# Energy and Carbon Reporting Framework

## Operational Energy and Carbon Information Exchanges for Government Soft Landings

October 2021

CONSTRUCTION INNOVATION HUB

UK Research and Innovation

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# About the Construction Innovation Hub

**Funded by Government in 2018 with £72 million from UK Research and Innovation's Industrial Strategy Challenge Fund, the Construction Innovation Hub brings together world-class expertise from BRE, the Centre for Digital Built Britain (CDBB) at the University of Cambridge and the Manufacturing Technology Centre (MTC). We believe that collective innovation can catalyse the change needed for our built environment to deliver better outcomes for current and future generations.**

We are enabling better decisions. Our Value Toolkit is a suite of tools to empower clients and policymakers to make value-based procurement decisions that will result in the environmental, social, and economic outcomes they want. Developed with Government, the Toolkit supports clients to comply with the policies in the Construction Playbook and to align with the United Nation's Sustainable Development Goals.

We are driving digital transformation by strengthening the business case for change and developing user-friendly guidance, training and tools to encourage more organisations to benefit from data-driven decision making and secure, resilient data sharing. Our resources support the adoption of the UK BIM Framework, Government Soft Landings, Digital Twins, Digital Estates and Security-Mindedness.

We are transforming construction delivery. Our Platform Programme is adapting proven manufacturing processes from other sectors in order to advance construction, developing new rules and standards to improve the safety, assurance and interoperability of platform construction systems. We are exploring proof of concepts with Government departments, including the Department for Education's Gen Zero schools programme, to deliver a platform construction system that offers clients the flexibility to create beautiful spaces and grow a strong pipeline of demand for standardised components.

Together, we are making a change. The Hub has partnered with more than 300 organisations to build client and supply chain capability and capacity, ensuring our work delivers legacy value to the sector and the nation, beyond the life-span of the programme. We are openly sharing programme outputs and the lessons we learn along the way, so that businesses of all size stand ready to meet the UK's future construction and infrastructure needs.

Through collective innovation we are making progress; by working together we will get there faster.

## Further information

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# Foreword

This guidance from the Construction Innovation Hub (the Hub) defines operational energy and carbon dioxide emissions information exchanges for Government Soft Landings (GSL) and other Soft Landings projects.

Digital technologies and innovation present a vital opportunity to improve the way that we deliver and extract maximum whole-life value from buildings and infrastructure. The Hub is collaborating closely with industry, government and academia to support this transformation, not just by promoting digital ways of working but also by making sure that we are demonstrating the very real benefits of digital transformation and providing the guidance and tools needed to help the sector adapt and thrive.

Written by Dr Roderic Bunn and James Warne at WMEBoom, this guidance provides a framework for the analysis of operational energy and emissions within a digital representation of a project. It applies to all construction, infrastructure and civil engineering projects where powered systems are used. The purpose of this tool is to enable information to be managed, transparently and clearly throughout the asset lifecycle so that it forms a record of what decisions are made and when. Ultimately tracking the performance of our decisions through the use of GSL.

This guidance can be used together with the Hub's GSL frameworks and forms part of a suite of digital tools that provide invaluable and extensive insights into how buildings and infrastructure are currently functioning in driving efficiency, as well as helping to deliver the wider Net Zero carbon agenda. It also supports the Construction Leadership Council's $CO_2$nstructZero programme which sets out how the construction sector can meet the Net Zero challenge, in particular points 7 and 8 in the action plan which focus on measuring and designing out carbon in construction activity including reducing embedded and operational carbon. It will be useful to government clients and project managers, as well as local authorities who are currently using the Hub's Local Authority Government Soft Landings (GSL) Interactive Navigator. GSL is intended to support the public sector but will also provide benefit for the private sector in enabling a smooth transition from construction to operation, and the Soft Landings approach is applicable to all public-sector and commercial clients. You will find other related resources at http://www.cdbb.cam.ac.uk/BIM/government-soft-landings

At its heart, GSL and Soft Landings are about supporting better operational and societal outcomes, including energy efficiency and reduced carbon dioxide emissions. It is about maintaining the "golden thread" of a facility's purpose by aligning the interests of those who commission, design and construct an asset, as well as those who use and maintain it. This guidance will help to ensure resilience and maximise the value of built assets over their lifetime by helping to build accurate representations of energy use and real-time calculations of energy cost and carbon dioxide emissions to monitor and optimise how a building will perform in operation.

**David Philp, Impact Director, Construction Innovation Hub**

# Contents

# Executive summary

**This guidance defines operational energy and carbon dioxide emissions information exchanges on Government Soft Landings projects and wider Soft Landings opportunities in both the public and private sectors.**

The operational energy and carbon (OpEC) data requirements described in this guidance are intended to be used by project teams that adopt Government Soft Landings (GSL) and Soft Landings (SL) procedures. Modelling a project's emerging energy performance during procurement, design and construction can enable a project team to keep track of the likely out-turn performance and to close any performance gaps as they appear, before they become fixed and irretrievable.

Soft Landings describes a set of activities that occur during project inception, design and construction that leads to a period (up to three years) of professional aftercare by the original project team in order to support asset managers as an asset comes into long-term operation. Soft Landings are applicable to all public-sector and commercial clients.

This guidance is also aligned with the *BS 8536* series and the need for information exchange requirements to be determined to support decision-making, in this case in relation to OpEC and related performance outcomes. The information exchanges for keeping track of operational energy and emissions have been defined to apply to all construction, infrastructure and civil engineering projects where powered systems are used. Powered systems are defined by those driven by renewable and/or fossil-fuel sources of energy during an asset's normal operation. The information exchanges do not apply to embodied energy, or to the energy and emissions consequences of construction works.

The operational energy and carbon information exchanges defined in this guidance are henceforth referred to as OpEC information exchanges, as itemised in Figure 1. The description of each OpEC information exchange is accompanied by a flowchart that describes the main energy inputs and outputs that should be reported at GSL and Soft Landings stage gateways.

The OpEC information exchanges are predicated on the analysis of operational energy and emissions within a digital representation of a project – such as a digital twin (for definition, see Glossary). A digital representation may range from a simple user-created spreadsheet to a more complex model, for example, constructed within a proprietary dynamic energy simulation tool.

