Decoding sustainability

Exploring the challenges and possibilities presented by concepts of sustainability in architecture, we launch the first of five pull-out charts published by engineers Max Fordham in the AJ. This week: building greener offices

In 2005 engineers Max Fordham and architecture practice Feilden Clegg Bradley Studios were asked by our client, the National Trust, to explain how their new headquarters building, Heelis, would meet their aspiration for ‘best practice and occasional innovation in sustainability’. Peter Clegg came up with the inspired idea of a matrix, and I worked on the engineering content. The matrix, together with the financial implications of achieving the criteria, provided a framework to help the board achieve a practical overview of their options and develop a well-informed client brief.

We have continued to use the matrices at Max Fordham to help communicate what sustainability-driven decisions will mean to our clients. We have now updated them to highlight ongoing and current issues. As a partnership of engineers we feel it’s good for our industry and for the sustainability agenda to make the matrices available to as wide an audience as possible. That’s why we are publishing them here in the AJ.

Guy Nevill, partner, Max Fordham

How to use this matrix

Think of the matrix as a communication tool to promote discussion during early design. Issues 1, 3, 4 and 5 of this series cover operational emissions for specific building types and should be read with issue 2, which covers wider sustainability considerations common to all building types.

We tailor strategies and options on each matrix to make them project specific. Boxes are highlighted to indicate what sustainability targets the project can achieve within the budget and assess investment options for achieving more.

Hero Bennett, sustainability consultant, Max Fordham

Case study

Completed in 2006, Heelis, the National Trust’s central office, is an exemplar in sustainable office design. It is a deep-plan naturally ventilated building with exposed thermal mass on both floor levels to maintain stable internal temperatures.

We focused particularly upon maximising the use of daylight: introducing it via north-facing roof lights and through voids in the first floor to ground level. At the same time, there is careful control of direct sunlight; the photovoltaics provide shading in the middle of the day and the roof ventilation cowls in the morning and evening.

The project was institutionally funded, and the design met both BCO guidelines and the specific needs of the National Trust. Finishing materials such as timber and carpets were sourced from National Trust property.

Heelis is part of our continuing story of sustainable buildings delivered over nearly 50 years of Max Fordham.

Case study information

Architect Feilden Clegg Bradley Studios
Client National Trust
Value £15m
Completion 2006

The matrix provides a simple way of illustrating a series of environmental benchmarks, encouraging discussion of key issues. We find it simpler than numerical systems such as LEED and BREEAM and it can be used to chart progress towards, for instance, carbon neutrality. Peter Clegg, senior partner, Feilden Clegg Bradley Studios

For myself as project director and for the NT board, the matrix worked really well as a communications tool, helping us understand the various dimensions of sustainability and their relative performance/contributions. Sue Holden, project director, National Trust

