ENERGY COST METRIC – SUPPLEMENTARY GUIDANCE

Version 1.1
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1 Background and Context

If the UK and the University are to meet their CO_2 reduction targets tackling the energy used to construct and operate buildings is critical.

The Energy Cost Metric (ECM) is a design tool which drives decisions towards pragmatic cost-effective energy savings in the built environment. The ECM was developed in response to a proposal by the late Sir David Mackay and colleagues at the Cambridge University Engineering Department that greater rigour be applied to decisions affecting the energy performance of the new buildings associated with relocation to West Cambridge.

The ECM was developed to help provide an approach than could be applied to built environment projects of any scale. It was judged that the best approach was to focus on energy rather than carbon minimization. Another key motivating factor in the development of the ECM was to create a methodology that drives cost effective decision making; ensuring eye-catching, expensive measures do not displace options that can deliver more energy saving per pound spent.

ECM assessments should be considered alongside some key headline principles:

University zero carbon target: The ECM is intended to assist in finding a cost-effective way of delivering the carbon reduction targets set by the University Design Standards and site masterplans. These targets are a given and should not be varied when using the ECM

Pleasant: For a truly sustainable building it is important to find a balance between energy performance and the comfort of the occupants. The building should be pleasant for its occupants and should promote health and well-being.

Zero-'bling': The design should not be swayed by a desire to parade green credentials/accreditations or showcase technologies that do not reduce energy in a cost-effective way such that they are not scaleable and widely useable.

Upgradeable: Technology and use of space may change in the future; as such the building should be easy to upgrade, extend, and modify.

Well Measured: It may be easy to promote a building's green credentials but without accurate measurement such claims are meaningless.

2 Overview of the Metric

Cost effective low energy design is demonstrated through minimisation of the ECM Factor *F* (kWh) which is defined as:

$$F = E + C/\alpha$$

Where ***E*** (kWh) is the approximate whole-life energy, ***C*** is the capital cost (£), and ***α*** (£/kWh) is a value of energy weighting. The higher the value of ***α*** the more costly the energy saving interventions that will be facilitated. The value of ***α*** is discussed in further detail in Section 4.

The total lifetime energy, ***E*** is defined as:

$$\boldsymbol{E} = E_{IU} + E_{OT} + E_E + E_{MT} - kE_R$$

Where:

E_{IU}	**In-Use Energy:** The energy used across the lifetime of the building. E.g. as would be measured at the electricity/gas meter. NB: Energy use is credited equally regardless of source. Energy generated from renewable technologies which is used on site will act as a credit (i.e. it will be subtracted from the in-use energy).
E_{OT}	**Occupant Transport Energy:** The predicted energy used in transporting occupants and visitors to and from the building. **NB: This component is not expected to be addressed by building projects unless potential alternative locations could significantly influence transport energy. .**
E_E	**Embodied Energy:** The embodied energy of all of the materials used. (In practice assessment of embodied energy need only include materials that substantially impact the optimization of the design.) Some of this energy may be reclaimable (see E_R below)
E_{MT}	**Material Transport Energy:** The energy used to transport materials to and from the site including any cut and fill. This takes into account the distance of transportation and the energy efficiency of the transportation methods.
E_R	**Reclaimable Energy:** The embodied energy that can be credibly reclaimed upon deconstruction thanks to design for disassembly, reuse or recycling. This component will act as a credit. The credit will be scaled down to allow for the inefficiency of reuse of material, i.e. the scrapping that is likely when a component is put to a new use for which it was not perfectly designed. The scaling factor ***k*** reflects the inefficiency associated with reclaiming the energy. Where no suitable data is available to determine an appropriate value the factor should be set to ***k***=0.5.

Table 1 Summary of energy components

Further detail regarding the types of calculation methods that need to be carried out for different aspects of the design at different RIBA stages is outlined in Section 4 .

3 How to use the ECM

Contribution to ECM Factor F Approach

Many design choices can be assessed in isolation. For instance an option to reduce the embodied energy of the structure by using laminated timber instead of a steel frame is essentially independent from a decision to use a ground source heat pump rather than an air sourced heat pump.

The relative impact of the different measures can be assessed by comparing the relative size of the change to the ECM Factor ***F*** for each option (ΔF).

For example $\Delta F_{Timber:Steel}$ could be compared to $\Delta F_{GSHP:ASHP}$. The measure with the larger ΔF value would represent the measure that has the biggest ECM impact.

Section 4 outlines the components of ***E*** that should be assessed for the required ECM design assessments. Where design aspects cannot be treated in isolation this is noted.