On many projects, it may be necessary to run spreadsheet and dynamic simulation methods (DSM) in parallel: dynamic simulation for complex thermal modelling, and a spreadsheet for electrical loads. Although it is technically possible to conduct both within a DSM environment, it may be impractical. Typical limitations are described in the guidance to help users of the OpEC information exchanges identify the most appropriate method of digitally twinning a project's operational energy and emissions during procurement.

# 1. Frameworks covered in this guidance

The operational energy and carbon (OpEC) information exchanges specified in this guidance primarily hinge off the highly structured procedures of the 2020 *Plan of Work* and the 2021 *Plan for Use Guide* developed by the Royal Institute of British Architects (RIBA). Where possible, OpEC information exchanges have been positioned to align with the stage breaks of similarly highly structured project delivery procedures, such as *BS 8536* and the UK BIM Framework.

Some projects may not adopt the RIBA *Plan of Work*, either because they are aligned to other frameworks or because an alternative plan of work is more appropriate. Examples of these may include hospitals and prisons or infrastructure projects such as bridges, tunnels and drainage schemes.

The original Soft Landings process, published jointly by BSRIA and the Usable Buildings Trust (UBT) as *BG54:2014 The Soft Landings Framework,* was written to apply to all non-domestic construction projects. The Soft Landings approach is therefore generic and is intentionally adaptable to the structures of many different project plans in-use, including the RIBA *Plan of Work*. The Government of the United Kingdom equivalent, Government Soft Landings (GSL), was designed to be applied by central government clients to their projects, and as such it was written to suit a wide range of both building and infrastructure schemes. As with the *Soft Landings Framework*, GSL is intended to act as an overlay to standard project plans and procedures.

Both Soft Landings approaches will benefit projects in the private sector and those undertaken by local authorities. However, non-government clients and project sponsors who specify Soft Landings in invitations to tender and employers' requirements should be specific about which version of Soft Landings is required, as an absence of direct client project leadership during GSL activities may necessitate additional appointments.

This guidance makes particular reference to procurement procedures adopted in Scotland that mandate the use of the *Scottish Capital Investment Manual* (*SCIM*). The *SCIM* mandates the use of the BSRIA reality-checking method, *BG27:2012 Pitstopping*. For this reason information exchanges have been aligned with *BG27's* reality-checking points.

In addition the Scottish Future Trust have produced the *Net Zero Public Buildings Standard*, for organisations participating in publicly funded new build and major refurbishment projects to develop and improve buildings to achieve a step change improvement in embodied and operational energy, and to take action on embodied carbon; Whole Life (WL) emissions and both indoor and other environmental aspects.  This is a voluntary standard.

Users of this guidance should note that *BS 8536-2:2016 Briefing for Design and Construction – Code of Practice for Asset Management* is largely a reproduction of *BG54:2014 The Soft Landings Framework*. Although BSRIA unilaterally revised *BG54:2014* in 2018, adding a much-needed construction stage, the 2014 edition of the *Framework* is the version authorised by the original developers and therefore cited in this guidance.

# 1.1. Using the OpEC approach in GSL

The OpEC approach to managing operational energy and emissions during project procurement is consistent with both GSL and the UK BIM Framework. The Framework comprises the *ISO 19650* series, the current *BS/PAS 1192* series and the *BS 8536* series. GSL is supported by the *BS 8536* series, with a complementary relationship particularly between the *BS 8536 series* and the *ISO 19650 series*. Both require that information requirements are determined, information is produced in collaboration, and information is reviewed, approved and accepted.

The review of information to ensure that it meets the exchange information requirements (and can be shared) is required by *ISO 19650* clause 5.6.4.
In the context of GSL, reviews of this kind are where the design is evaluated by members of the project team to check whether it meets target performance outcomes (see box example). These review activities should continue throughout a project.

### Reviews of energy and emissions in a GSL review process

A lesson learned from previous projects might concern wasteful energy consumption from air conditioning equipment, such as chillers. CIBSE *TM54* states that monitored cooling energy use can be over 30% above the estimated energy use for various reasons, such as weather data used for modelling being different from the actual weather conditions. Equally, energy penalties could be due to simultaneous heating and cooling, chillers not operating at their optimal efficiency, and/or small power loads being higher than an energy model had assumed. These issues could be raised through plain language questions such as “Which weather file has been used to reflect local conditions?” or “Have all unregulated loads been incorporated in the model as they emerge?” The answers should appear as an exchange information requirement for the relevant design consultant. The performance outcomes could be recorded in the OpEC model/digital representation for consideration at a GSL pre-gateway review meeting.

Figure 1 shows how the expected performance outcomes noted in *BS 8536-1* clause 4.3, key decision point/information exchange requirements (clause 4.5) and associated plain language questions (clause 4.9.1) are articulated in the client’s project information requirements. The guidance presented in this document unpacks the requirements for “performance outcomes” in Figure 1 as they relate to operational energy consumption and carbon dioxide emissions.