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For more in-depth matrices, please visit www.maxfordham.com/publications/sustainability_matrix
<table>
<thead>
<tr>
<th>Sustainability criteria</th>
<th>Minimum standard</th>
<th>Best practice</th>
<th>Innovative</th>
<th>Pioneering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CO2 emission design target</td>
<td>30kg CO2/m²/yr D+ rating</td>
<td>21kg CO2/m²/yr B rating</td>
<td>8kg CO2/m²/yr A rating</td>
<td>0 kg CO2/m²/yr A rating</td>
</tr>
<tr>
<td>2. DEC rating</td>
<td>61W/m²/yr</td>
<td>48W/m²/yr</td>
<td>30W/m²/yr</td>
<td>15W/m²/yr</td>
</tr>
<tr>
<td>3. Energy consumption:</td>
<td>17kWh/m²/yr</td>
<td>14.5kWh/m²/yr</td>
<td>13kWh/m²/yr</td>
<td>26kWh/m²/yr</td>
</tr>
<tr>
<td>Heating and hot water load</td>
<td>10/10 (Part L 2010)</td>
<td>7.5/7.5 (Part L 2010)</td>
<td>6/6 (Part L 2010)</td>
<td>&gt;50% on-site generation or agreed off-site generation</td>
</tr>
<tr>
<td>Electrical base load</td>
<td>0.35 (Part L 2010)</td>
<td>0.2 (Part L 2010)</td>
<td>0.15 (Part L 2010)</td>
<td>&gt;20% on-site renewables</td>
</tr>
<tr>
<td>IT and small power</td>
<td>10m³/h/m² (Part L 2010)</td>
<td>2m³/h/m² (BICO Guide)</td>
<td>2m³/h/m²</td>
<td>1m³/h/m²</td>
</tr>
<tr>
<td>Average window</td>
<td>50-80% of desks occupied at any time during the working day</td>
<td>Hot-desking/desk sharing for peripatetic staff. Cleaners and right security aware of energy use</td>
<td>Hot-desking, remote working, 24-hour use restricted to small areas</td>
<td>Continual monitoring and fine-tuning. Formal external review. Results published to industry. Energy use rewards/ penalty system</td>
</tr>
<tr>
<td>Wall</td>
<td>Seasonal commissioning; Produce DEC; report to senior management</td>
<td>Commissioning company retained to monitor over first year. Full post occupation evaluation. Action plan to respond to DEC</td>
<td>Responsibilities for reading, reviewing, actioning changes defined. Anonymised external reporting.</td>
<td>Energy use and carbon emissions could also be considered per person per day worked. Evaluations show actual performance KPIs (eg in energy and water) are much greater than design predictions. This is often a result of poor commissioning, training and management. <a href="http://www.soflandings.org.uk">www.soflandings.org.uk</a></td>
</tr>
<tr>
<td>Roof</td>
<td>Facilities staff trained at building handover. Building log book provided with O&amp;M manual</td>
<td>Facilities staff involved in commissioning. Non-technical user guide produced and all staff inducted. Energy use fed back to users</td>
<td>Facility management system for small areas</td>
<td>Continual monitoring and fine-tuning. Formal external review. Results published to industry. Energy use rewards/ penalty system</td>
</tr>
<tr>
<td>Ground Floor</td>
<td>28ºc for &lt;1% working hours. External: 24ºc. Nat vent: 25ºc for &lt;5% and cooling or mixed-mode with heat recovery. Server rooms: 20ºc.</td>
<td>Technical user guide produced and all staff inducted. Energy use fed back to users</td>
<td>Building design tested to UKCIP 2050</td>
<td>Design to CBSE Lighting Guide 10, BS8206 Part 2 and the BRE Site Layout Guide 10</td>
</tr>
<tr>
<td>Airtightness at 50Pa</td>
<td>2.2 (Part L 2010)</td>
<td>1.4</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>7. Building occupancy</td>
<td>0.15</td>
<td>0.12</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>8. Controls, metering and monitoring</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>9. User involvement</td>
<td>&gt;2% average daylight factor where possible.</td>
<td>BICO design targets and test to UKCIP 2020. Dress code partly relaxed in warm weather as ISO7730</td>
<td>Maximise adaptive comfort; dress code entirely relaxed; eg allow shorts and short sleeves in Summer. Building design tested to UKCIP 2050</td>
<td>Building design tested to UKCIP 2080</td>
</tr>
<tr>
<td>10. Summer thermal targets for energy reduction</td>
<td>CIBSE/BCO design targets. Air-con spaces: 24 +/- 2ºC. Nat vent: 25ºC for &lt;5% and cooling only for &lt;1% working hours. External temperatures to suit geographic location.</td>
<td>BICO design targets and test to UKCIP 2020. Dress code partly relaxed in warm weather as ISO7730</td>
<td>BICO design targets and test to UKCIP 2020. Dress code partly relaxed in warm weather as ISO7730</td>
<td>Building design tested to UKCIP 2080</td>
</tr>
<tr>
<td>11. Thermal mass, ventilation and cooling</td>
<td>Nat vent where possible, otherwise mech vent and comfort cooling.</td>
<td>Thermal mass in roof. Nat vent plus low grade cooling or mixed-mode with heat recovery. Server room uses free cooling when possible</td>
<td>Nat vent with comfort cooling served by GSHP or mech vent with heat recovery. Free cooling and heat recovery to server room</td>
<td>Highly dependent on how staff use the building</td>
</tr>
<tr>
<td>13. Daylighting</td>
<td>Provide fixed external shading. Manual internal blinds</td>
<td>Narrow plan floorplates or rooflights to provide daylight. Views to sky. 80% floor area &gt;2% average daylight and uniformly 0.4</td>
<td>Building form heavily influenced by daylight design. 80% floor area &gt;3% average daylight factor</td>
<td>Highly site dependent.</td>
</tr>
<tr>
<td>14. Artificial lighting and controls</td>
<td>Average 2% daylight factor where possible. Views to outside. Glare control blinds</td>
<td>300 lux background lighting plus task lighting. Daylight dimming and presence detection throughout building</td>
<td>Building form heavily influenced by daylight design. 80% floor area &gt;3% average daylight factor</td>
<td>Design to SLL Lighting Guide L87</td>
</tr>
<tr>
<td>15. IT strategy</td>
<td>300-500 lux to BCO and CIBSE guidelines. PIR detectors in WCs etc. Fluorescent fittings throughout</td>
<td>300 lux background lighting plus task lighting. Daylight dimming and presence detection throughout building</td>
<td>Off-site internet-based cloud-computing systems</td>
<td>Cloud computing = software and resources provided by internet on demand, like the electricity grid</td>
</tr>
</tbody>
</table>

**Notes**

- Zero carbon’ not yet fully defined
- Typical design stage modified target
- The DEC used rather than EPC = highly user dependent
- Approximate values for Nat Vent. Defined by a combination of the design strategy and operation
- Electrical base load note: ‘includes lighting and mechanical plant. Includes server cooling
- Highly site dependent
- Difficult to pass 2010 Building Regs using minimum regulation values: 20-30% improvement in U-values and air tightness typical

Decoding sustainability

The third in this series of five pull-out charts from engineers Max Fordham tackles the challenges of building sustainable schools, and teaching the communities within them how best to use their buildings.

Question: How do schools learn to be sustainable? The key to answering this question lies in recognising that the school is not just the building itself, but the communities that use it. We know all about designing energy efficiency into buildings – it’s what we do every day. But we also know that actual energy use can be significantly higher than predicted. A recent Max Fordham study revealed the factors that account for the difference between energy performance predicted at design stage and the actual energy performance of schools in use. From this study we can identify the critical variable factors that influence energy use. The way the building is used is as important as the way the building is designed. To really achieve sustainable schools, we need to engage with the school community so we can design for how the building is going to be used, and the school community can understand what the design means to them and their choices about how they use the building. This offers immediate and rich source material for learning. Matt Dickinson, partner, Max Fordham.

How to use this matrix

Think of the matrix as a communication tool to promote discussion during early design. Boxes 1, 3, 4 and 5 of this series cover operational emissions for specific building types and should be read with issue 2, which covers wider sustainability considerations common to all building types. We tailor strategies and options on each matrix to make fit project specific. Boxes are highlighted to indicate what sustainability targets the project can achieve within the budget and assess investment options for achieving more.

Hero Bennett, sustainability consultant, Max Fordham.

Case study

Students at City Academy, Hackney, learn in optimum natural light and comfortable, well ventilated, quiet spaces – a good environment in which to learn. A ground-source heat pump underneath the sports field supplies three quarters of the energy needed for heating, while 130 photovoltaic panels on the roof deliver enough electricity to light 50 classrooms. All insulation material used in the provision of building services is zero ozone depletion potential. The school community was involved from the outset of the project. City Academy Hackney is part of our continuing story of sustainable schools delivered over nearly 50 years of Max Fordham.

