Retrofitting Cambridge University Buildings to a Passivhaus Standard

Zero Carbon, Low Energy, Sustainable, Environmentally Fit Passive Buildings

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INTEGRITY BUILDINGS AND CUBE-S

INTEGRITY BUILDINGS

• Integrity built London’s first accredited Passivhaus

CUBE-S

• >15 years designing & project managing to Passivhaus standard
• Leading R & D for ‘Austria Plus’ and ‘Zero’
• Developing methods and standards with University of Vienna
• Extensive experience of Retrofit Market to Passivhaus and better

INTEGRITY AND CUBE-S

• a unique innovative partnership
• New developments on-going in technology and methodology
STATE OF THE ART
CLIMATE CHANGE

We are facing:

• Increase in cooling degree days
• Decrease in heating degree days

We look at not only heating in winter, but also cooling in summer.

Other considerations include:

• Wetter winters
• Dryer summers
• More intense rain periods
• Ground water content – greater fluctuation in clay soils

We look to deliver buildings that are low carbon, low energy, sustainable, cost effective and user friendly using innovative and practical solutions that can be rolled-out.
WHAT IS RETROFIT

Retrofit applies to any building that improves both carbon reduction and energy efficiency

The percentage of energy lost proportionally from a typical building occur through:

• Walls 50%
• Roof 20%
• Ventilation 15%
• Windows 10%
• Floor 5%

Cube-s by utilising innovative, creative and practical solutions found that the following key measures have proved to be particularly effective:

• Improved thermal insulation
• Reduction of thermal bridges
• Improved air tightness
• Use of high quality windows
• Ventilation with highly efficient heat recovery
PASSIVHAUS

Passivhaus is the fastest growing energy performance standard in the World and is the leading international design standard for:

**Zero Carbon, Low Energy, Sustainable, High Quality, Environmental Fit Passive Buildings**

In simple terms:

- Super insulated
- Free of thermal bridging
- Very low air-leakage
- Mechanically ventilated (with heat recovery)
- Passive solar with solar shading

Passivhaus standard better than Code 4 for Sustainable Homes,

Close to the Zero Carbon “Carbon Compliance” standard

**Significant carbon reduction and energy savings of between 80 - 90%**
The EnerPhit Standard has been developed as a good practice refurbishment guide for Passivhaus standard renovations.

**Significant carbon reduction and energy savings of between 75 and 90%**

Specific energy demand criteria:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Traditional House</th>
<th>Passivhaus</th>
<th>EnerPHit</th>
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<tbody>
<tr>
<td>Space Heat Demand</td>
<td>+55 kWh/m².yr</td>
<td>≤ 15 kWh/m².yr</td>
<td>≤ 25 kWh/m².yr</td>
</tr>
<tr>
<td>Air-Tightness</td>
<td>n&lt;sub&gt;50&lt;/sub&gt; 7 - 10</td>
<td>n&lt;sub&gt;50&lt;/sub&gt; ≤ 0.6&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>n&lt;sub&gt;50&lt;/sub&gt; ≤ 1.0&lt;sup&gt;-1&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Prime energy demand for Passivhaus and EnerPhit is <120kWh/m² yr.

- How much energy is needed to power all of the activities within the building (heating, water, lighting, cooking and appliances).
THE BIG PICTURE
Overview: Energy in Buildings

Today's construction standards

State of the Art: Perfect Heat Recovery („Passivhaus“)

The next step: Full Scale Energy Balance

Life Time Cycle: from construction to the very end

Recycling of old substance

Old Substance becomes low energy: Retrofit

Technological Evolution

Energy consumption impact

Today's construction standards

New substance

Old Substance becomes low energy: Retrofit

Recycling of old substance

Life Time Cycle: from construction to the very end

The next step: Full Scale Energy Balance

State of the Art: Perfect Heat Recovery („Passivhaus“)

Technological Evolution
ENERGY BALANCE IN BUILDINGS

- Infiltration heat loss
- Transmission heat loss
- Insolation gains
- Internal heat gains
- External energy input
- 'Neutral gains': Solar, Wind, Geothermic, etc
... AND WHAT ABOUT OLD BUILDINGS?