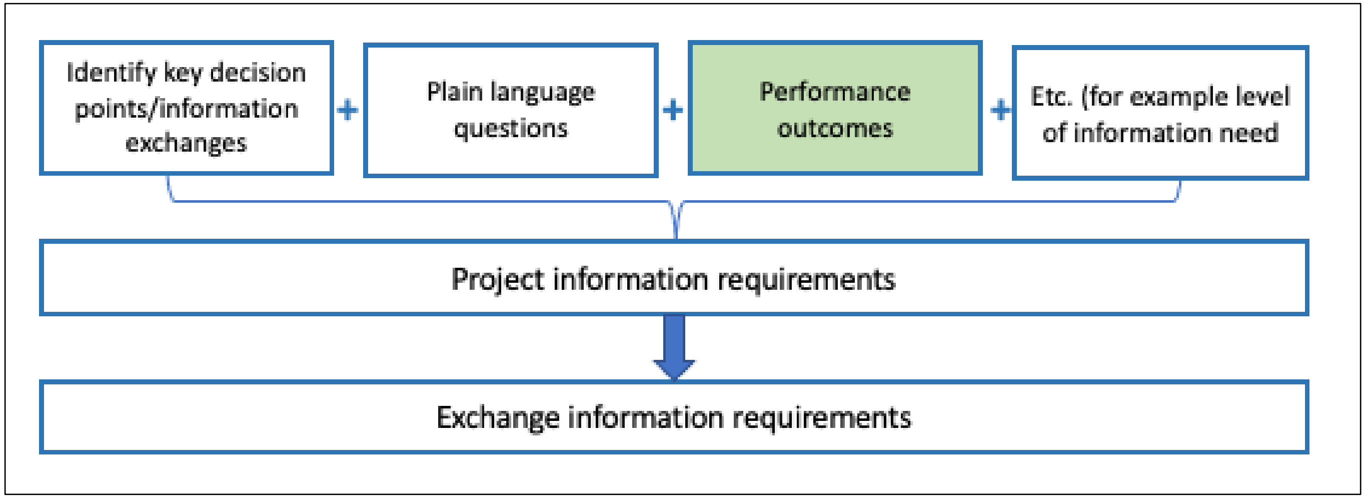



*Figure 1 reproduces Figure 1 (GSL requirements and information requirements) of the CDBB guidance: Government Soft Landings revised guidance for the public sector on applying BS 8536 Parts 1 and 2. This guidance provides the information requirements for “performance outcomes” in Figure 1 as they relate to managing operational energy and emissions.*

# 1.2. Tools and procedures covered

This document, enabled by the Construction Innovation Hub, explains the rationale behind proposed operational energy and carbon information exchange points (OpEC), where digital representation is required to predict and monitor a project's energy and emissions as they gradually emerge during project delivery. Figure 2 defines OpEC information exchanges relevant to the gateways within plans of work and procedures routinely adopted by non-domestic projects using Government Soft Landings (GSL) and Soft Landings (SL). The information exchange points are also consistent with the requirements of the *BS 8536* series and *ISO 19650-2*.

The OpEC information exchange gateways defined in this guidance are primarily relevant to non-domestic new build, refurbishment and fit-out projects delivered under GSL, in addition to infrastructure and civil engineering projects that involve powered engineered systems. They are also broadly relevant to mixed-use developments. They are not designed to apply to solely residential projects.

The UK Building Information Modelling (BIM) Framework defines the need to determine information exchanges to support key decisions for projects adopting the *ISO 19650* suite. The information exchanges in the *BS 8536* series effectively acts as stage gates – points at which information can be analysed and decisions considered based on the information available. The stage gates exist to ensure that projects are properly validated and controlled as they develop. Many tasks and data outputs described under each information exchange gateway will be owned or otherwise led by an appointed GSL champion (and/or a property asset manager (PAM), where one exists in the client body).

Projects that adopt BSRIA *BG6:2018 A Design Framework for Building Services* may choose to adopt its reporting gateways, in particular, the three intermediate gateways in Stage 4 of *BG6:2018* (Figure 2). Note that the intermediate information exchanges for BSRIA *BG6:2018* usefully align with the requirements of BSRIA *BG 27:2011 Pitstopping*.

Figure 2 also contains energy assessment procedures and tools that are routinely used on construction projects. The Chartered Institution of Building Services Engineers (CIBSE) publishes two key procedures: CIBSE *TM54:2013 Evaluating the Operational Energy Performance of Buildings at the Design Stage;* and *TM63:2020 Building Performance Modelling and Calibration for Evaluating Energy Performance In-Use*. These publications largely define how energy and emissions should be analysed. They do not, however, specify reporting points. It is therefore up to the users of these tools to decide the level of detail to report, and at which Soft Landings and GSL information-exchange gateways.

BREEAM, the commercial environmental assessment tool, contains energy assessment and reporting requirements. BREEAM is a mandatory requirement on some GSL projects. The proposed information exchanges have therefore been aligned with BREEAM energy and emissions-related activities.

Central government projects are required to adopt HM Treasury's *Green Book*. Although the *Green Book* requires projects to follow sustainable design principles, it does not define operational energy and emissions measures; nor does it stipulate gateway reporting-points. Government clients using the OpEC information exchanges in a GSL context will need to satisfy themselves that they are meeting the requirements of the *Green Book* in terms of assessing and reporting operational energy and emissions targets.

Users of this guidance who will be working on non-building-related projects such as civil engineering projects or construction procured under different roadmaps (e.g. offsite prefabrication and manufacturing) may require information exchange gateways at slightly different times. Similarly, measurement, verification and quality assurance procedures may be procurement-specific, as may a project's key performance indicators.

The prescribed energy and emissions information exchange points are largely independent of the form of procurement. The requirements and precise positioning of Information Exchange Gateways 3 and 4, for example, will depend on whether a procurement route is traditional or a form of design and build. The user of this guidance therefore has some flexibility over what is reported at RIBA Stages 3 and 4. Nonetheless, agreed stage gateways should be adhered to in order to provide consistency and certainty to the project team.

At the time of writing (March 2021), the Design for Performance (DfP) initiative was in its early development phase. The voluntary DfP scheme, led by the Better Buildings Partnership and managed by the BRE, is notable for requiring project teams to maintain detailed energy modelling of base-building energy services throughout project delivery. Although the OpEC procedures are broadly equivalent to the requirements of the DfP scheme, they have been devised to be applicable to all types of project, large and small. For consistency, the energy and emissions information exchanges proposed in this guidance have been aligned with the DfP stage gateways, insofar as they are defined.[1]

[1] The Design for Performance (DfP) initiative is the UK version of the National Australian Building Environmental Rating Scheme (NABERS). DfP is also referred to as NABERS UK. DfP certification applies to the design of landlords' base-building energy services for high-end commercial offices. For more information, go to https://www.betterbuildingspartnership.co.uk/our-priorities/design-performance.