Architects on school design

‘Schools learn to be sustainable by taking charge of an agenda that works for them. Architects can help them develop this by providing a building that supports their goals, including the development of an ecological curriculum which uses the building as a teaching tool. Technical solutions can help where a school understands how to use them effectively and efficiently.’ Sarah Wigglesworth, Sarah Wigglesworth Architects.

City Academy, Hackney, London

‘Schools learn to be sustainable by understanding the environmental, social and economic benefits of sustainability, and ensuring the whole school community understands what this means. KPMG helped the City academy students set up an environmental committee to drive environmental awareness. One of the first things they decided to do was invite the architects and engineers to demonstrate how to use the building so that they could communicate this to the rest of the school. KPMG is committed to a sustainable approach in its own offices and, together with the City of London Corporation as joint sponsor, has driven these values through the whole academy design and construction process, ensuring that the community was engaged with from the very outset.’ Charlotte Rogers, CSR manager, KPMG.

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Matt Dickinson and Matt Oliver, school specialists
Hero Bennett, sustainability consultant
For more in-depth matrices, please visit
www.maxfordham.com/publications/sustainability_matrix

To see our report go to www.maxfordham.com/publications/energy_performance_in_schools
SCHOOLS

ENERGY CRITERIA TO BE USED IN CONJUNCTION WITH WIDER SUSTAINABILITY PARAMETERS

MAX FORDHAM

**Sustainability criteria**

<table>
<thead>
<tr>
<th>a: Building and operational targets</th>
<th>b: User and operational interaction</th>
<th>c: Design elements and strategies</th>
<th>d: Acoustic targets</th>
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</thead>
<tbody>
<tr>
<td>Proposed Building Regulations</td>
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</tr>
<tr>
<td>1. CO2 emission – Design calculation for benchmarking</td>
<td></td>
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<tr>
<td>2. CO2 emission – Actual operational</td>
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<tr>
<td>3. DEC rating</td>
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<tr>
<td>4. Actual operational loads by usage:</td>
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<tr>
<td>Heating and hot water load</td>
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<tr>
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<tr>
<td>Small power and IT load</td>
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<tr>
<td>Catering load</td>
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<tr>
<td>5. On-site energy generation</td>
<td></td>
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<tr>
<td>6. U-values (W/m2K)</td>
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<tr>
<td>Wall</td>
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<td></td>
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<tr>
<td>Average window</td>
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<td>Ground floor</td>
<td></td>
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<td></td>
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<tr>
<td>7. Airtightness at 50Pa</td>
<td></td>
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</tbody>
</table>

**Minimum standard**

- 2010 Part L Regulation
  - 20kCO2/m2/yr
  - 4 kWh/m2/yr
  - D-C rating
  - 3kWh/m2/yr
  - 31 kWh/m2/yr
  - 10 kWh/m2/yr
  - Up to 20% (to comply with local planning)
  - 0.36 (Part L 2010)
  - 0.36 (Part L 2010)
  - 0.36 (Part L 2010)

**Best practice**

- PFI Paymech Target
  - 15kCO2/m2/yr
  - 27 kWh/m2/yr
  - B rating
  - 24 kWh/m2/yr
  - 33 kWh/m2/yr
  - 27 kWh/m2/yr
  - 30% CO2 emission
  - 0.2
  - 1.4
  - 0.16
  - 0.16

**Innovative**

- 2013 Part L Regulation
  - 19kCO2/m2/yr
  - 17 kWh/m2/yr
  - A+ rating
  - 6 kWh/m2/yr
  - 6 kWh/m2/yr
  - 50%–100%
  - 0.15
  - 1.0
  - 0.12
  - 0.12
  - 2m²/ft²

**Pioneering**

- 2016 ‘Zero Carbon’
  - 0 kgCO2/m2/yr
  - 0 kgCO2/m2/yr
  - 0 kgCO2/m2/yr
  - 0 kgCO2/m2/yr
  - 0 kgCO2/m2/yr
  - 0 kgCO2/m2/yr

**Notes**

- [Zero carbon] not yet fully defined
- Typical design stage modelled loads
- Typical metered loads
- Target DEC highly user dependent
- Modelled on secondary schools and based on typical metered loads
- Includes server cooling
- Highly client driven
- Pioneering: nothing hot cooked onsite
- Highly dependent on site conditions
- Difficult to pass 2010 BuildingRegs using minimum regulation values: 20-30% improvement in U-values and airtightness typical

**Proposed Building Regulations**

- 2010 Part L Regulation
  - 20kCO2/m2/yr
  - 4 kWh/m2/yr
  - D-C rating
  - 3kWh/m2/yr
  - 31 kWh/m2/yr
  - 10 kWh/m2/yr
  - Up to 20% (to comply with local planning)
  - 0.36 (Part L 2010)
  - 0.36 (Part L 2010)
  - 0.36 (Part L 2010)

**Seasonal commissioning**

- Produce DEC report to senior management
- Facilities Staff trained at building handover
- Building log book provided with O&M manual

**Commissioning company retained to maintain over first year**

- Full post occupancy evaluation
- Action plan to respond to annual DEC
- Facilities staff involved in commissioning
- Non-technical user guide produced and all staff instructed
- Energy use fed back to users

Responsibilities for reading, reviewing, acting
changes defined
Anonymised external reporting
Departmental energy targets
Soft Landings framework (see note) followed
Energy use and guide on interactive display screen and online
Building use part of curriculum

Pupils involved in monitoring
Continual monitoring and fine-tuning
Formal external review
Results published to industry
Energy use reward/penalty system
Departmental energy use feeds into personal carbon trading (eg WSPI’s PACT scheme)

