Part L Compliance
Building Control Role

IBCI Conference
Thursday, 28th March 2019

Colin Gallagher, BE, CEng, PGDip fire, MIBCI.
Programme

- Buildings in Ireland
- Building Regulations
- Part L – the History
- Part L – 2019
- Near Zero Energy Buildings (nZEB)
- Compliance with Part L
- Design Compliance
- Construction Compliance
- Current Issues
- The Future
Buildings in Ireland

- How much energy is used
- Age and efficiency of buildings
- Drivers – EU targets since 1997, cost, economy etc

Note: Energy consumption in agriculture, fishing and “other” makes up 3% of final energy consumption, and is not included in the above figure.
Source: DG Energy: EU Energy in Figures 2012

- 32% of all energy in the EU is used for transport
- 25% of all energy in the EU is used by industry
- 40% of all energy in the EU is used by buildings
Building Regulations

- Second Schedule Part A to M
  - Part A Structure
  - Part B Fire Safety
  - Part C Site preparation and resistance to moisture
  - Part D Materials and workmanship
  - Part E Sound
  - Part F Ventilation
  - Part G Hygiene
  - Part H Drainage and waste water disposal
  - Part J Heat producing appliances
  - Part K Stairways, ladders, ramps and guards
  - Part L Conservation of fuel and energy
  - Part M Access and Use.
Building Regulations History

Terms: Thermal Conductivity (\( \lambda \)), Thermal Resistance (R), Thermal Transmittance (U Value)

\[
R = \frac{I}{\lambda} = \frac{1}{U}
\]

Where this approach is adopted in relation to a dwelling, the following maximum average elemental U values must be met in addition to meeting the overall value:

- roofs: 0.35W/m2K
- Walls: 0.55W/m2K
- Ground floors: 0.45W/m2K.
Part L 1997 to 2019

- **B Rgs part L**: A building shall be so designed and constructed as to secure, insofar as is reasonably practicable, the conservation of fuel and energy.

![Part L Energy Limits in 3 Bed Semi](chart)

- **Part L amendment**
  - **1997**: 225 kWh/m²/yr
  - **2005**: 150 kWh/m²/yr
  - **2007**: 90 kWh/m²/yr
  - **2011**: 60 kWh/m²/yr
  - **2020**: 45 kWh/m²/yr

DEAP - dwellings
Part L 1997 to 2019

- **B Rgs part L**: A building shall be so designed and constructed as to secure, insofar as is reasonably practicable, the conservation of fuel and energy.

![Part L Energy Limits in 3 Bed Semi](chart.jpg)

- **Baseline**
- **1997**: 225 kwh/m²/yr
- **2005**: 150 kwh/m²/yr (40% reduction)
- **2007**: 90 kwh/m²/yr (60% reduction)
- **2011**: 60 kwh/m²/yr
- **2020**: 45 kwh/m²/yr (70% reduction)

DEAP - dwellings
- A1 ≤ 25
- A2 ≤ 50
- A3 ≤ 75
Near Zero Energy Buildings

- Energy harvest vs Energy conservation

  - all new buildings should be nZEB by 31st December 2020.
  - all buildings acquired by public bodies by 31st December 2018.

- Definition: ‘Nearly Zero Energy Buildings’, nZEB
  - a building that has a very high energy performance where the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources including energy from renewable sources produced on-site or nearby.

- implemented through the Building Regulations
  - The conservation of energy section of the Building Regulations for non-dwelling buildings was introduced 28th November 2017 and replaces Part 2008 by 31st Dec 2018. The Amended Regulation for dwellings is to be published this year.
Part L–Technical Guidance Doc

- L1 Conserve Energy and CO2 emissions
- L2 Existing dwellings
  - Material Alterations
  - Change of Use
  - Extensions
  - Replacement Boilers
  - Replacement doors and windows
  - Major renovations – cost optimum
- L3 New dwellings
  - Use of DEAP for MPEPC and MPCPC
  - Renewables RER 20%? Current is 10Kwh/m²/yr
  - Building Fabric
  - Thermal Bridge
  - Air Permeability
  - Heating and cooling systems
  - Controls
  - User information
Part L–Technical Guidance Doc