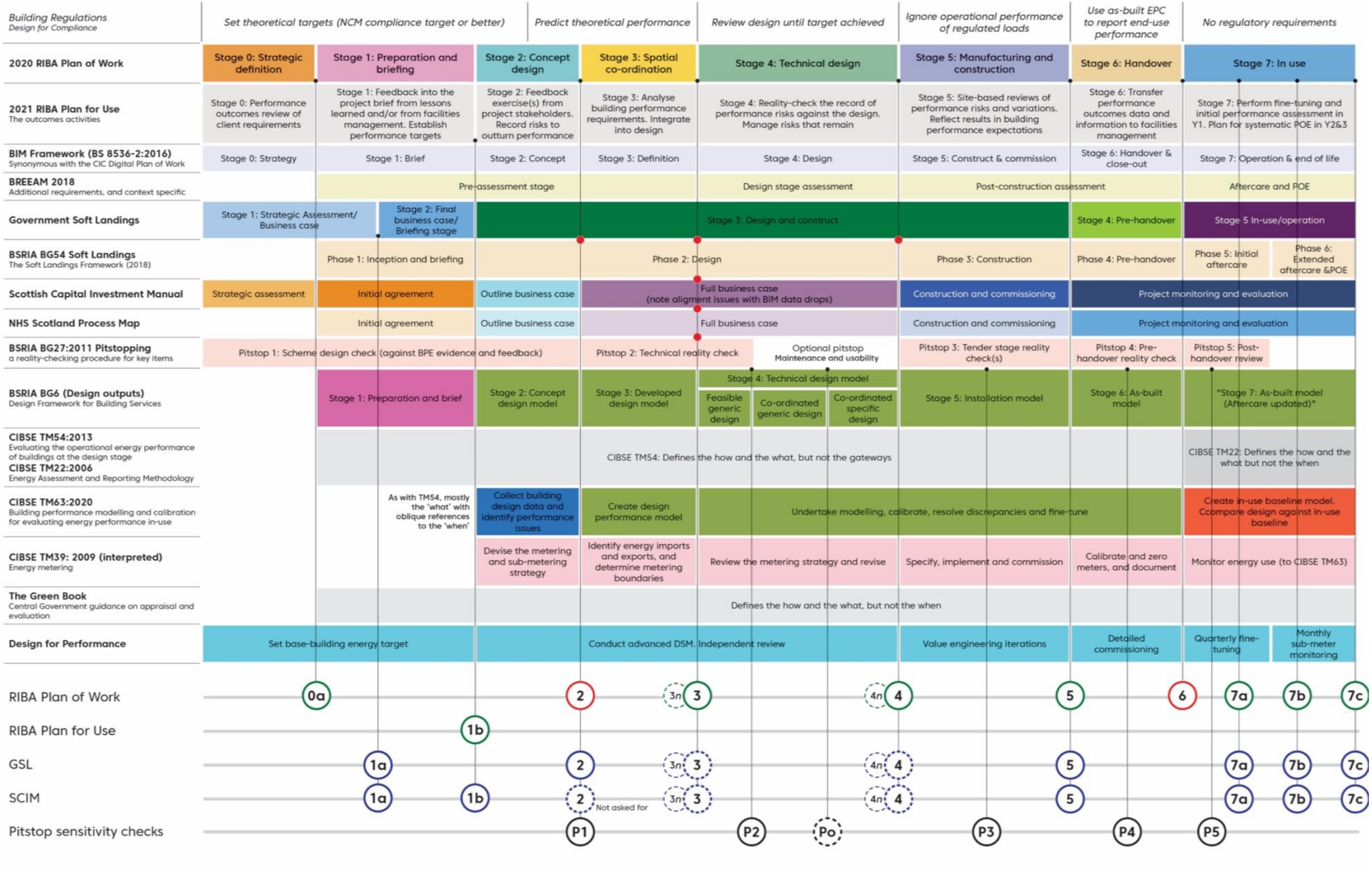



*Figure 2: The operational energy and carbon dioxide (OpEC) information exchange points universally applicable to the stage gateways and intermediate reporting points of the plans and procedures shown*

## Explanatory annotation for Figure 2

2 Red circles denote energy-use reporting points that are synonymous with the compliance requirements of the *UK Building Regulations*. For example, Information Exchange Gateway 2 denotes the National Calculation Methodology (NCM) outputs for regulatory compliance, planning approvals and the design Energy Performance Certificate (EPC). Information Exchange Gateway 6 denotes the information exchange point for the as-built EPC. These two information exchanges are the only mandatory reporting points in the proposed energy reporting structure.

**0a** Green circles relate to additional energy assessment information exchange gateways suggested by the 2021 RIBA *Plan for Use Guide*, where Soft Landings activities are specified. Information exchanges continue into a three-year period of Soft Landings aftercare and post-occupancy evaluation.

2 Blue circles denote energy and carbon reporting information exchange gateways specific to the requirements of GSL, as published in 2019 by CDBB. The early information exchanges in Figure 2 are also aligned with the strategic, business-case and cost-reporting elements of asset planning that are a requirement of central government procurement. They apply to the *Scottish Capital Investment Manual* (*SCIM*)and the *BS 8536* series (with Soft Landings requirements based on *BS 8536-2:2016 Briefing for Design and Construction*).

**3** **4** Hashed green and blue circles denote additional energy and emissions (non-gateway) information exchanges. They may be appropriate for lengthy and/or complex projects, where multiple iterations on operational energy and emissions during design and construction may be beneficial. The actual number and frequency of additional information exchanges (and any associated project gateways) would be context-specific and set at the discretion of the client and the project team.

P Black circles denote the information exchanges suggested by BSRIA *BG27:2011 Pitstopping*, BSRIA's reality-checking procedure for Soft Landings projects. The hashed circle (Po) in Figure 2 denotes an optional information exchange at the tender stage. This is to ensure that tender requirements (and the subsequent responses) address any risks to the out-turn performance and that the required mitigation strategies are clearly communicated to tenderers.

Red dots in Figure 2 identify the energy and emissions information exchanges that are intermediate reporting points in GSL and *SCIM*– guidance documents where the design and construction phases are combined into a single stage. In the absence of reference points that link to the RIBA *Plan of Work* or stage gateways in *BS 8536-2:2016 Briefing for Design and Construction*, the reporting points are at the discretion of a client and its project team. However, where other procedures such as BREEAM or BSRIA *BG6:2018 A Design Framework for Building Services* are adopted, the information exchange reporting points are likely to be determined by the gateways of those procedures.