**Notes**

- Evaluations show actual performance KPI’s (eg in energy and water) are much greater than design predictions
- This is often a result of poor commissioning, training and management

**11. Ventilation strategy**

- 24°C with a swing not more than +4°C
- Above 28°C for no more than 80 hours
- Not vent where possible, otherwise mech vent
- Cool server rooms to no less than 24°C
- Max vapour use of daylight
- PIR detectors in WCs etc. Low energy fittings throughout
- Users encouraged to switch off PCs overnight

**Encourage adaptive clothing. Design to UKCIP 2020**

- BMS control and night cooling
- Heat recovery on all areas with mech vent
- Heat recovery on server room cooling in winter.
- Ground source heat pump coupled cooling
- 80% floor area >2% average daylight and uniformity 0.4

24°C with a swing < +4°C. Above 28°C for no more than 120 hours. Design fabric to UKCIP 2060

- Exposed thermal mass or mech vent with heat recovery. Assisted nat vent for peak summertime
- Ground source free cooling

- 20-30% improvement in u-values
- 2020 Part L Regulation

- 14kWh/m2/yr
- 12kWh/m2/yr
- 2kWh/m2/yr
- 11kWh/m2/yr
- 9kWh/m2/yr
- 7kWh/m2/yr
- 5kWh/m2/yr

- Test fabric to UKCIP 2080
- Use of pre-cooked air for peak summer time and increased levels of thermal mass or phase change materials

- Nat vent = natural ventilation
- Mech vent = mechanical ventilation

**12. Server room cooling systems/ sources**

- 24°C with a swing not more than +4°C
- Above 28°C for no more than 80 hours
- Not vent where possible, otherwise mech vent
- Cool server rooms to no less than 24°C
- Max vapour use of daylight
- PIR detectors in WCs etc. Low energy fittings throughout
- Users encouraged to switch off PCs overnight

**Ground source free cooling**

- 20-30% improvement in u-values
- 2020 Part L Regulation

- 14kWh/m2/yr
- 12kWh/m2/yr
- 2kWh/m2/yr
- 11kWh/m2/yr
- 9kWh/m2/yr
- 7kWh/m2/yr
- 5kWh/m2/yr

- Test fabric to UKCIP 2080
- Use of pre-cooked air for peak summer time and increased levels of thermal mass or phase change materials

- Nat vent = natural ventilation
- Mech vent = mechanical ventilation

**13. Daylighting**

- 24°C with a swing not more than +4°C
- Above 28°C for no more than 80 hours
- Not vent where possible, otherwise mech vent
- Cool server rooms to no less than 24°C
- Max vapour use of daylight
- PIR detectors in WCs etc. Low energy fittings throughout
- Users encouraged to switch off PCs overnight

**Ground source free cooling**

- 20-30% improvement in u-values
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- 14kWh/m2/yr
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- 11kWh/m2/yr
- 9kWh/m2/yr
- 7kWh/m2/yr
- 5kWh/m2/yr

- Test fabric to UKCIP 2080
- Use of pre-cooked air for peak summer time and increased levels of thermal mass or phase change materials

- Nat vent = natural ventilation
- Mech vent = mechanical ventilation

**14. Artificial lighting and controls**

- 24°C with a swing not more than +4°C
- Above 28°C for no more than 80 hours
- Not vent where possible, otherwise mech vent
- Cool server rooms to no less than 24°C
- Max vapour use of daylight
- PIR detectors in WCs etc. Low energy fittings throughout
- Users encouraged to switch off PCs overnight

**Ground source free cooling**

- 20-30% improvement in u-values
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- 14kWh/m2/yr
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- Test fabric to UKCIP 2080
- Use of pre-cooked air for peak summer time and increased levels of thermal mass or phase change materials

- Nat vent = natural ventilation
- Mech vent = mechanical ventilation

**15. IT strategy**

- 24°C with a swing not more than +4°C
- Above 28°C for no more than 80 hours
- Not vent where possible, otherwise mech vent
- Cool server rooms to no less than 24°C
- Max vapour use of daylight
- PIR detectors in WCs etc. Low energy fittings throughout
- Users encouraged to switch off PCs overnight

**Ground source free cooling**

- 20-30% improvement in u-values
- 2020 Part L Regulation

- 14kWh/m2/yr
- 12kWh/m2/yr
- 2kWh/m2/yr
- 11kWh/m2/yr
- 9kWh/m2/yr
- 7kWh/m2/yr
- 5kWh/m2/yr

- Test fabric to UKCIP 2080
- Use of pre-cooked air for peak summer time and increased levels of thermal mass or phase change materials

- Nat vent = natural ventilation
- Mech vent = mechanical ventilation

**16. Acoustic targets**

- Design to BB93 schools acoustic targets
- Music rooms: airborne sound insulation 5dB higher and impact sound insulation 5dB lower than in BB93. BB93 ancillary space guidance performance standards met

BREEAM rain noise requirements on ceilings achieved

Ventilation openings react to external noise conditions – controlled by BMS to balance with other constraints
Decoding sustainability

The second in this five-part series of pull-out charts from engineers Max Fordham explores sustainability beyond energy, and how best to balance green ambitions with the budgetary realities of clients.

Question: Why is it so difficult to decipher sustainability? Sustainability is an optimistic philosophy at the big-picture scale: to give it meaning, it has to be narrowed down. The outcome depends on opinion and context, so the uncertainty can feel paralyzing. In terms of the built environment, many different factors affect sustainability at widely different scales, from water infrastructure at a regional scale to embodied energy of materials. Metrics are a starting point, but aren’t everything. What this sustainability matrix offers is a way to make choices explicit, which can then be costed to inform decision-making.