Alpha Breakeven (α_{BE})

For energy reducing measures that entail a cost uplift it can be informative to ascertain the value of alpha ***α*** where an intervention would become favourable with respect to the ECM. This value is referred to as Alpha Breakeven (α_{BE}). This can provide a helpful sense check.

For example more innovative measures are often not favoured under the ECM because of the associated cost uplift, however, comparing the α_{BE} value could give insight into how such measures may compare to each other.

Time Dependence

There are two time dependent factors that have a significant impact on the ECM:

- Lifetime of the building, *L*
- Replacement frequency of components, *f*

This is critical as some of the ECM components occur once or only when replacement is required, while others extend across the whole lifetime of the project. Table 2 outlines time dependent nature of the ECM components and how they relate to the lifetime and replacement frequency.

$\boldsymbol{E}_{IU}$, $\boldsymbol{E_{O T}}$	Extend across the whole lifetime of the project
E_E, E_{MT}, E_R, C	Occur once per replacement cycle

Table 2 Time dependent implications for ECM components

For an ECM assessment to be valid, design aspects must be assessed using the same time scales. Components that the will last for the life whole lifetime of the project need to be calculated for the full lifetime, while components that occur once per replacement cycle need to be multiplied by the number of times that they will occur (i.e. multiplied by (f/L).

Worked Example

Consider the purchase of a new fan to be used as part of a small refurbishment project that is expected to have the same function for the next 40 years. There is a choice of fan technology available from two different manufacturers:

- *Manufacturer A* – This is the latest technology, it is more efficient than the incumbent technology. It also comes with a guarantee that it can be re-manufactured at the end of its life. It is shipped from Japan and is also the more expensive option. It has an anticipated lifetime of 20 years.
- *Manufacturer B* – This is the leading fan of the established technology. It is good quality but less efficient but will end up being classed as standard electrical waste at the end of its life. It is distributed from Cologne by road. It has an anticipated lifetime of 15 years.

The differences and calculation can be tabulated as follows:

			Manufacturer A	Manufacturer B
Motor Power		W	400	550
Total embodied energy		kWh	280	256
Project capital cost		**£**	**4700**	**3100**
Reclaimable Energy		kWh	180	0
Material Transport distance		km	20050	670
Material Transport Energy		kWh/km	0.1	1.1
Annual run time		hours	6000	6000
Lifetime of the building / function	L	years	40	40
Replacement factor (frequency / Lifetime of the building)	f	years	2/40 = 0.05	3/40 = 0.075
In-Use energy per year	E_{IU}	kWh/yr	2400	3300
Embodied Energy per year (total x replacement factor)	E_E	kWh/yr	280 x 0.05 = 14	256 x 0.075 = 19
Material Transport Energy (total x replacement factor)	E_{MT}	kWh/yr	20050x0.1 x 0.05 = 100	670 x 1.1 x 0.075 = 55
Reclaimable Energy per year (total x replacement factor)	E_R	kWh/yr	(180 x 0.05 = 9)	(0)
Annual Energy	E	**kWh/yr**	**2505**	**3374**
Annualised Capital Cost (total x replacement factor)	C	£/yr	£4700 x 0.05 = £235.00	£3100 x 0.075 = £232.50
Alpha	α	£/kWh	0.25	0.25
ECM factor	F	$E + C/\alpha$	**3,445**	**4,304**

The conclusion of this study is that the more expensive, more efficient fan offers a good value solution for reducing overall lifetime energy.

Salient points:

- A cost driven (both capital and whole life) would favour the less efficient fan.
- A whole life energy assessment would heavily favour the more efficient fan.
- The in-use energy dominates the lifetime energy calculation.
- Although the re-manufacture of the fan may have other environmental benefits, it has little impact on the overall energy cost of the fan.
- Annualisation of all parameters simplifies the way in which replacement is addressed. In practice, at each replacement cycle one would expect technology to have developed and a new analysis be required.
- The outcome of the calculation is not sensitive to alpha across a broad range. Alpha Breakeven is <£0.01/kWh

4 Where and how to apply the ECM

Section 5 sets out the choices that should be assessed using the ECM. It is acknowledged that there are other factors that also influence the decision, as such it is not intended that the outcome of the ECM analysis is the only driver to the ultimate decision. The ECM implications are to be acknowledged, assessed and reported to the Project Team for review at key decision making stages.

The analyses only have value if they are undertaken *before* decisions are made. It is expected that ECM reports are issued in a timely manner during design development such that the final stage reports capture the decision and are not the first point at which the Project Board or Project Quality Team are given insight into the analysis.

The accuracy of the energy and cost assessments should reflect the RIBA stage in which they are undertaken. In some instances it may be necessary to bring forward certain technical analyses in order to inform decision making at an appropriate stage. E.g. using a dynamic energy model to appraise heating/cooling loads at RIBA Stage 2.

