Low Carbon
Design & Construction

Prof. Kevin McCartney, UCC
Cork Centre for Architectural Education

Energy Cork
Breakfast Briefing April 2016
Sustainable Materials ...

GWP

carbon emissions

Renewable materials

sequestered carbon

Embodied Energy

LCA is the answer
Life Cycle Assessment (LCA)

“Designers are not qualified to properly assess and understand the full implication of LCA”

"ALL THOSE YEARS OF ARCHITECTURE SCHOOL FOR THIS?"
Principles of low carbon design

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• ?
Loss of heat through building fabric requires a balancing input of heat to maintain occupant comfort. This requires fuel combustion causing CO2 emissions.
Reduce Operational Energy

Cut uncontrolled ventilation heat loss & cut fabric heat loss
Energy efficiency in Irish dwellings improved by 2.5% per year from 1995-2011

Principles of Low Carbon Design

1. Minimise fuel demand
Kingsmead Primary School Canterbury

Sir Colin Stansfield Smith, John Pardy, Kevin McCartney

Joint Winner, RIBA International Competition for 2001
Sustainable School Design,
Wood chip boilers were specified for Kingsmead school. This reduced CO₂ emissions by as much as 68% compared with electric heating, and by 42% compared with high efficiency GAS boilers (McCartney, 2001).
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
How much does your building weigh?
How much does your building weigh?
Ohio Institute of Historic Structures
Buckminster Fuller proposal for a city-scale dome providing controlled micro-climate
"to make the world work for 100% of humanity, in the shortest possible time, through spontaneous cooperation without ecological offense or disadvantage of anyone". BF

Bamboo Institute: Ignacio Platas
Shortlisted for Buckminster Fuller Challenge Prize, 2009
How much does your building weigh?
How much does your building weigh?

Casa López/Lujano
by Oficina 3 Estudio de Arquitectura
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability
Sustainable Materials ...

- GWP
- Primary energy
- Renewable materials
- Sequestered carbon
- Embodied Energy
- LCA
  is the answer
Delivered Energy
Primary Energy

Delivered Energy
Sustainable Materials ...

- Primary energy
- Renewable materials
- Sequestered carbon
- Embodied Energy
- GWP

LCA is the answer
Embodied Energy (EE)
The total primary energy required to produce a material
• Non- Renewable Material
  – Finite: extracted once or developed over a long period of time e.g. stone, minerals, steel

• Renewable Material
  – One Kilogram of dried timber can contain 1.8 Kilograms of CO$_2$eq/kg stored as Carbon or a negative GWP -1.8 KgCO$_2$eq/kg $^{(5)}$  
  – Sustainability depends on consumption not exceeding regeneration  
  – Sustainable production can have benefits to the wider ecosystem  
  – Procure responsibly from sustainable sources
Comparison of Embodied Energy in glulam timber, concrete and steel beams of the same strength.
Steel has 6 times more Embodied Energy than glulam timber.

FABRIC ROLE IN EE AND GWP

222 sq. m. low operational energy home
(42 kWh/sq.m./yr)

Fabric responsible for 30% of Total Embodied Energy

Fabric responsible for 41% of Global Warming Potential GWP

Heating energy savings over 75%
Embodied energy will be dominant contributor to carbon emissions

PBA’s graph shows that embodied rather than operational carbon will soon become the dominant factor in reducing new buildings’ carbon footprints. New building regulations in 2016 will enforce the need for all new homes to be zero carbon from that date - with non-residential to follow by 2019.

Building Design 1/5/2013
Sustainable Materials ...

- Renewable materials
- GWP
- Primary energy
- Sequestered carbon
- Embodied Energy
- LCA
  is the answer
RENEWABLE VERSUS NON RENEWABLE BUILDING FABRIC
A COMPARATIVE STUDY ON THE EFFECT OF MATERIAL CHOICE
ON THE EMBODIED ENERGY AND GLOBAL WARMING POTENTIAL
OF LOW ENERGY BUILDINGS (2011)

by
Minka McInerney & Simon Tucker
How much does your building weigh?

Weight Comparison

85 Tonnes

- Non-Renewable: 140 Tonnes
- Renewable: 20 Tonnes

- Walls
- Roof
- Windows
- Floor
Global Warming Potential Comparison
fabric & operational energy 25 yrs

Fabric Weight Comparisons

Tonnes CO2e

NON RENEWABLE

RENEWABLE

Fabric: GWP
Gas: GWP 25 years
Electricity: GWP 25 years

Fabric Weight

Tonnes

windows
roof
walls
floor
## Renewable fabric implication

<table>
<thead>
<tr>
<th>Total GWP Fabric</th>
<th>Total GWP Fuel over 25 Years of operation (TC0₂e)</th>
<th>Equivalent operational (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-26 TC0₂e</td>
<td>Gas 24</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Electricity 93</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>Biomass 16</td>
<td>41</td>
</tr>
</tbody>
</table>

### Renewable Comparison GWP:
**Fabric & Operational demand**

- **Fabric: GWP**
- **Gas: GWP 25 years**
- **Electricity: GWP 25 years**
- **Biomass: GWP 25 years**

“Zero Carbon Design?”
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability
4. Select low embodied energy materials
Sustainable Materials ...

- GWP
- Primary energy
- Renewable materials
- sequestered carbon
- Embodied Energy
- LCA
  is the answer
Global Warming Potential (GWP)
The metric adopted by the IPCC to assess Green House Gases

- **Embodied Carbon**: positive GWP of material production – a function of energy generation

- **Sequestered Carbon**: negative GWP of the Carbon stored in plant based renewable materials
Carbon Dioxide Absorption

1 square metre of forest can absorb 1 kg/year
ECOLOGICAL FOOTPRINT
buildings require a forest area 40-80 times their floor area to absorb its CO2 emissions from operating energy.
Principles of Low Carbon Design

1. Minimise fuel demand
2. Select fuels with low carbon coefficient
3. Use less material/appropriate durability
4. Select low embodied energy materials
5. Select materials which sequester carbon
Designers Role
(Minka McInerney & Simon Tucker)

• Potential of Carbon Sequestration in building materials should not be ignored
• EE & GWP become very significant in low energy design
• Low operational energy design lends itself to simple LCA such as EE & GWP i.e. easy to calculate fabric quantities in tandem with U-value calculations
• Designers should become familiar with Construction material inventories & seek Environmental Product Declarations (EPD)
• Design for dematerialization\(^{(3)}\) & durability
• Source renewable materials sustainably
“Now that you have an overview of the system, we’re ready for a little more detail”
As the operational carbon of buildings is reduced following the more stringent requirements of Approved Document L, embodied carbon is moving higher up the agenda when it comes to making decisions about the best way to reduce a building’s overall carbon footprint.

PBA’s graph (below) shows that embodied rather than operational carbon will soon become the dominant factor in reducing new buildings’ carbon footprints, especially with the introduction of the new building regulations in 2016. These have been dubbed “zero carbon” because the regulations will enforce the need for all new homes to be zero carbon from that date - with non-residential to follow by 2019.

“It is likely that embodied carbon reductions will be permitted as an ‘allowable solution’ in the ‘zero carbon’ building regulations 2016, and presently these are increasingly being accepted by local authorities as a trade-off against uneconomic renewables targets,” says Dr Kelly, adding that embodied carbon is also being given more attention in the current draft of Breeam assessments.

http://www.bdonline.co.uk/where-the-embodied-is-buried/5054003.article
Pamela Buxton, Building Design, 1 May 2013