# 2. Information exchange gateways

### OpEC Information Exchange Gateway 0
### (RIBA Stage 0: Strategic Definition)

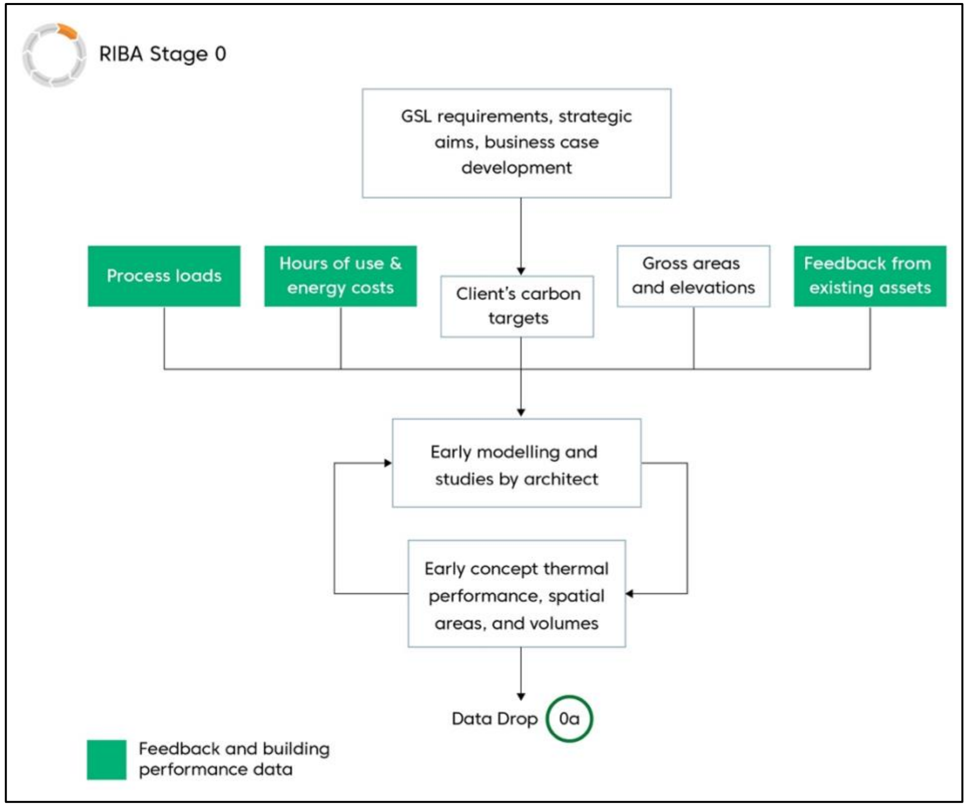



*Figure 3 distils the requirements for Information Exchange Gateway 0. As Figure 3 shows, the architectural conceptualising of a client's initial requirements (e.g. for an understanding of massing and volumes) will be an iterative process.*

Information Exchange Gateway 0 represents the earliest point at which information on the operational energy and carbon dioxide emissions of a project would need to be considered and communicated to project stakeholders (Figure 3). For central government procurement, a Soft Landings champion and/or PAM may be in place to lead the process. For public-sector projects (and commercial projects) that opt to follow GSL procedures, a Soft Landings champion may not have been appointed at RIBA Stage 0. Championing tasks may be written into the appointment of the client's lead professional advisor, who could be the custodian of data and information, passing it onto the Soft Landings champion once appointed or nominated.

Although Information Exchange Gateway 0 is consistent with the end of RIBA Stage 0: Strategic Definition, it is unlikely that an architect will have generated, for instance, gross areas, volumes and elevations, although such data may be available for refurbishments and extensions. Process loads may be known for complex projects, such as laboratories and medical facilities. For new-build projects, however, Information Exchange Gateway 0 is likely to be limited to the sourcing of prevailing building or construction typology benchmarks, intelligent modification of those benchmarks to suit the specific project context, and the setting of aspirational performance targets. A client may be able to define any operational peculiarities of the proposed project, such as a school requiring to be used by its local community outside teaching hours. Both qualitative and quantitative data may be sourced from building performance feedback studies, as required by Stage 0 of the 2021 RIBA *Plan for Use Guide*.

Quantitative and qualitative feedback should be captured and held by the client's GSL champion or PAM (within a government client) and stored for future use, notionally for early modelling and iterative analysis. The client's representative architect needs to ensure that all energy and emissions data is retained for future detailed modelling.

### RIBA *Plan for Use Guide*

The RIBA *Plan for Use Guide* requires architects to conduct a performance outcomes review, which should collate energy and other energy-related performance data from previous evaluations and from the experiences of team members. Lessons should be extracted to inform the briefing process and early design concepts.

This is consistent with Stage 1 of GSL, the BIM Framework, *BS 8536-2:2016*, and the *Scottish Capital Investment Manual* (*SCIM*), all of which require a lessons-learned review. Note that the performance data gathered will be a mix of qualitative and quantitative information, best preserved in its full richness rather than distilled, filtered or abridged.

### *Scottish Capital Investment Manual*

Although GSL and *SCIM* do not make specific requirements for assessing energy use or carbon dioxide emissions at the Stage 0 gateway, *BS 8536-2:2016* nonetheless calls for targets to be set.

GSL and the *SCIM* require clients to conduct business-case assessments. As the operational costs of a project – including energy – are a key part of a business case, energy performance feedback from similar buildings and published benchmarks will need to be gathered and reported at the Stage 0 gateway for future reference. In the absence of a client brief and a concept design (and in the absence of design professionals appointed to perform early calculations), benchmark references are likely to be generic and broad-brush.

HM Treasury's *Green Book* requires central government projects to calculate social costs as part of the business case. This includes the estimated costs of emitting greenhouse gases. In the absence of any project details, this requirement would be satisfied by reference to the benchmark data and performance evaluations of similar existing facilities.

*BS 8536: Design and Construction – Code of Practice* for asset management and facility management requires consideration of the digital representation of a construction project at this stage. An operational energy and carbon digital representation (OpEC) could potentially be constructed for Information Exchange Gateway 0 (particularly for refurbishments and extensions), but only if a person is appointed to do so and has the requisite skills in handling energy data. Otherwise, all quantitative and qualitative operational energy and emissions benchmarks should be stored in an information exchange project file for use when an OpEC digital representation is created.

