was 22ºC, the experience of thermal comfort was measured at 21ºC.

It should also be noted that the density and capillarity of insulations have a profound effect on how well they work. Comparing EPS with wood fibre insulation, they both have identical thermal conductivity values (0.039 W/mK) and therefore identical U-values. However, the EPS has a density of 20 kg/m^3, while the wood fibre has a density of 55 kg/m^3. Thanks to its increased density and therefore its ability to delay heat transfer, the wood fibre insulation will outperform the EPS in a real life situation.

Comparing wood fibre to mineral wool insulation, the latter has low capillarity. Should it get wet, it is very slow to dry out. Wet insulation does not perform well. In an experiment where a perfectly sealed vapour barrier had a 1mm x 1m tear introduced and so water vapour could enter the structure, the U-value of the insulation deteriorated from 0.3 W/m^2K to 1.44 W/m^2K, almost five times worse (source – Ecological Building Systems). Wood fibre insulation can get wet too, but it is much quicker to dry out and return to its intended performance.

Does Energy Efficiency Guarantee Health Benefits?

p.27 *"Achievement of Article 7 energy savings targets will bring with it a broad range of benefits. These include the value of energy savings, greenhouse gas emission reductions, alleviation of energy poverty, improved comfort and health …."*

The issue of indoor air quality is starting to raise its head. Many people feel that highly-energy efficient, air-tight, mechanically ventilated homes will improve our health.

However there is more and more research being done into the problems associated with toxic build-ups in air-tight homes which rely heavily or exclusively on mechanical ventilation. Research is currently being carried out in Queens University in this regard, as well as other studies in Europe.

While insulation and air-tightness are of course necessary to achieve good energy efficiency, extreme degrees of air-tightness may not actually be the best for our health. As a nation, we are not a people who are good at servicing our equipment or changing filters when necessary, or even running equipment on the correct setting.

Again, sealing up buildings without any regard for the materials which enclose those buildings does not seem like a sensible way to approach energy efficiency. Natural (low-embodied energy) materials do not possess the same risks as certain other conventional building materials to the health of the occupants on a micro scale and to the health of the planet on a macro scale.

I would also contest that the more houses need to rely on equipment to achieve energy efficiency, the more expensive it becomes for the owners to build. While their fuel bills are low, the initial building costs can be very high, so they are enslaved to debt anyway. Of course, using plenty of the cheapest, most toxic, high embodied energy materials to build a house will help to reduce this burden for the owners. However, has that actually done climate change any favours?

Qualifications of Assessors for Certain Applications

p.32 *"… if a Member State considers that the national level of technical competence, objectivity and reliability of qualification, accreditation and certification schemes is not sufficient, then it will be required to ensure that by 31December 2014, certification and/or accreditation schemes and/or equivalent qualification schemes, are available for the providers of energy audits."*

p.56 *"Industry has in depth knowledge of the kinds of core competencies that are required to ensure a high standard and may be aware of areas where stricter standards should apply."*

The document recognises that there are gaps in the competencies of assessors and even the type of assessment carried out.

As a conservation-accredited architect, I feel that it is important that assessors of historic buildings should have specific knowledge of that type of construction and should have some understanding of conservation principles. This should not only extend to protected structures, but also to common vernacular buildings, e.g. stone and lime cottages. Some of the refurbishment advice I have seen on BER certificates is completely inappropriate for the type of construction.

Real Choice for Consumers

p. 48 *"…consumers must be empowered to have a more prominent place in energy policy and to this end consumers require* ***real choice*** *… in tandem with market transparency."*

I agree with this, but think that because of this, the issue of embodied energy and life cycle assessment of building materials cannot be ignored. There was a suggestion at the Better Building Conference 2013 that there should be similar grading system for materials with regard to their embodied energy. Therefore, one could buy a house with a A3 rating for operation energy but an F rating for embodied energy. It makes sense.

…."