It is expected that the ECM be applied to the following project types:

- Infrastructure
- Plant Replacement
- Minor Works
- Major Building Refurbishments
- Masterplans
- New Build –All project scales

Defining which items to appraise

The list of design decisions expected to be appraised using the ECM is defined in Section 5. This list has been devised based on finding a balance between the *impact* of the decision to be made and the *complexity* of undertaking the analyses. It should be treated as a definitive starting point for all projects. Any alternatives to the list should be agreed with the Project Quality Team at briefing stage.

RIBA Stage & Project Type

- Masterplans, should apply the action associated with lowest RIBA stage outlined.
- Plant Replacement/Minor Works should apply the action associated with highest RIBA stage outlined.

All other project types should apply ECM assessment to all relevant stages.

5 Design Aspects

The elements of the design that are expected to be assessed are summarised in the tables below. The first table summarises the following:

- The energy components
- The appropriate design stage
- The type of project to which this applies
- The parties involved in that aspect

The summary tables provide more detail about the nature of the assessments, the specific type of input data and any impacts on the contractor or building users.

The 'cost' element is colour coded, with notes where appropriate. The colours reflect the degree of additional complexity compared to a standard appraisal at the given design stage i.e:

- Green – standard work associated with cost management
- Amber – standard analysis brought forward in time
- Red – Additional options appraisals to a greater level of detail to standard cost management.

The aspects are listed in alphabetical order, it is acknowledged that the impact of these assessments vary greatly. In general, the complexity of the calculation task aligns with the potential impact on the overall energy use and its cost-effectiveness.

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<tr><th></th><th colspan="6">Stage</th><th colspan="5">Component</th><th colspan="7">Project Type</th><th colspan="4">Parties</th></tr>
<tr><th></th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>E_{IU}</th><th>E_E</th><th>E_{MT}</th><th>E_R</th><th>C</th><th>Infrastructure</th><th>Plant Replacement</th><th>Small Works</th><th>Major Refurbishment</th><th>New Build</th><th>Build)</th><th>Masterplans</th><th>Architect</th><th>MEP</th><th>Civil/Structures</th><th>QS</th></tr>
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Table 3 - Design Aspects to be assessed: The appropriate design stage, type of project, type of energy components and the parties involved.

Substructure & Superstructure

Assessment Overview	
A large proportion of the embodied energy of a new building will reside in these elements. They are assessed together given that the amount of material required in the substructure typically depends upon the choice of superstructure.	
Stage 2 Assessment	
E_E	A high level assessment for the embodied and reclaimable energy associated with a number of appropriate structural options should be considered. This should be based on total mass of key components only (e.g. concrete/steel/CLT). It is the intention of the university to provide standardised input data, in the absence of this use the BSRIA Inventory for Carbon and Energy. If alternatives are proposed, the design team is to set out and justify the input data that they have used.
E_{MT}	Where there are likely to be significant differences in material transport energy (for example where procurement is likely to be from overseas) this should also be taken into consideration. Material transport energy can be based on kWh/km/kg values for the most likely transportation options.
E_R	To be applied as appropriate
C	Masses - In-line with typical level of detail provided for cost plans
Stage 4 Assessment	
E_E	A more accurate assessment should be undertaken based on updated design and material quantities required. Any options still under consideration, e.g. through the Value Engineering process, regarding structure should be tested.
E_{MT}	Where possible, update to known supplier distances. It is not certain this will be possible
E_R	As Stage 2
C	
Data Collection	
The following should be collected to interrogate the chosen solution: • Delivery notes/distances • Available material data	
User Impact	
None anticipated.	

Envelope Performance & Façade

Assessment Overview
Where alterations are made to both the primary heating and cooling plant and the façade performance both aspects must be assessed together. This will generally apply to new builds and extensive retrofit projects. **Masterplan/Stage 1: Early Stage Assessment** An initial assessment should be carried out as early as possible in the design process.
Stage 2&3: Detailed Assessment A more detailed assessment should be carried out during the design process. The timing depends upon the production of frozen layouts with established adjacencies and functions. There is a preference to undertake at Stage 2. If any changes in U-value or airtightness are proposed during stage 3 then assessment should be updated. **Stage 4-5: Updated Assessment** If any changes in U-value or airtightness that are proposed during stage 3 the assessment should be updated. The final assessment should reflect the as installed parameters.