### BREEAM

Where BREEAM is adopted, a BREEAM advisor may be appointed at an early stage (under BREEAM Man01). A BREEAM advisor may act as a project's sustainability champion, facilitating the achievement of targets (including operational energy and emissions) during the feasibility stage. The sustainability champion could initiate the OpEC assessment process (or at least highlight if it needs to be done) and take ownership or control of the initial energy model. On a GSL project the client sponsor or the PAM should act as the GSL champion. However, this role could be passed to the BREEAM assessor if the assessor is to be appointed for the entire project. Crucially, they will need to be endowed with a high degree of authority within the project team to ensure that the OpEC information exchange process is adhered to.

## OpEC Information Exchange Gateway 1a (RIBA Stage 1: Preparation and Briefing)

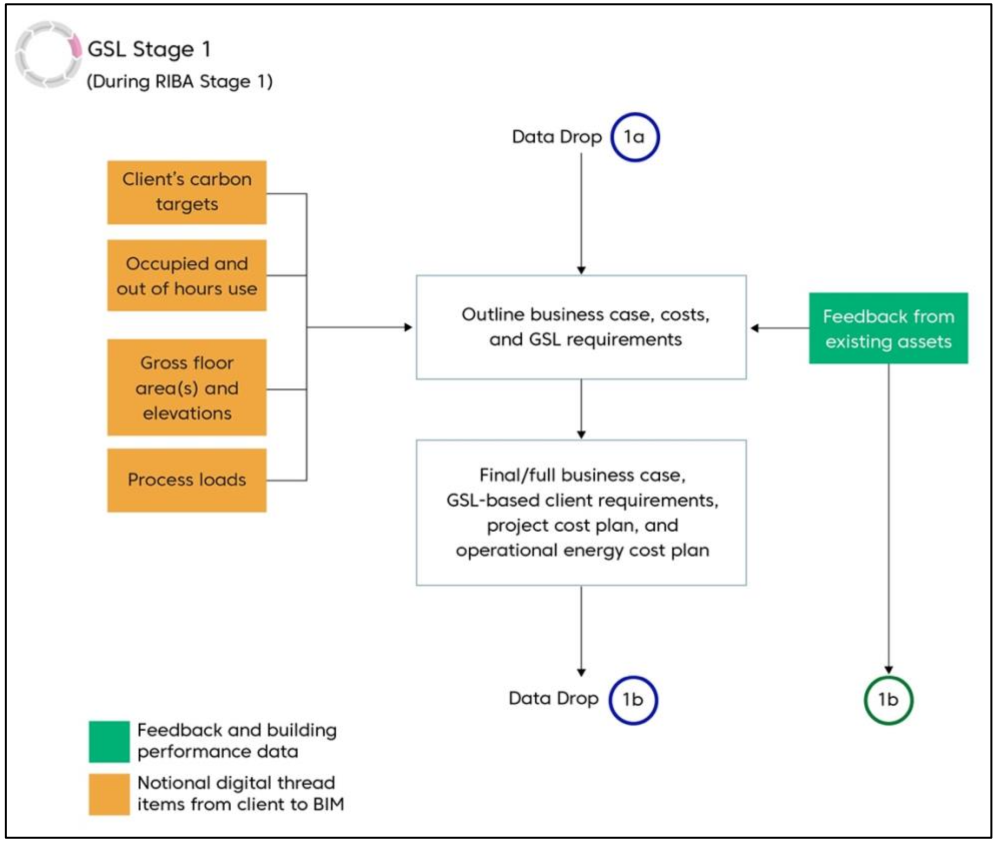



*Figure 4: Blue-circled Information Exchange Gateways 1a and 1b are specific to GS and, SCIM requirements. These work plans require a client to construct a business case for their project, within which operating cost is a key performance indicator. Building performance feedback for SCIM requirements may be classified as an output for projects adopting the RIBA Plan for Use Guide (see explanatory annotation to Figure 2).*

### Cost modelling

Cost metrics are not covered in either BSRIA *BG54:2014 The Soft Landings Framework* or the 2021 RIBA *Plan for Use Guide,* as Soft Landings exclusively concern the out-turn building performance and not the performance or efficiency of a project's delivery. However, central government clients are required to set capital and operational cost metrics when using GSL. Data is required for the initial business case at Information Exchange Gateway 1a, and for a final business case at Information Exchange Gateway 1b. For projects in Scotland following the *Net Zero Public Buildings Standard* or *SCIM*, an outline business case is required at Information Exchange Gateway 1b, and a full business case is developed when a project is going through RIBA Stages 3 and 4.

### RIBA *Plan for Use Guide*

The green-circled Information Exchange Gateway 1b is an optional performance feedback gateway for a Soft Landings project working under the 2021 RIBA *Plan for Use Guide*. Clients who have specifically requested building performance evaluation should see the outputs of such research at this point, pursuant to any lessons learned being used to inform the briefing and the design process. For example, the feedback could be used to tailor energy and emissions benchmarks to a specific project (typically for mixed-use developments).

Note that Information Exchange Gateway 1a is shown in Figure 4 as an input. For GSL projects procured under *SCIM*, the client is required to generate an initial brief of operational requirements. Those requirements are to be modelled for output to Information Exchange Gateway 1a as part of the project's sustainable design strategy.

### Scotland

The *Net Zero Public Sector Building Standard* encourages an Application Stage report to set outcome objectives in relation to achieving a net zero goal, either via for handover, or through the projects life cycle. For other public buildings there are various guides to refer to such as National Digital Engagement Programme (NDEP), the NHS Scotland Design Assessment Process (NDAP) and the Achieving Excellence Design Evaluation Toolkit (AEDET). The NDAP calls for energy dynamic simulation modelling (DSM) at the outline business case stage. However, AEDET only covers energy consumption at a cursory level. Furthermore, as the outline business case stage is aligned with RIBA Stage 2

(Concept Design), a detailed energy model would be required at an earlier stage than is typical requiring specialist input.