- L4 Existing Buildings other than dwellings -
  - Material Alterations
  - Change of Use
  - Extensions
  - Replacement Boilers
  - Replacement doors and windows
  - Major Renovation – greater than 25% surface area

- L5 New Buildings other than dwellings
  - Use of NEAP for MPEPC and MPCPC
  - Renewables RER 20% to 10%
  - Building Fabric
  - Thermal Bridge
  - Air Permeability
  - Solar overheating
  - Heating and cooling systems
  - Controls & Lighting
  - User information
Compliance with Part L

- **Desktop Design Check**
  - MPEPC and MPCPC
    - DEAP-Dwelling Energy Assessment Procedure
    - NEAP-Non-Dwelling
  - Part L Conformance report
    - Backstops on Fabric, Air tightness, Thermal bridging
  - Drawings
  - Specification

- **Site Construction Check**
  - Building Fabric - Insulation
  - Renewables
  - Thermal Bridging detail
  - Air Tightness test
  - Heating and cooling plant
  - Controls
  - Information
Desktop Compliance

- **LAW**: BC Regs require at CN:
  - such plans, calculations, specifications and particulars as are necessary to outline how the proposed works or building will comply with the requirements of the Second Schedule to the Building Regulations relevant to the works or building concerned,

- **LAW**: Design Certifier undertaking
  - DC certifies having exercised reasonable skill, care and diligence the proposed design is in compliance

- **LAW**: BC Regs require at CCC:
  - such plans, calculations, specifications and particulars as are necessary to outline how the works or building as completed...complies with the requirements of the Second Schedule to the Building Regulations
Desktop Compliance

- **DEAP**
  - DEAP3
  - DEAP4 -web

- **NEAP**
  - iSBEMie
### Desktop Compliance

#### Part L Conformance Report - DEAP

**Part L Specification**

**Property Details**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwelling Type</td>
<td>Semi-detached house</td>
</tr>
<tr>
<td>Type of Dwelling</td>
<td>Semi-Detached</td>
</tr>
<tr>
<td>Year of Construction</td>
<td>2019</td>
</tr>
<tr>
<td>Date of Assessment</td>
<td>22/11/2018</td>
</tr>
<tr>
<td>Date of Plan</td>
<td>09/06/2018</td>
</tr>
<tr>
<td>County</td>
<td>Co. Dublin</td>
</tr>
<tr>
<td>Post Code</td>
<td>2051 T03 L</td>
</tr>
<tr>
<td>Has a rating been previously awarded?</td>
<td>Yes</td>
</tr>
<tr>
<td>BER Number</td>
<td>M36581</td>
</tr>
<tr>
<td>Purpose of rating</td>
<td>Performance</td>
</tr>
<tr>
<td>Comment</td>
<td></td>
</tr>
</tbody>
</table>

**Dimension Details**

<table>
<thead>
<tr>
<th>Floor</th>
<th>Area [m²]</th>
<th>Length [m]</th>
<th>Width [m]</th>
<th>Volume [m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Floor</td>
<td>57.55</td>
<td>5.75</td>
<td>9.95</td>
<td>278.38</td>
</tr>
<tr>
<td>First Floor</td>
<td>81.50</td>
<td>5.75</td>
<td>9.95</td>
<td>404.99</td>
</tr>
<tr>
<td>Second Floor</td>
<td>94.00</td>
<td>5.75</td>
<td>9.95</td>
<td>547.97</td>
</tr>
<tr>
<td>Total Floor Area</td>
<td>115.00</td>
<td>5.75</td>
<td>9.95</td>
<td>604.44</td>
</tr>
<tr>
<td>Living Area [m²]</td>
<td>22.60</td>
<td>5.75</td>
<td>9.95</td>
<td>109.56</td>
</tr>
<tr>
<td>No. of Storeys</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Ventilation Details**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHL - Does the permeability test need to be carried out?</td>
<td>Yes</td>
</tr>
<tr>
<td>TPS - Open Fires</td>
<td></td>
</tr>
<tr>
<td>FS - Fans &amp; Extracts</td>
<td>0.1125</td>
</tr>
<tr>
<td>NOEX - Number of exposed bedrooms</td>
<td>2</td>
</tr>
<tr>
<td>No. of sides sheltered</td>
<td>0.2</td>
</tr>
<tr>
<td>Ventilation method</td>
<td>Whole house extract ventilation</td>
</tr>
</tbody>
</table>