	Masterplan/ Stage 1 Assessment
E_{IU}	The architect should identify a range of feasible façade types. The MEP in consultant in consultation with the architect/façade consultant should set a range of target U-values and airtightness for each façade type. A minimum of a low, medium and high performance should be assessed for each façade type. The MEP consultant should assign an anticipated heating/cooling load to each performance option. Benchmarks should be used to estimate the heating and cooling loads per m². These benchmarks should be applied to the proposed floor area. If possible it is suggested that UoC precedent projects are used as the benchmarks. Details of what benchmarks have been used should be recorded and comment given to their reliability. The efficiency of each plant option proposed should be applied to the heating/cooling load estimate for each. If preferred designers can use an alternative approach. The alternative approach should be described and reasons for use in preference given. Only in-use energy needs to be assessed for the early stage assessment. If the designers have reason to believe that that they will be considering façade options with significantly different embodied/reclaimable energy then these components may be added to the assessment.
C	The architect should provide proposed façade types architect for each performance option. Multiple types may require cost estimates. Cost information should be provided for each performance option.
	Stage 2&3 Assessment

E_{IU}	All viable façade options for the project should be considered. Viability is determined by a number of external factors such as planning, access for maintenance, acoustics etc. Façade options should not be excluded on the basis of aesthetics alone. The Architect and Structural Engineer are responsible for determining the material energy components for each envelope option. Replacement cycles for the key components should be taken into account. The Architect is responsible for assigning a range of U-values and airtightness values achievable for each option. The MEP engineers are responsible for determine the in-use energy. This should be determined using a dynamic thermal model based on the ranges of U-values and airtightness values provided by the architect. The model should include the following: • Hourly gain from electrical load profiles for different spaces. If suitable measured data is available the gain profiles used should be based on this. If this is not available then hourly gain profiles should be developed from comparable benchmarks or ground up calculation with all assumptions clearly stated. • Solar gains • Occupancy gains • Space conditioning types The CIBSE TM54 methodology is preferred. • Factors other than the ECM are likely to affect the final preference. Examples could include daylight performance, ventilation strategy, appearance, maintenance, adaptability, interface with environmental strategy. All facade options should be scored for any other key factors along with their ECM performance. All influencing factors in the final decision must be clearly outlined.
E_E	For each façade type an elemental breakdown and replacement period is required. Consideration of the practical implications of component replacement is required, e.g. do window sills need to be removed when glazing units fail? It is acknowledged that input data is difficult to obtain. Where possible façades used in the assessment should have EPDs. If not available then a calculated embodied energy based on component composition will be acceptable. Embodied energy of the HVAC equipment should be considered is major differences exist. E.g. large quantities of ductwork.
E_{MT}	Consideration made of the number of lorry movements and average distance is appropriate at this stage. E.g. CLT from mainland Europe or Scandinavia. It is not the intent that a commitment is made that constrains the contractor's procurement options at this stage.
E_R	Design team estimates of the recycling possible and the associated energy benefit at end of life are needed.
C	There are a number of assessments that require time input above the normal level of Stage 2/3 cost manager engagement.
	Stage 4-5 Assessment
E_{IU}	As Stage 2, updated for final design.
E_E	As Stage 2, updated for final design.
E_{MT}	Updated to suit chosen supplier.
E_R	Updated to suit chosen façade system.
C	Actual costs to client are known and documented.

Data Collection
The following should be collected to interrogate the performance of the chosen HVAC and façade system: - Actual energy use - EPDs for façade components - Delivery notes/distances

User Impact
The users need to be fully engaged to provide inputs into the energy use model. E.g. occupancy patterns, times, set points etc.

Renewable Technology (Non-Primary Heating/Cooling)

Assessment Overview	
The ECM is well placed to appraise the cost effectiveness of built environment renewable energy technologies.	
Stage 2/3 Assessment	
E_{IU}	In-use energy must be assessed. In the case of generation technologies the in-use energy will be a negative value equivalent to the energy generated. Only energy generated that can be reasonably expected to be used on onsite should be included in the assessment. Technology efficiencies should be based on manufactures information. Generation potential must address site constraints, e.g. the maximum capacity should be dictated by avoiding any poorly sited renewables, which will have much reduced generation in practice.
E_E	To be included. Comparison of not utilising the technology, e.g. utilising grid energy only to be the baseline.
E_{MT}	Not assessed in early stage unless options are known to have significantly different origins and/or transportation methods.
C	
Stage 4/5 Assessment	
E_{IU}	As above.
E_E	As above.
E_{MT}	Material transport energy should be assessed if options have significantly different origins and/or transportation methods.
C	
Data Collection	
In-use/Embodied energy as appropriate	

Access Control Approach

Assessment Overview	
The aim of this assessment is to ensure that standby energy use is understood and the need justifies its use.	
Stage 2 Assessment	
E_{IU}	High level assessment of type of approach e.g. maglocks/electric strikes/battery systems/keys. Focus on standing loads. Suppliers Data
C	
Stage 3/4 Assessment	
E_{IU}	Assessment should be made for different manufacturers under consideration. Energy estimate should be based on information provided by suppliers. If different approaches are still under consideration, then a comparison should be made for all system types under consideration. Suppliers Data
C	
Data Collection	
None.	