It’s tempting to aspire to be pioneering across every parameter; the challenge is to find the balance which delivers an achievable scheme that fits the client and their budget. Success is most likely to result from an integrated design process that includes sustainability from the outset. Metrics are a starting point for intelligent choices by all project stakeholders. These matrices help narrow down and communicate the objective; the hard bit is managing priorities when you can’t have everything.

Adam Ritsbic, partner, Max Fordham

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Heno Bennett, sustainability consultant, Max Fordham

Sustainability issues

Architects on sustainability

Sustainability is only as hard to decipher as we make it. The tendency is to be too all-encompassing: that results in muddling quantitative with qualitative judgement: things we have control of with things we don’t, phenomena that we have recently related to the integrity of the earth system with established principles of sound design. We are ending up with the wrong type of codes: the ones that are hard to break.

Samund Peaun, senior partner, Ponwrey & Peaun

As a communication tool, getting a succinct but comprehensive sustainability agenda onto one sheet of A3 is extremely powerful. By setting out the broad range of the issues that need to be taken into account, with a range of targets against each of them characterised by levels of aspiration (from Minimum Standard to Pioneering), it enables non-experts to see at a glance how their project fits into the range of the possible. The use of colour coding to indicate what is included in the project at a particular stage helps make sure that the fundamentals are covered to a consistent standard and allows the client and their team to focus on those issues where it might be possible or appropriate to go further.

The linking of defined, quantifiable targets to levels of aspiration is particularly useful in that it enables non-specialists “to understand the numbers.” However, the tool can be used quite effectively in a qualitative way, particularly at the early stages of the project when building up the brief.

Bill Gehring, Sustainability + Architecture
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<tbody>
<tr>
<td>1. Embodied carbon in construction materials</td>
<td>Embodied carbon not assessed. Preference stated for locally sourced materials</td>
<td>Structure engineered to minimise material mass. Cement replacements, eg GGBFS. Materials specified to be from local sources</td>
<td>Detailed life cycle analysis for material selection. Low carbon materials where possible. Structure engineered to work at 90% capacity. Building flexibility document produced. Most materials and structure designed for dismantling</td>
<td>Structure made from entirely low embodied carbon materials, with known provenance. Building serviceability regulations challenged [Wasa]. Building carbon profiled [Sturgis]. Flexibility or dismantling drives design. Label and or e-tag main elements</td>
</tr>
<tr>
<td>2. Building and materials re-use</td>
<td>Preference for standard sizes of elements such as steel beams/columns or precast units</td>
<td>High-grade elements designed for recyclability. Future flexibility of building considered</td>
<td>45% recycled content</td>
<td>60% recycled content</td>
</tr>
<tr>
<td>3. Recycled and reclaimed content</td>
<td>19% recycled content likely as standard</td>
<td>PVC piping exchanged for LSF. No petro-chemical based insulation materials. All ‘C’ rated materials avoided</td>
<td>‘B’ and ‘C’ rated materials avoided. VOC-free paints and timber. PVF-free building. Natural materials where possible</td>
<td>Use only natural materials where products exist. 80% of materials A or A+ rated</td>
</tr>
<tr>
<td>4. Material toxicity</td>
<td>Avoid high VOC content paints, sealants etc and all ozone-depleting materials, including insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Climate change adaptation</td>
<td>No considerations beyond those embodied in regulatory compliance</td>
<td>Potential impacts reviewed with client, strategic principles discussed and reported concerning key risks</td>
<td>Measures included in upgrade strategies to address projected risks as appropriate for life expectancy of building components</td>
<td>Design approach driven by climate change adaptation implications with agreed emissions scenario and probabilistic range appropriate to each key risk</td>
</tr>
<tr>
<td>6. Landscape and biodiversity</td>
<td>Local planning requirements met. Mitigate against negative biodiversity impacts where feasible</td>
<td>Consult an ecologist on biodiversity enhancement, giving preference to local sources. Integrated landscape and water strategy. Landscape management plan</td>
<td>Develop Green Infrastructure Strategy. Landscape works in harmony with building design and climate. Extensive planting to reduce summer urban heat island. Deciduous planting for shading windows</td>
<td>Biodiversity enhancement key driver in Green Infrastructure Strategy. Landscape significantly influences building design</td>
</tr>
<tr>
<td>7. Mains water consumption</td>
<td>Commercial – &gt;5.5m³/person/yr</td>
<td>Commercial – 4.5m³/person/yr</td>
<td>Commercial – 1.5m³/person/yr</td>
<td>Commercial – &lt;1.5m³/person/yr</td>
</tr>
<tr>
<td>8. Drainage systems</td>
<td>Carry out Flood Risk Assessment. No increase in run off</td>
<td>Thorough site hydrological characterisation, design responds to environment, including SUDS where appropriate. Rainwater harvesting for WCs and irrigation</td>
<td>Flood risk defines site selection. Drainage system fully integrated into environment. Consider need for treatment for erosion.</td>
<td>Closed loop water system. Wasteto-Energy plant or alternatives to water based foul drainage</td>
</tr>
<tr>
<td>9. Construction waste minimisation</td>
<td>Contractor to produce Site Waste Management Plan (SWMP) to identify waste streams and areas for segregation on-site or post collection</td>
<td>Establish waste streams during design, set key KPIs early on. Waste reviews on design team meeting agendas. Divert 75% by weight of non hazardous project waste from landfill</td>
<td>Implement Modern Methods of Construction throughout design. Account for site conditions impacting waste. Materials logistics plan</td>
<td>Achieve zero net waste for project</td>
</tr>
<tr>
<td>10. Operational waste recycling</td>
<td>Adequate space for storing recyclable waste</td>
<td>Managed recycling processes involving space for separating and collecting recyclables. Encourage occupant to recycle</td>
<td>Provide incentives for recycling. On-site composting for biodegradable waste</td>
<td>Waste stream feeds on or off-site anaerobic digestion for biogas production</td>
</tr>
<tr>
<td>12. Stakeholder involvement and design process</td>
<td>Use of industry standards. Standard client briefing</td>
<td>Stakeholder consultation. Stakeholders understand standards and design</td>
<td>Design strategy tested with stakeholders. New boundaries set</td>
<td>Feed back the results of briefing and design process into industry standards</td>
</tr>
<tr>
<td>13. Sustainable procurement of consumables</td>
<td>Sourcing of office supplies and cleaning products considered</td>
<td>Sustainable procurement of office supplies, cleaning products and food and monitoring of consumption</td>
<td>All consumables sustainably procured. Mostly paperless organisation. Some food grown on site</td>
<td>Some organic food grown on site, with the rest seasonal, local</td>
</tr>
<tr>
<td>14. Healthy environments</td>
<td>Building has no or only a slight negative impact on productivity. Meet regulation for internal comfort, including air quality</td>
<td>No impact on productivity. Connection to outside. Air quality monitored</td>
<td>Slightly positive impact on productivity. Psychological and social impacts assessed during design</td>
<td>Building has noticeable positive impact on productivity. Strive to create a ‘sense of place’</td>
</tr>
</tbody>
</table>