**Building Elements - Floor Details**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>U-Value [W/(m²K)]</th>
<th>Area [m²]</th>
<th>Total Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>100mm MUPF</td>
<td>0.120</td>
<td>57.55</td>
<td>7.500</td>
</tr>
</tbody>
</table>

**Building Elements - Roof Details**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>U-Value [W/(m²K)]</th>
<th>Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulated</td>
<td>Insulated</td>
<td>0.115</td>
<td>57.55</td>
</tr>
</tbody>
</table>

**Building Elements - Wall Details**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>U-Value [W/(m²K)]</th>
<th>Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100mm Cavity</td>
<td>Front Elevation</td>
<td>0.150</td>
<td>27.66</td>
</tr>
<tr>
<td>300mm Cavity</td>
<td>Rear Elevation</td>
<td>0.150</td>
<td>39.99</td>
</tr>
<tr>
<td>500mm Cavity</td>
<td>Dbl Elevation</td>
<td>0.150</td>
<td>39.99</td>
</tr>
<tr>
<td>300mm Cavity</td>
<td>Ventilation</td>
<td>0.150</td>
<td>3.93</td>
</tr>
</tbody>
</table>

**Building Elements - Door Details**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>U-Value [W/(m²K)]</th>
<th>Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry Door</td>
<td>Single leaf</td>
<td>1.090</td>
<td>2.150</td>
</tr>
</tbody>
</table>

**Building Elements - Window Details**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>U-Value [W/(m²K)]</th>
<th>Area [m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double-glazed argon filled</td>
<td>Low-E, u=0.90</td>
<td>1.900</td>
<td>14.06</td>
</tr>
<tr>
<td>Double-glazed argon filled</td>
<td>Low-E, u=0.55, stylised</td>
<td>1.800</td>
<td>8.79</td>
</tr>
<tr>
<td>Double-glazed argon filled</td>
<td>Low-E, u=0.55, stylised</td>
<td>1.600</td>
<td>6.98</td>
</tr>
</tbody>
</table>

**Other Details**

- Thermal Bridging Factor [W/(m²K)]: 0.068
- Thermal Mass Category of Dwelling: Resid
### Desktop Compliance

- Part L Conformance Report continued

#### Part L Specification

**HEATING SYSTEM - Solar Water Heating**

- Type, manufacturer, model: Copper (designed for 1.2500 kWk)
- Zero loss collector efficiency: 90%
- Collector heat loss factor: 0.116
- Annual Solar Fraction (W/Wm²): 1.000
- Collector storage volume (L): 144
- Collector efficiency: 77.2%
- Solar fraction (%): 47.2%

**HEATING SYSTEM - Hot Water System**

- Distribution losses: Yes (see below)
- Supplementary electric water heating: No
- Average storage volume (L): 205
- Average storage manufacturer and model: Glass (details not provided)
- Temperature factor multiplied: 0.70
- Primary Circuit loss type: Solar with insulated primary piping and with cylindrical chamber:
- Hot water storage indoors or in group: Yes

**HEATING SYSTEM - Dist. system losses and gains (Table 4 in DEAP)**

<table>
<thead>
<tr>
<th>Loss/Gain</th>
<th>Control Category</th>
<th>Percentage losses/spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central heating pump</td>
<td>Oil Boiler Pump</td>
<td>Oil boiler pump node heating</td>
</tr>
<tr>
<td>Gas boiler flue-fan</td>
<td>When air heating or fan coil radiators present: No</td>
<td></td>
</tr>
</tbody>
</table>