User Impact
Operational implications of final decision.

Boiling Water Provision

Assessment Overview	
Fixed water boilers have a standing loss that kettles do not. These losses can be justified for intensively used areas, but not so in other areas. The aim of this study is to highlight when their use is and isn't justified in energy and cost terms.	
Stage 3/4 Assessment	
E_{IU}	Assessment should be made between standard kettles and any other method of provision. Assumptions will need to be made regarding the volumes of boiled water that may be required and the usage patterns. Assumptions should be based on the proposed occupancy and take into consideration the number of kitchens/tea points provided and any catering provision. The same required volume should be used for each provision type assessed. Any efficiency, wastage of heat loss factors should then be taken into consideration. All assumptions should be stated clearly in reporting of the analysis. Suppliers Data
C	Replacement to be included
Data Collection	
If possible.	
User Impact	
Operational implication.	

Building Provided Services/Specialist Facilities

Assessment Timing
Assessment should be carried out on any of the following services if included in the briefing: e.g. localised versus centralised compressed air; deionised water; lab gases; vacuum systems; fume cupboard extraction e.g. value of heat recovery and/or wind responsive variable flue exhaust velocity; demand controlled ventilation e.g. value of specialist air quality sensing in labs / cleanrooms; cryogen storage versus more frequent cryogen delivery.

	Stage 2 Assessment
E_{IU}	A high-level assessment should be made as to whether services should be provided centrally or locally. The assessment should consider the following: • Distribution losses/leakage • Efficiency of equipment
C	
	Stage 3/4 Assessment
E_{IU}	Where different options are available a more detailed assessment of how any centralised services are provided should be undertaken. Suppliers data is to be used where possible. It is noted that obtaining data from suppliers for some systems is difficult and that this may undermine the ECM study.
C	
	Data Collection
	Yes. Collection of data for electricity use and consumables as appropriate.
	User Impact
	Yes. The available solutions may have different operational considerations.

Floor & Roof Finishes

Assessment Overview	
The embodied energy and recyclability of roof and floor finishes vary greatly. The choice of finish is driven by many factors, ECM performance should be one of them.	
Stage 3/4 Assessment	
E_E	The replacement frequency is a key consideration. Feedback from the wider estates team as well as input from manufacturers and Factors other than the ECM may affect the final preference. Examples could include appearance, procurement, design complexity, buildability, reliability of quality control, maintenance, recovery costs, appearance, performance. If the best performing ECM option is not selected, then the other factors influencing this decision must be outlined.
E_{MT}	If available
E_R	If available
C	
Data Collection	
EPDs collected if available	
User Impact	
May impact appearance and maintenance schedule.	

Form Factor

Assessment Overview	
Where design flexibility exists the form factor should be assessed.	
Masterplan/ Stage 1 Assessment	
E_{IU}	The Architect is responsible for proposing the form factor options that suit the site. The Architect and Structural Engineer are responsible for determining the material energy components for each option. This should be determined based on kWh/m^2. The MEP engineers are responsible for determining the in-use energy. Benchmarks may be used with form factor correction values applied.
E_E	Headline rates and benchmarks
E_R	If applicable
C	Costed as standard options appraisal.

Heating/Cooling Networks

<table>
<tr><th colspan="2">Assessment Overview</th></tr>
<tr><td colspan="2">This assessment is to include the infrastructure and enabling works as well as the implications for the energy used to generate and distribute heating, cooling or any other form of energy network.</td></tr>
<tr><th colspan="2">Masterplan Assessment</th></tr>
<tr><td>E_{IU}</td><td>An assessment should be made as to whether a networked or local approach should be taken.
In-use energy should be considered taking the following factors into consideration:
• Distribution losses taking into account distribution temperatures
• Effects of diversification
• Plant efficiency
• Impact of storage
• Re-use of secondary heat
• Storage (it is noted that this will lead to greater cost and energy use, value in terms of enabling the use of energy at less intense times is not captured in this assessment method. However, if proposed it should be included such that the energy and cost implications are understood.)</td></tr>
<tr><td>E_E</td><td>The material energy assessment must assess buried pipework. A comparison of key plant (HIUs, circulation pumps etc.) may be included at the designer's discretion.