Notes:
- Highly building specific. Wise, Chris, ‘What If Everything We Did Was Wrong?’
- Only applies to relevant materials
- For more see WRAP
- Biodiversity is the variety of species within an ecosystem, used as a measure of the health of biological systems
- Biodiversity significantly influences building design
- See TSB report ‘Design For Future Climate’, 2010, and Summer Targets in Energy sheet
Decoding sustainability

The fourth instalment of this five-part series of pull-out charts from engineers Max Fordham examines how an uncertain economic climate and a trend towards refurbishment over new builds offer excellent green possibilities.

**Question:** Is the bottom line or sustainability driving refurbishment?

Commercial reality will probably always mean that it is the impact on the bottom line that drives decision-making. The commercial edge of the offices sector is very sharp indeed, particularly in the current economic climate.

New York is as commercially savvy as a city gets, so it was refreshing to hear the developers of the Empire State Building describe their decision to ‘green’ the 1931 landmark as driven by ‘business sense’. When doing the right thing makes good business sense, you know that a productive convergence of interests is happening.

The responsibility and opportunity for refurbishment designers is to help clients understand the ways in which their commercial decisions and corporate social responsibilities align.

Nonwithstanding the financial drivers, if we are to make substantial carbon reductions, focusing on new builds is not going to be enough.

We need to address our existing building stock and building reuse has obvious energy benefits over demolition and new build.

Alasdair Reid, partner, Max Fordham

**Case study**

This Grade II-listed 10-storey building was originally the headquarters of an insurance company. It has grand marble-lined entrances and staircases and the offices have substantial floor-to-ceiling heights.

Victoria House has been redeveloped as modern speculative offices, the remodeling incorporating glazed atria with suspended meeting room pods. The pods needed specially designed self-contained services, and lighting was modeled to assess the effect of the pods in the atria. All the services were designed to be sensitively integrated into the listed building.

Victoria House is part of our continuing story of sustainable refurbished offices delivered over nearly 50 years of Max Fordham Consulting Engineers.

‘Undoubtedly, the current economic situation is driving refurbishment over new build, yet this represents an univalved opportunity to improve the energy efficiency and attractiveness of our buildings. Since refurbishments are typically more cost effective and faster to achieve, there is a double benefit of speeding up decarbonisation without the cost of replacing our entire stock.’

Katherine Duus, managing director, Low Carbon Workplace – Carbon Trust

‘Money will always be the main driver but in borderline cases sustainability arguments may tip the balance with responsible and/or image-conscious clients. Initiatives such as the Low Carbon Workplace are helping the sustainability argument be heard and well in due course prove the viability of energy efficient refurbishment projects.’

Jason Martin, associate, Haberlin/Brosan

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Alasdair Reid and Guy Heavilin, refurbishment specialists.
Alasdair, sustainability consultant.
Max Fordham

**How to use this matrix**

Think of the matrix as a communication tool to promote discussion during early design. Boxes 1, 3, 4 and 5 of this series cover operational emissions for specific building types and should be read with box 2, which covers wider sustainability considerations common to all building types.

We tailor strategies and options on each matrix to make them project specific. Boxes are highlighted to indicate what sustainability targets the project can achieve within the budget and assess investment options for achieving more.

Hero Bennett, sustainability consultant, Max Fordham

For more in-depth matrices, please visit www.maxfordham.com/publications/sustainability_matrices
### Minimum standard

<table>
<thead>
<tr>
<th>Sustainability criteria</th>
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<th>Best practice</th>
<th>Innovative</th>
<th>Pioneering</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CO₂ emission target</td>
<td>20%-40% improvement on existing E-C</td>
<td>40%-60% improvement or to Part L2A 2008 Level D-C</td>
<td>&gt;60% improvement or to Part L2A 2010 Level C-B</td>
<td>Green Office Best Practice or better</td>
</tr>
<tr>
<td>2. DEC rating improvement</td>
<td>10% (2010 building regulations Part L2B) 20%</td>
<td></td>
<td>50%</td>
<td>A 50%</td>
</tr>
<tr>
<td>3. Proportion of capital spent on “consequential improvements”</td>
<td>Dependent on existing conditions. See Green Office for some typical target levels 9% on-site renewables</td>
<td>Dependent on existing conditions. See Green Office for some typical target levels 19% on-site renewables</td>
<td>Minimum Green Office new build minimum standard 25% on-site renewables</td>
<td>Minimum Green Office new build best practice &gt;40% on-site renewables</td>
</tr>
<tr>
<td>4. Energy targets</td>
<td>Upgrade thermal elements’ U-values to achieve L2B threshold values (Part L2B Table 5)</td>
<td>Where feasible replace windows with operable better thermally performing units. Improve thermal elements to at least Part L2A 2010 values</td>
<td>Replace and upgrade or replace thermal elements to 30% better than Part L2A 2010 values</td>
<td>Target 2m³/hm²</td>
</tr>
<tr>
<td>5. On-site energy generation</td>
<td>No pressure testing but improve airtightness where upgrading fabric.</td>
<td>Consider thermal imaging. Target 10m³/hm²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. U-values (W/m²K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7. Airtightness at 50Pa</td>
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</tbody>
</table>