**HEATING SYSTEM - Energy Requirements (individual)**

- Main space heating system efficiency [%]: 55%
- Hot water heating system efficiency [%]: 35%
- Secondary heating system efficiency [%]: 0.9
- Fraction of heat from CHP: 0
- Electrical efficiency of CHP: 0
- Heat efficiency of CHP: 0
- CHP Fuel type: None

**SUMMARY FOR PART L CONFORMANCE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>BBR Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EER Result</td>
<td>W/Wm²</td>
<td>4.12</td>
<td>Pass</td>
</tr>
<tr>
<td>CO₂ emissions (kg/m²):</td>
<td></td>
<td>0.65</td>
<td>Pass</td>
</tr>
<tr>
<td>EPC</td>
<td></td>
<td>0.363</td>
<td>Pass</td>
</tr>
<tr>
<td>GBC</td>
<td></td>
<td>0.38</td>
<td>Pass</td>
</tr>
</tbody>
</table>

**PART L CONFORMANCE - Fabric**

- Conformed with Minimum U and U-Value requirements: Pass
- Conformed with Minimum U and U-Value requirements: Pass
- External doors, windows: Pass
- Floors with under floor heating: Pass
- Walls: Pass

**PART L CONFORMANCE - Renewables**

- Total renewable distribution (kWh/m²): 1.50
- Total thermal equivalent: 1392.99
- Total electrical: 0.00
- Total thermal equivalent: 1392.99
- Does total thermal equivalent meet Part L requirement? Pass

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Fingal County Council

fingal.ie
### Example building

**Date:** Mon Feb 11 16:34:26 2019

**Administrative information**

- **Building Details**
  - Address: Street Name One, Street Name Two, Town Name One, Town Name Two, Co. Carlow, A6 F4E2B
  - Telephone number: 967004321
  - Address: Any Road, Dublin, A6 F4E2B

- **NEAP**
  - Calculation engine: SBEEME
  - Interface to calculation engine: SBEEMe

- **Energy Assessment Details**
  - Name: John Jones
  - Telephone number: 967004321
  - Address: Any Road, Dublin, A6 F4E2B

**Primary Energy Consumption, CO2 Emissions, and Renewable Energy Ratio**

- **Heat Transmission through Building Fabric**

<table>
<thead>
<tr>
<th>Element</th>
<th>Unvent.</th>
<th>Unvent.</th>
<th>Unvent.</th>
<th>Unvent.</th>
<th>Surface with maximum U-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st floor</td>
<td>0.21</td>
<td>0.21</td>
<td>0.6</td>
<td>0.21</td>
<td>z181bf</td>
</tr>
<tr>
<td>2nd floor</td>
<td>0.21</td>
<td>0.21</td>
<td>0.6</td>
<td>0.21</td>
<td>z181bf</td>
</tr>
<tr>
<td>3rd floor</td>
<td>0.21</td>
<td>0.21</td>
<td>0.6</td>
<td>0.21</td>
<td>z181bf</td>
</tr>
<tr>
<td>Windows, roof windows, and rooflights</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>z0984w8d</td>
</tr>
<tr>
<td>Personnel doors</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>z0984w8d</td>
</tr>
<tr>
<td>Vehicle access &amp; similar large doors</td>
<td>1.5</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>No ext. vehicle access doors</td>
</tr>
<tr>
<td>High usage entrance doors</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>No ext. high usage entrance doors</td>
</tr>
<tr>
<td>Air Permeability</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>This Building’s Value</td>
</tr>
</tbody>
</table>

**Building Services**

- **1. HVAC for the example building**
  - Heating efficiency: 1.56
  - Cooling efficiency: -
  - Radiant efficiency: 1.2
  - FSP [kW/ha]:
  - Standard value: 2.75
  - Automatic monitoring & targeting with alarms for out-of-range values: YES