A key factor will be whether or not an energy centre is required.</td></tr>
<tr><td>E_R</td><td>Not necessary for this assessment.</td></tr>
<tr><td>C</td><td>Basic assessment in keeping with standard practice</td></tr>
<tr><th colspan="2">Data Collection</th></tr>
<tr><td colspan="2">Earthworks data – lorry movements, landfill etc.</td></tr>
</table>

Lab Humidity Control

Assessment Overview	
Humidity control uses large amounts of energy. Depending on the specific case it may be justifiable to use a lower energy technology, or to engage users on the set points required.	
Stage 4 Assessment	
E_{IU}	Assessment should include: • Method of humidity control - Technology used (e.g. desiccant/cooling) • Bandwidth of humidity control Constraining of controlled zone. i.e. Identifying functions which require humidity control and allowing for additional partitions in order to reduce the size of the controlled zone.
C	Formal quotations
Data Collection	
In use energy to be metered	
User Impact	
The decision may impact the chosen humidity set points, or the amount of space that will be conditioned.	

Lighting

Assessment Overview	
This assessment is to address the lighting technology to be used, e.g. lamp types/ lighting strategies It should be noted that under current circumstances LED lighting is likely to easily out perform any other option. Given this an assessment is **only** required if the designers propose an alternative technology. Any assessment of lighting type should assume the same usage hours and illumination levels provided for each option tested.	
Bespoke Assessment – timing variable	
E_{IU}	Bespoke assessment based on lighting efficacy
C	Manufacturer's quotations
Data Collection	
In use metering	
User Impact	
Possible, although unlikely as a pre-requisite to any lighting technology would need to meet lighting requirements	

Lighting Controls

Assessment Overview	
The assessment of lighting controls should be applied to the lighting type identified by the ECM assessment of the lighting. Lighting control systems have parasitic loads, it is uncertain whether the in-use energy reduction of the control system itself justifies these loads and the costs involved.	
Stage 2 Assessment	
E_{IU}	An assessment should be made of the energy savings of including lighting controls. The assessment should be made between different controls types (e.g. absence/presence detection, time clocks, daylight linked dimming, manual controls) individually or in combination as deemed appropriate for the different space types under consideration. The assessment should include the following: • Assessment of parasitic loads based on CIBSE TM54 guidance/LENI calculations • All assumptions regarding lighting usage hours should be reported The assessment should always include an assessment of manual controls as a benchmark
C	
Stage 3/4 Assessment	
E_{IU}	Assessment should be re-visited for control options taken forward using data from suppliers for parasitic loads.
C	
Data Collection	
In use energy to be metered.	
User Impact	
There will be an interface between the chosen solution and the way in which the users manage lighting controls	

Passive Cooling

Assessment Overview	
Elsewhere within the design guide there is a requirement to avoid active cooling unless operationally necessary. However, where challenging sites mean that passive schemes rely upon automation and acoustic vents (dampers/actuators/controls) then there may be justification to appraise cost effectiveness of overall energy saving. This assessment is likely to be highly bespoke and potentially interfaces with multiple other design aspects (solar shading, plant efficiency, structural solution). In the event that a team wishes to appraise the value of active cooling against the ECM the nature of the assessment should be explicitly agreed with the estates advisors.	
Stage 2/3	
E_{IU}	A passive design that meets the requirements CIBSE TM52 is to be undertaken to define a workable natural ventilation scheme that addresses: • Overheating • Draughts • Clash between glare prevention and ventilation openings. This design is to be used to provide costs and address concerns that can be raised regarding the use of natural ventilation. The energy use of a cooling system is to be assessed for comparison using either: • the dynamic simulation model if made for other studies • CIBSE degree day methodology for smaller projects.
E_E	If available. Not required.
C	Standard options appraisal.
User Impact	
May change proportion of space with active cooling.	

Primary Heating/Cooling Technology

Assessment Overview	
NOTE - Where alterations are made to both the primary heating and cooling plant and the façade performance both aspects must be assessed together. This assessment is to take place a stand alone assessment for plant room replacements, building alterations etc.	
Stage 1 Assessment	
E_{IU}	A range of primary heating and cooling plant options should be tested. Heating and cooling loads should be determined using a degree days calculation. It the primary plant can make use of waste heat by transferring heat from the cooling system to the heating system this should be taken into consideration in the calculation.
C	
Stage 2 Assessment	
E_{IU}	Plant options should be re-assessed using a dynamic thermal model to determine heating and cooling loads. Refer to fabric performance requirements for further details regarding model construction. Where plant efficiencies are dependent on external temperatures (e.g. air source heat pumps, chillers) temperature dependant plant efficiencies should be taken into consideration.
C	Replacement cycles to be accounted for.
Stage 3/4 Assessment	
E_{IU}	Different manufacturers for the chosen plant options should be tested.
C	
Data Collection	
Metered data of performance.	