The evidence required for Information Exchange Gateway 1b should include the client's emissions targets (with references to any benchmarking and feedback generated for Information Exchange Gateway 0), gross areas, any known process loads, and notional expectations from the client with respect to possible hours of operation of the proposed facility. Clients may already know their energy supplier(s). If so, carbon factors for the fuels could be identified at Information Exchange Gateway 1b. The values should be made transparent from the outset and revisited and updated, if necessary, as the project progresses.

Such data – even if notional – will enable an embryonic OpEC digital representation to be initiated and the concept introduced to the project team as a data analytics tool. For projects where a DSM consultant has not been appointed at RIBA Stage 2, the digital representation may be captured in a simple spreadsheet rather than initiated within a DSM. The latter can only be developed once a professional design team has been appointed and instructed to create a DSM digital representation.

### BREEAM

Where BREEAM is a client requirement, procurement should be informed by the outputs from BREEAM Mat 03: Sustainable Procurement Plan. Information Exchange Gateway 1a should also include a schedule of lessons-learned reports based on precedent and from case study evidence. For Information Exchange Gateway 1b, the BREEAM pre-assessment process will set performance benchmarks. The subsequent concept and technical design stages will be required to acknowledge targets agreed during the BREEAM assessment.

## OpEC Information Exchange Gateway 2 (RIBA Stage 2: Concept Design)

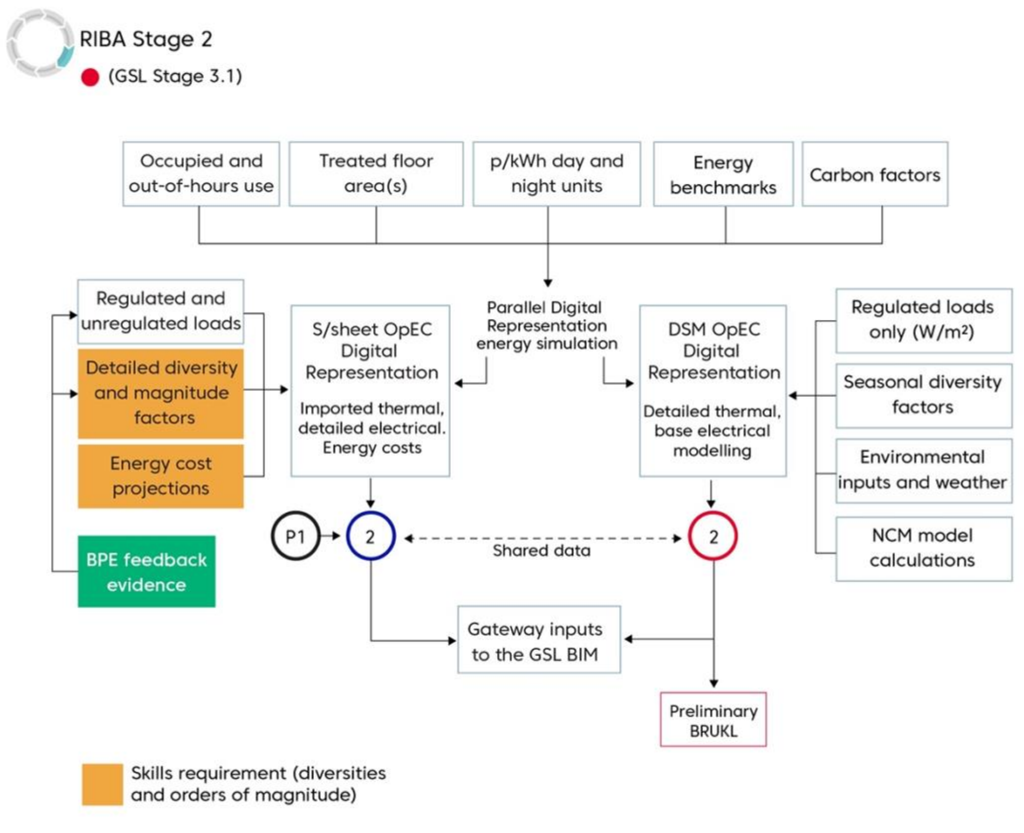



*Figure 5 presents project teams with the choice of conducting analysis in a standalone spreadsheet (e.g. Excel) to the procedures in CIBSE TM54:2013 Evaluating Operational Energy Performance of Buildings at the Design Stage and/or routines conducted within a dynamic simulation model (DSM).*

During the concept design stages (as defined by the RIBA *Plan of Work*, the BIM Framework, BSRIA *BG6:2018*, and CIBSE *TM63:2020*), the professional design team will gather information to populate the project's digital representation (Figure 5). During this process the project team will need to decide the appropriate route for creating a project's operational energy and carbon digital representation (the OpEC).

Figure 5 presents project teams with the choice of conducting analysis in a standalone spreadsheet and/or within a dynamic simulation model (DSM). Whatever route is chosen (or a parallel approach, as shown in Figure 5), project teams are required to ensure that the requisite skills and expertise are available in the team for conducting sensitivity analyses, calculations of diversities, and orders of magnitude. The GSL champion should ensure that feedback evidence from building performance evaluations (BPE) is an input into the OpEC digital representations. Ideally, any resulting energy targets should be aspirational rather than merely reflecting established and historical references such as published benchmarks.

It is not the purpose of this guidance to advise GSL clients and project teams on the most appropriate route for generating an OpEC digital representation. The choice will depend on a variety of context-specific factors. These are covered below in Section 3: Energy Assessment Tools and in the box item: Parallel OpEC digital representations.

### *Building Regulations*

The national *Building Regulations* require a minimum standard to be achieved rather than an optimal level of energy performance involving all power loads. Modelling of non-regulated loads is, by definition, not required.

The widespread convention during RIBA Stages 3–5 is to conduct energy and emissions analysis for thermal and electrical loads in a DSM using the National Calculation Methodology (NCM) for the ultimate purpose of reviewing the project for regulatory compliance (i.e. a *BRUKL* report). Information Exchange Gateway 2 may therefore be a combination of supplementary energy use simulation: a DSM based on the NCM for the purpose of calculating the thermal and regulated electrical loads for *BRUKL* submission; and a spreadsheet-based digital representation (or separate DSM) for calculating regulated, unregulated and process loads.