**Local mechanical ventilation, exhaust, and terminal units**

- **ID System type in Building Regulations documents**
  - A: Local supply or extract ventilation units serving a single area
  - B: Zonal supply system where the fan is remote from the zone
  - C: Zonal extract system where the fan is remote from the zone
  - D: Zonal supply and extract ventilation systems serving a single room or zone with heating and heat recovery
  - E: Local supply and extract ventilation system serving a single area with heating and heat recovery
  - F: Other local ventilation units
  - G: Fan-assisted terminal VAV unit
  - H: Fan coil units
  - I: Zonal extract system where the fan is remote from the zone with a grease filter

**General lighting and display lighting**

- **Luminous efficiency [lm/W]**
  - Standard value: 99
  - Display lamp: 16
  - General lighting [W]:
    - z100: 96
    - z100: 100
    - z100: 100
    - z100: 600
Desktop Compliance

- Part L Conformance Report Key information
  - Ventilation – air permeability (ac/h 0.125used), SFP, MV, HR
  - Building elements – Building Fabric U-values
  - Other details –
    - Thermal Bridging coefficient 0.15-0.08(ACDs)-modelled. (0.08used)
    - Amount of low energy Lighting – LENI. Parasitic energy.
  - Heating system – space and water heating
    - Solar, Heating-Heat pump/Gas boiler, Storage
  - Heating system – Energy Requirements
    - Heating system efficiencies
    - Solar gain of building
    - Overheating
  - Cooling system – SEER
  - Controls - BMS

- SUMMARY FOR PART L CONFORMANCE – pass/fail
  - BER result and energy value kWh/m²/yr
  - EPC & CPC – DEAP and NEAP values
  - Fabric U-values
  - Percentage opening areas
  - Renewables – RER 20%
Drawings/Specs

- Plans, calculations, specifications and particulars to enable construction in compliance
  - Not planning drawings
  - Must match the building
  - Must be accurate – scale/dimensions/products
  - Demonstrate compliance with Building Regs A-M (or in the Spec)
  - Detailing avoid TB (or in the Spec) and ensure air tightness
  - Info on the Renewables

- What do we look for at CCC
  - Documents to show compliance – Air test, Part L Conformance report, As const drawing
**Drawings/Specs**

- **Render on 215mm blockwork**
- **25mm battens**
- **Air gap**
- **62.5mm insulated dry lining**

To achieve a minimum overall U value of 0.14W/m²K

Therefore, TC = 0.01 W/mK
Site Construction Compliance

- **LAW: Section 11 Powers – key elements**
  - Power to inspect during construction or following completion and inspection includes any building, plans or documents relating to such building
  - Power to request plans, documents, information as necessary to establish compliance with requirements of building regulations
  - Take samples of materials

- **LAW: Section 8 Enforcement Notices:**
  - WHERE (a) the construction of any building, (b) the building or works are not carried out in conformity with building regulations, and (c) the BCA would be prepared to grant a dispensation or relaxation, the BCA may serve a S8 Enforcement notice

- **Certificate of Compliance on Completion**
  - Consider within 21 days of the date of its receipt whether the CCC is valid having regard to submitted information showing compliance and that all enforcement notices, information requests and statutory processes have been satisfactorily concluded
Construction of Building Fabric

- Insulation – 2011 Backstop wall U-Value is 0.21W/M²K
  - nZEB Backstop – 0.18W/M²K – 15% reduction

nZEB Requirements
For Dwellings
**Const of Building Fabric**

- **Types of insulation materials**
  - Mineral Wool - Thermal conductivity of 0.031 to 0.044W/mK
  - Expanded polystyrene (EPS) and Extruded polystyrene (XPS) - Thermal conductivity of 0.030W/mK approx
  - Polyurethane (PUR) and polyisocyanurate (PIR) - thermal conductivity of 0.022 to 0.020W/mK
  - Phenolic (PF) - thermal conductivity of 0.021 to 0.018W/mK
  - INSULATION FROM RENEWABLES - sheep’s wool (0.038W/mK), Recycled newspaper, cellulose or wood fibre (0.035 to 0.040W/mK), Cotton fibre (similar to sheep wool), Calcium silicate boards (sand and lime) (0.059 W/mK) and Hemp (0.04 W/mK).