User Impact
Minimal. All options will meet technical requirements

Solar Shading

Assessment Overveiew	
NOTE – If the façade performance is being assessed then solar shading will be included within that assessment. A stand-alone assessment is required if solar shading is being considered as part of a refurbishment **or** the exact specification is flexible during later stages, e.g. aluminium vs. terracotta. This assessment includes external shading only, internal binds do not need to be considered.	
Stage 3 Assessment	
E_{IU}	The impact of solar shading on cooling loads should be assessed using a dynamic thermal model. It is noted that most solar shading solutions are driven/necessitated by overheating or regulatory (Part L) considerations. This item deals with the nature of the solar shading if there are cost and energy implications of possible solutions. The use of solar shading or otherwise as part of a passive cooling appraisal is addressed separately.
E_E	Include a material breakdown, with EPDs if possible
E_{MT}	Benchmark if appropriate
E_R	Benchmark if appropriate
C	Detailed options appraisal
Data Collection	
Likely not to be practical/possible	
User Impact	
Not significant.	

Space Provision

Assessment Overview	
NOTE – space allowances are covered in the design guide. An ECM assessment is required if exploring density and flexibility is appropriate.	
Stage 1/2 Assessment	
E_{IU}	An assessment of density of occupation taking into account the proportion of open plan to cellular office arrangement should be carried out. This should take into account the following: • The impact on heating/cooling demand • The impact on material use for increased/reduced requirements for partitions The use of benchmarks based on area are anticipated.
E_E	Informed by material quantities, based on benchmarks.
E_R	Informed by material quantities, based on benchmarks.
C	Standard approach using area allowances
User Impact	
The amount of space, and how it is used will be affected.	

Surface Water Attenuation

Tanks/blue roof

Assessment Overview	
The strategy used for surface water attenuation can incur large earth movements and associated transport energy. The options available will be site specific and are often driven by cost alone. An ECM assessment is required to ensure that lower energy options are considered.	
Masterplan / Stage 1/2 Assessment	
E_E	Consider the additional structural loading of the building if blue roof options are considered.
E_{MT}	Consider the movements of earth from site for tank/landscape solutions.
C	Standard cost appraisal
Data Collection	
Collect and report waste movements.	
User Impact	
Not significant	

Ventilation Strategy

Assessment Overview	
The university design guide stipulates that natural ventilation is the preferred means of providing ventilation for fresh air. For some cases this decision results in very simple openings that are intuitive and simple to operate and maintain. However, in other instances this can result in costly measures to enable natural ventilation with challenges such as acoustics, glare and cold draughts leading to complex automated design solutions. Additionally, depending on the heat source used, there are instances where the use of MVHR saves sufficient heat to justify the additional cost. NOTE – This is not an assessment of the use of cooling over natural ventilation for overheating mitigation, which is preferred.	
Stage 2 Assessment	
E_{IU}	An assessment should be made between natural ventilation and MVHR.
	Any spaces requiring specific ventilation strategies may be excused from the assessment. The area associated with all spaces falling into this category must be reported along with the reason for an alternative ventilation approach being required The calculation should include the following: • Heat losses associated with natural ventilation and MVHR • Plant energy for MVHR and any automated natural ventilation systems • Calculation should be based on a dynamic energy model but may consider the whole building as a single space. • The natural ventilation model should be set up for ventilation requirements only (i.e. flow rates should be based on ventilation requirements only, not on any assessment of summertime overheating requirements) Ranges of outcomes for over/under ventilation where manual openings are used should be presented.
C	Additional detail compared to standard options appraisals.
Data Collection	
None	
User Impact	
The outcome of the study may alter the nature of the ventilation openings and the extent of automation.	

6 ECM inputs - Alpha

Alpha is often identified as the lever that can tip a decision in one direction or another. In practice the outcome of the ECM assessments described above are not particularly sensitive to the value of alpha used, over a sensible range. This is because most assessments are dominated by the cost and energy terms.

Although this guidance is not prescriptive about the value of alpha used, it is suggested that the central figure in the table below is used as a default unless specific justification is given in either direction.

This value is greater than the current unit cost of electricity as it includes an estimate of a more appropriate cost for reliable, renewable electricity, and associated electrical infrastructure costs. It is expected to be updated as circumstances change

	Low Aspiration	Expectation	High Aspiration
Alpha (p/kWh)	15 p/kWh	20 p/kWh	25 p/kWh

7 ECM inputs – Cost

To adequately assess design options using the ECM will require the cost data to be of sufficient quality for the analysis being undertaken. If the cost information is not sufficiently detailed, then a marginal decision as to the best option under ECM might go the wrong way.

It is important to understand the nature of cost information normally available at different project stages and where ECM work will necessitate a greater level of costing detail than is normally required.