### Building occupancy

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>8. Building occupancy</td>
<td>50%-80% of desks occupied at any time of working day</td>
<td>Hot-desking/day sharing for peripatetic staff. Cleaners/night security aware of energy use</td>
<td>Hot-desking, remote working, 24-hour use restricted to small areas</td>
<td>As innovative</td>
</tr>
<tr>
<td>9. Controls, metering and monitoring</td>
<td>Seasonal commissioning. Produce DEC, report to senior management</td>
<td>Commissioning company retained to monitor over first year. Post occupancy evaluation. Action plan to respond to annual DEC</td>
<td>Responsibilities for reading, reviewing, actioning changes defined. Authorised external reporting. Departmental energy targets</td>
<td>Continue monitoring and line-terminating formal external review. Results published to industry. Energy use reward/penalty system</td>
</tr>
<tr>
<td>10. User involvement</td>
<td>Facilities staff trained at building handover. Building big book provided with O&amp;M manual</td>
<td>Facilities staff involved in commissioning. Non-technical user guide produced and all staff inducted. Energy use fed back to users</td>
<td>Departmental energy use feeds into personal carbon trading (eg. WP1s PACT scheme)</td>
<td></td>
</tr>
</tbody>
</table>

### Summer thermal targets

<table>
<thead>
<tr>
<th>Sustainability criteria</th>
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<th>Best practice</th>
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<th>Pioneering</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Summer thermal targets</td>
<td>Air con spaces: &lt;22-24°C. External temperature to suit geographical location</td>
<td>Air-con spaces: 24°C +/- 2°C. Nat vent: 25°C for &lt;5% and 28°C for &lt;1% working hours. BICO Dress code partly relaxed in warm weather as ISO7730</td>
<td>Consider alternative vent strategy. If Nat vent, replace fixed windows with operable, up to 5% of active floor area. Expose thermal mass</td>
<td>Consider adaptive comfort: 2°C external temperature when external temperature &gt;27°C</td>
</tr>
<tr>
<td>12. Ventilation</td>
<td>Assess existing plant and re-use/upgrade</td>
<td>New, more efficient chillers. Upgrade emitters or replace fan coils with modern EC motor units</td>
<td>Consider renewable cooling source such as GSHP combined with new emitters such as chilled beams</td>
<td>Consider use of deciduous trees; sun tracking louvres; insulated window/rooflight blinds with reflective outer coating</td>
</tr>
<tr>
<td>13. Cooling systems/sources</td>
<td>Re-use existing. Retest, commission, add controls where necessary. More efficient emitters if &gt;15 yrs old and financially viable</td>
<td>Provide some level of external shading. Consider mid-pane blinds, solar control glass</td>
<td>Consider external shading to S/E/W facades and limit direct sunlight. Consideration of glazing % when re-cladding</td>
<td>Consider use of education; sun tracking louvres; insulated window/rooflight blinds with reflective outer coating</td>
</tr>
<tr>
<td>15. Daylighting</td>
<td>Replace blinds to improve daylight. Consider repainting surfaces to improve reflectivity</td>
<td>New light fittings and controls. 300-500 lux on the working plane, PR detectors in WCs etc. Low energy fittings throughout</td>
<td>External shading to S/E/W facades and limit direct sunlight. Consideration of glazing % when re-cladding</td>
<td></td>
</tr>
<tr>
<td>16. Artificial lighting and controls</td>
<td>Re-use existing lighting if it complies</td>
<td>Use of external shading. Consider mid-pane blinds, solar control glass</td>
<td>Refractivate floorplate to maximise daylight</td>
<td></td>
</tr>
<tr>
<td>17. IT strategy</td>
<td>Energy use of IT system considered</td>
<td>Kit switch for non essential peripherals. Servers ramp down under load. Heat reclaim on server room</td>
<td>Consider thin client system. Servers running virtualisation software. Consider wireless office (reduced embodied carbon of cabling)</td>
<td></td>
</tr>
</tbody>
</table>

### Notes

- Potential for improvement depends largely on existing building.
- Consequential improvements = additional spending on improving energy usage.
- Highly dependent on existing construction.
- Indicative figures. Entirely site dependent.
- Consideration of conservation constraints due to planning.
- Be aware of minimum ventilation rates for the building structure.

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**REFURBISHED OFFICES**

**ENERGY CRITERIA TO BE USED IN CONJUNCTION WITH WIDER SUSTAINABILITY PARAMETERS**

**MAX FORDHAM**
Decoding sustainability

The fifth and final instalment in this series of Max Fordham Consulting Engineers pull-outs examines the unique challenges and opportunities gallery, museum and archive projects present to the ecologically-conscious architect.

When it comes to energy performance, galleries and museums can be the victim of their own success. They need to attract people and this requires us to deliver comfortable, delightful spaces. They also need to preserve the exhibits, which requires a level of environmental control greater than that for our comfort alone.

The irony is that the more popular a venue, the greater the difficulty and energy cost of maintaining appropriate conditions. This isn’t due simply to the extra loads people bring, but that any passive environmental control measures incorporated can be overwhelmed. Their energy performance can therefore appear poor in comparison to other building types, unless we look at energy use per visit. The picture then changes as you get a truer, more balanced view of relative performance and the building’s overall success.