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<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Conductivity (W/m K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brickwork</td>
<td>0.77</td>
</tr>
<tr>
<td>Concrete - high density</td>
<td>1.93</td>
</tr>
<tr>
<td>Concrete block - lightweight aggregate</td>
<td>0.57</td>
</tr>
<tr>
<td>Glass</td>
<td>1.022</td>
</tr>
<tr>
<td>Plaster lightweight</td>
<td>0.18</td>
</tr>
<tr>
<td>Insulation mineral wool batt</td>
<td>0.038</td>
</tr>
<tr>
<td>Insulation polyurethane board</td>
<td>0.025</td>
</tr>
<tr>
<td>Steel - mild structural</td>
<td>60</td>
</tr>
<tr>
<td>Timber - softwood</td>
<td>0.13</td>
</tr>
<tr>
<td>Tiles - clay roof</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Const of Building Fabric

- **Insulation Location**
  - Cavity wall (with no insulation U-value is 1.5W/M²K)
  - Internal Insulation
  - External Insulation
Const of Building Fabric

- **Insulation Problems**
  - Gaps in Rigid insulation
  - Gaps between Insulation and warm wall – Convection looping
  - Cavity closure detail
  - Gaps in blown in Insulation – workmanship – how to check?
Const of Building Fabric

- **Insulation Problems**
  - Cavity wall ties incorrectly used
  - Cavities not cleaned out
  - Water penetration into insulation
  - Interstitial Condensation
  - Building Users – e.g. TM house
Construction – air tight

- **Air Tightness** – 2011
  - Part L is $7 \text{m}^3/(\text{hr.m}^2)$
  - nZEB proposed to be $5 \text{m}^3/(\text{hr.m}^2)$
  - Below $3 \text{m}^3/(\text{hr.m}^2)$ recommends Mechanical Ventilation – MV, DCV, MVHR
  - Occupier complaint
Construction - detailing

- **Thermal Bridging**
  - Means ‘Break in the insulation’ or Thermal bypass
    - Default value 0.15 for DEAP
    - ACDs (acceptable construction designs)
    - Calculated
    - Thermal model
    - \( TB = \text{Mould} - fRsi = \frac{(Tsi - Te)}{(Ti - Te)} \)

- **Recommendations:**
  - Thermal insulation and airtightness barrier should form a continuous line
  - No gaps or breaks in the thermal insulation or air barrier
  - Extra attention to air tightness membrane at junctions
  - Isolate thermal bridge with insulation
Renewables

- **Renewables**
  - Solar Panel
  - Photovoltaic Panel
  - Wind turbine
  - CHP – combined Heat and Power
  - District Heating
  - Biomass/biofuel
  - Heat Pumps

- **Heat Recovery**
  - MVHR
  - WWHR

- **RER** – Renewable energy ratio
Part L Compliance

- Heating and cooling efficiencies
- Energy Controls
- Lighting

User Information – maintenance schedule, Control info, air test result, renewables
Part L Current Issues

- **Modern Methods of Construction**
  - Timber frame
  - Precast Concrete
  - ICF
  - Steel framed
  - Modular

- **M&E reliance**

- **Overheating**

- **Workmanship** – TB and Air tightness

- **USERS** – Controls/modifications

- **Existing stock**
The Future

- **Renewable technology advances**
  - Solar Glass
  - Solar Tiles
  - Heat Pump technology
  - Heat Exchangers
  - Energy storage

- **Thermal Bridging**
  - Passive design

- **Improved building products**

- **ZEB by 2050**

- **Energy Plus**