- Infiltration heat loss

- Transmission heat loss

- Insolation gains

- Internal heat gains

- External energy input

!!!

'SNeutral gains': Solar, Wind, Geothermic, etc
NOTHING CAN BE THE SAME, BUT SOME TALKING POINTS...

Horizontal or vertical cabling?

Facade cladding...

Automatic windows-ventilation...
...AND A GLIMPSE OF THE FUTURE: THE PLUS HOUSE

Comparison of primary energy demand excluding photovoltaic gains in kWh/m²

- Server etc
- Elevator, Kitchen, etc
- Lighting
- Ventilation
- Cooling
- Heating

Before After Retrofitting
THE CURRENT ENERGY BALANCE

Energy demand in kWh electric power/year

"minus"

Energy earnings in kWh electric power/year

- Server
- Social rooms (kitchen)
- Elevator
- Computer, Office
- Ventilation
- Lightning
- Hot water
- Dehumidification
- Humidification
- Cooling
- Heating

- Roof, neighbour building
- Roof, skyscraper TU
- Facade SE
- Facade SW
The future: old and new becomes one

Autarchic Life Cycles
old & new

- Recycling of old substance
- Old Substance becomes low energy
- Life Time Cycle: from construction to the very end

Clusters & Clouds:
Teaching – Leisure – Living – Shopping

→ Cambridge Campus and City has all preconditions for the perfect Cloud concept!
THE CAMBRIDGE PROJECT
# RETROFITTING HISTORIC BUILDINGS

## CONSIDERATIONS:

<table>
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<tr>
<th>Carbon demand reduction</th>
<th>Planning issues</th>
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<td>Building energy – single or multiple building – biomass, etc.?</td>
<td>Conservation issues</td>
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<tr>
<td>Energy and fuel demand reduction</td>
<td>Design issues</td>
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<tr>
<td>Thermal issues</td>
<td>Building performance</td>
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<td>Insulation issues</td>
<td>Materials and methods</td>
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<td>Air tightness strategy</td>
<td>Metering and monitoring</td>
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<tr>
<td>Moisture management</td>
<td>Finance and funding</td>
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<tr>
<td>Smart energy technologies</td>
<td>How will building cope with new conditions</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Windows and doors</th>
<th>Resource efficiency – energy / water</th>
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<td>Glazing solutions with conservation solutions</td>
<td>Multi-use pattern – energy demand spread and pattern</td>
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</table>
THE APPROACH

Low Energy = Low Carbon

To ensure carbon reduction, sustainability, energy efficiency, and comfort, we need to:

• consider design requirements
• Look at materials and methods
• creative and practical solutions
• Model and calculate proposed works
• Produce cost effective programme

We also need to achieve:
• Constant air temperature
• Uniform surface temperatures
• Draft free spaces
• Managed humidity

Works to be looked at as a whole-building approach, even if works are phased.
CAMBRIDGE SURVEY REQUIREMENTS

Analysis of Building: *every building is unique*

Research and Survey First:
- Knowledge of how the existing building and fabric works
- Detailed Survey and measurement of building
- Investigation of existing fabric
- Speak to: facilities manager, lecturers, staff and students
- Lux level requirements
- How many computers & other technical equipment
- How many people sitting / standing - for which days, terms, hours
- Activity planned per room

Design, Plan, Anticipate – there will still be surprises
THE NEXT STEP

Cambridge University to consider how Integrity/Cube-s might contribute towards achieving its objectives in retrofitting a University Building.

This may involve Integrity/Cube carrying out a detailed site survey which would include:

- External Walls
- Internal Walls
- Floors
- Roof
- Windows and Doors
- All Fabric Penetrations

Integrity/Cube-s to then:

- Calculate carbon reduction and energy efficiency using PHPP
- Model the works, sustainable technologies and materials
- Detailed report on findings and our proposals
- Budget to carry out and differing scenarios
- Produce a draft programme of the works
INTEGRITY BUILDINGS AND CUBE-S

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