Archives and storage facilities are at the other extreme. Their very low occupancy allows a primarily passive approach, using the enclosure and materials of construction to control the internal environment with minimal energy.

Henry Luker, senior partner, Max Fordham

Case study: MAXXI, Rome

MAXXI is no ordinary gallery. With 20,000m² of glass, unencumbered daylight could have been harmful and inefficient. The roof is an intricate array of shading devices and buffer spaces to manage daylight and heat gain to exacting standards. This connection to nature delivers dynamic spaces and a feeling of well-being inside the building.

In hot, sunny climates, natural processes alone can’t deliver the environment that artwork requires. High efficiency air-conditioning plant has therefore been integrated into the building’s fabric, so nothing is on show. These systems allow the internal environment to respond to the external seasons, further reducing energy cost.

MAXXI is part of our continuing story of delivering beautifully engineered, sustainable galleries and museums over nearly 50 years.

Transforming Tate Modern, London

Max Fordham continue its long-standing relationship with Tate and is currently providing building services and low-energy design advice for the Transforming Tate Modern project. ‘The building will be a model of environmental sustainability, setting new benchmarks for museums and galleries in the UK. It will draw the majority of its heating and cooling energy needs from the waste heat emitted by EDF’s transformers within the adjoining switch station and by tapping into the groundwater resource of the River Terrace Gravels surrounding the building. With high thermal mass, natural ventilation where possible, and employing the stack effect of its vertical form, the new building is predicted to use 54 per cent less energy and generate 44 per cent less carbon than current building regulations demand.’ Alex Board, deputy director, Tate

Notes

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MAX FORDHAM in association with AJ

GALLERIES, MUSEUMS & ARCHIVES MATRIX

05 / 05

Transforming Tate Modern project.

This image

Proposed Tate Modern extension. Left: View towards the roof of MAXXI in Rome.

MAXXI Gallery, Rome, Italy / Transforming Tate Modern, London
<table>
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<tbody>
<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. CO₂ emission design target</td>
<td>55kg CO₂/m²/yr</td>
<td>70kg CO₂/m²/yr</td>
<td>50kg CO₂/m²/yr</td>
<td>5kg CO₂/m²/yr (carbon neutral)</td>
</tr>
<tr>
<td>2. Display Energy Certificate (DEC)</td>
<td>G-D rating</td>
<td>F-B rating</td>
<td>F-B rating</td>
<td>A rating</td>
</tr>
<tr>
<td>3. Energy consumption: Heating and hot water</td>
<td>180kWh/m²</td>
<td>120kWh/m²</td>
<td>50kWh/m²</td>
<td>20-40kWh/m²</td>
</tr>
<tr>
<td>4. Lighting</td>
<td>60kWh/m²</td>
<td>33kWh/m²</td>
<td>30kWh/m²</td>
<td>0-10kWh/m²</td>
</tr>
<tr>
<td>5. U-values: Wall</td>
<td>Up to 20% to comply with local planning</td>
<td>&gt;20% on-site renewables</td>
<td>50-100%</td>
<td>100% on site generation or agreed off-site generation</td>
</tr>
<tr>
<td>6. Ground floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Average window</td>
<td>0.15</td>
<td>0.15</td>
<td>0.35</td>
<td>0.1</td>
</tr>
<tr>
<td>8. Roof</td>
<td>1.4</td>
<td>1.1</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>9. Average window</td>
<td>1</td>
<td>0.8</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>10. Ground floor</td>
<td>2</td>
<td>1.2</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>11. Average window</td>
<td>5m²/m²</td>
<td>2m²/m²</td>
<td>2m²/m²</td>
<td>1m²/m²</td>
</tr>
<tr>
<td>12. Ground floor</td>
<td>5</td>
<td>1.2</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
<td>b.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Controls, metering and monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Seasonal commissioning. Produce DEC, report to senior management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Facilities staff trained at building handover. Building Log Book provided with O&amp;M Manual</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. User involvement</td>
<td></td>
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<tr>
<td>a.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Environmental design criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Control to fixed point with small variations (so-called ‘international standards’) in most and adjustable in any area (Archives – conditions to BS5454)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Full temperature and relative humidity (RH) control in most building areas (Archives – full control of both temperature and RH)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Full air conditioning plant using high energy sources of cooling/ dehumidification and heating (eg air-cooled chillers and gas-fired boiler plant). Constant volume rating system. Heat recovery systems may be provided</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>d. No daylight or windows of any orientation which cover only part of a bigger gallery space, with or without blinds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Natural lighting</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>a.</td>
<td></td>
<td></td>
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<tr>
<td>5. Artifical lighting and controls</td>
<td></td>
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</tr>
<tr>
<td>a.</td>
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</tbody>
</table>

**Notes:**

- **CO₂ emission rating:** DEC rating and consumption figures highly dependent on area of building air-conditioned, particularly area to art preservation standards. Heating and cooling requirements also dependent on visitor numbers.
- **Highly site dependent:** Difficult to pass 2010 Building Regs using minimum regulation values: 20-30% improvement in U-values and airtightness typical.
- **DEE:** Energy use reward/pension system. Departmental energy use feeds into personal carbon trading (eg. WRAP’s ‘PACT’ scheme).
- **BREEAM:** (such as gis conditions or Bizot group’s). Allow set points to change seasonally.
- **BREEAM:** (Archives – work within a broad defined range of temp and RH) in most building areas. Buffer spaces between art and non-art areas.
- **BREEAM:** (Archives – work with respect to the world’s leading museums and galleries. The use of passive control only is difficult in venues with high visitor numbers but is still beneficial during unoccupied hours.
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