Stage 0/1 – Strategic Definition – Preparation and Brief

Benchmarks. The cost data normally available at this stage are square metre rates for benchmark buildings. For a larger scheme this costing might break into a few square metre rates for significant components (e.g. structural frame, fit- out, M&E).

ECM analyses done at this stage should be used for strategic direction and be revisited when more detailed cost assessment is possible.

Stage 2 – Concept Design

Normally during Stage 2 the information available is the Cost Manager's first elemental cost model. Square metre rates for different elements (e.g. finishes, HVAC, water systems, slabs, columns, facades) can be varied to test options against ECM and it is at this stage that many of options with the largest ECM impact will be tested.

In addition to the cost model, ECM work for some specific elements may benefit from budget quotes.

Stage 3 – Developed Design

Detailed cost plan based on measured drawings, budget supplier quotes. Level of accuracy improves to review previous decisions and inform more detailed option comparisons.

Stage 4 – Technical Design

Tendered costs, subcontractor returns, formal supplier quotations.

Stage 5 - Construction

Actual costs to the university

8 Data collection and reporting for ECM methodology improvement

Application of the ECM to university projects is expected to be a constantly improving process. For this reason, the following are to be issued to the University for collation and review:

- The data used to justify the decisions listed in Section 5. outlined in the tables above
- ECM updates in design stage reports
- Information should be sent to environment@admin.cam.ac.uk
  (Subject: Sustainable Buildings - ECM – [Project title])

9 Interface with BREEAM

The University of Cambridge Design and Standards Brief mandates a BREEAM assessment for construction work classed as a 'Major Project'.

For some BREEAM credits there is an overlap with the input data required for the ECM studies described as follows:

Credit	Study/Data	ECM element interface
Man 02 – Elemental life cycle cost	An elemental life cycle cost is carried out at RIBA Stage 2 and should inform the Strategic Business Case for the project. A project lifespan should be defined (or a default 60 year period used). The analysis looks at replacement, service life, maintenance, operational costs.	The data obtained through obtaining this credit could be used for many of the applicable ECM areas. Namely: • Envelope Performance/Façade • Heating/Cooling networks • Passive Cooling • Primary Heating/Cooling technology • Ventilation strategy
Man 02 – Component life cycle cost	A component level life cycle cost is carried out prior to completion of RIBA Stage 4. It should inform selection of key components such as envelope, services, finishes and external finishes.	The data obtained through obtaining this credit could be used for many of the applicable ECM areas. Namely: • Access control approach • Boiling Water provision • Floor/Roof finishes • Laboratory Humidity Control • Lighting Controls
Ene 01 – Reduction of Energy and Carbon Emissions	A dynamic simulation model (DSM) is required for these credits. This can used as a basis of a TM54 operational energy assessment (as required elsewhere in the design brief). The DSM can also be used to test other design aspects	• Envelope Performance and Façade • Renewable Technology • Passive Cooling • Primary Heating/Cooling technology • Solar Shading • Ventilation Strategy
Mat 01 – Life Cycle Impacts	A life cycle carbon analysis (LCA) is undertaken of the building design, reviewing embodied carbon impacts over the life time of the project (60 years). This model can be used to inform design and steer solutions to lower embodied carbon options. The LCA can also be analysed in tandem with the LCC, providing insight into which low carbon and cost solutions can be aligned. Obtaining this credit involves analysis of the following: • Envelope Performance and Façade • Structural and floor build up • Foundations • Façade and roof build up • Finishes • Services strategies • Landscape and civil strategies	There is significant crossover with the ECM in this credit, namely: • Envelope Performance and Façade • Substructure/Superstructure • Surface Water Attenuation • Floor/Roof finishes • Renewable technologies • Primary Heating/Cooling technology

Mat 06 – Material Efficiency	A material efficiency study is undertaken to outline where material savings can be made in the design, the aim of which is to streamline and optimise the structural and architectural design and reduce embodied materials and waste.	The data obtained through obtaining this credit could be used for many of the applicable ECM areas. Namely: • Envelope Performance and Façade • Substructure/Superstructure • Surface Water Attenuation • Floor/Roof finishes • Renewable technologies • Primary Heating/Cooling technology

For economy the expectation is that design teams will use the same analysis to satisfy both the BREEAM and ECM requirements.

10 Acknowledgements

The following organisations have contributed to the development of the ECM through testing on real world design decisions and via a series of workshops:

- University of Cambridge Engineering Department (CUED)
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- AECOM
- SDC
- Ramboll
- R H Partnership Architects
- KJ Tait
- Architype Architects
- BDP Building Services Engineers
- Gardiner & Theobold