### RIBA *Plan of Work*

Under the 2020 RIBA *Plan of Work*, architects are required to perform sufficient energy and other modelling to test and refine the architectural concept, the sustainability strategy and delivery of sustainability outcomes (in line with the 2021 RIBA *Plan for Use Guide*). Similarly, the BIM Framework requires the project team to adopt an evidence-based approach that can demonstrate that the expected benefits and required operational performance will be achieved. It calls for high-level simulation models for operational outcomes and/or targets based on reliable estimates of regulated and unregulated loads.

Information Exchange Gateway 2 aligns with the completion of RIBA Stage 2: Concept Design. At this time the professional team will conduct thermal and power modelling, ultimately to be in accordance with the compliance requirements of the *Building Regulations*. However, it is important to stress that Information Exchange Gateway 2 energy assessments carried out on GSL projects are not driven by regulatory requirements. The energy and emissions analysis should instead be focused on operational outcomes, therefore covering both regulated and unregulated loads and not merely statutory compliance values.

Note that while Information Exchange Gateway 2 is consistent with completion of the corresponding stages in the 2021 RIBA *Plan for Use Guide*, the BIM Framework (*BS 8536-2:2016*), BSRIA *BG6:2018 A Design Framework for Building Services*, and CIBSE *TM63:2020 Building Performance Modelling*, it does not align with a stage completion in the design phase of *BG54:2014 The Soft Landings Framework*. The same is also true of GSL and the *SCIM* layer. This is not a shortcoming, as the latter have different purposes to the 2020 *Plan of Work*.

The *Net Zero Public Buildings Standard* requires a Concept Stage report demonstrating the design is on track to acheave the project objectives in regards to energy performance. Also included should be an outline measurement and verification plan relating to metering strategies.

### Parallel OpEC digital representations

Parallel energy calculations may be regarded as inefficient. Project teams may elect to create an OpEC solely within a dynamic simulation model (DSM). However, some Soft Landings procedures (e.g. the NHS Scotland Design Assessment Process – SDAP) call for separate *BRUKL* outputs and accurate simulation models to be created during a design development phase. Although this is technically possible (and from a data-handling standpoint a desirable evolution of conventional DSM), the issues listed in Section 3: Energy Assessment Tools will need to be resolved. Furthermore, the practicalities and difficulties of separating NCM-oriented energy modelling from scenario-based modelling (conducted to the procedures in CIBSE *TM54:2013*) require careful consideration.

Under the current objectives of *Part L* of the *Building Regulations*, the objectives of compliance-based modelling using simplified boundary conditions are different to those of operational energy modelling. In addition, simulation modellers rarely possess expertise in building performance analysis. Being detached and remote from the project team, energy modellers are poorly positioned and arguably ill-equipped (in terms of knowledge and access to data) to calculate diversities and orders of magnitude that drive up a building's operational energy consumption and emissions beyond the notional values calculated for regulatory compliance, as submitted in a *BRUKL*. Furthermore, the duties under which energy modellers are typically appointed would not include detailed modelling (thereby constraining the model's inputs) until RIBA Stage 3: Spatial Coordination. If detailed modelling is performed in RIBA Stage 2: Concept Design, the concept options will need to be narrowed sufficiently early in the design stage to allow the team to provide robust calculations. These limitations may require a rethink of the normal programming requirements. (Admittedly, they also provide a strong argument for much better collaboration within and between the design professions.)

In practice, either the contracted role of the DSM modeller will need to be changed (as in the Design for Performance initiative – see glossary) or an alternative route will need to be found for modelling operational energy and emissions. For most projects, the simplest solution may be a spreadsheet-based digital twin designed to handle detailed modelling of regulated and unregulated operational energy projections. It will not require specialist DSM skills to populate or maintain during design and construction, and it will be easier for asset managers to use and update after handover. It will still be a usable digital representation, albeit not an overly sophisticated one.

## Government Soft Landings

Under a GSL project, the energy and emissions results for Information Exchange Gateway 2 should be lodged within the information model and versioned appropriately. For GSL, Information Exchange Gateway 2 requires specific information about project costs. Although this is not made an explicit requirement for projects working under the *SCIM*, it may be assumed that cost reporting will be required at Information Exchange Gateway 2, particularly where a client or GSL champion has requested it. This is reflected in an optional information exchange in Figure 2 for *SCIM*-related construction projects. Its need may be proportional to the project time span and the degree to which project costs may change or be refined over time.

Information Exchange Gateways 2–4 are therefore intermediate gateways (defined by the red information exchange markers in Figure 2). For GSL Information Exchange Gateway 2 (and other non-aligned information exchange gateways), the reporting point will need to be predefined by the client's GSL designed for the calculation of thermal loads, as they cannot easily take into account the thermal characteristics of fabric and windows. Detailed thermal analysis is therefore more likely to be derived from generic NCM calculations, with the resulting heating energy value exported as a power load input to a spreadsheet-based OpEC digital representation.

The supplementary modelling would need to share essential parameters such as treated floor areas, energy benchmarks and projected occupied and out-of-hours use. Whereas the DSM would use the NCM model and weather files for detailed thermal modelling, the spreadsheet OpEC would calculate regulated and unregulated loads, and it would estimate detailed diversity and load factors to the levels of approximation defined by CIBSE *BG54:2013*. Those iterations should be informed by feedback evidence gathered earlier in the project, additional feedback from design professionals as they are appointed, and the *BG27* champion and/or PAM and its data-reporting requirements written into professional appointments and contract documentation.

## Energy modelling

In terms of allowable approximations on operational energy and emissions, BSRIA *BG6:2018* suggests that a ±25% level of precision in energy modelling could be achieved by the end of RIBA Stage 2. The 2021 RIBA *Plan for Use Guide* quotes levels of confidence. At RIBA Stage 2 the approximation band is ±75–80%. CIBSE *TM54:2018* contains greater flexibility, merely advising users to set margins of error to their energy and emissions calculations commensurate with the amount of knowledge and detail (and degree of engineering certainty) about diversities and potential run-times at the time of modelling.

With the notable exception of the Passivhaus Planning Package (PHPP), spreadsheet-based energy assessment tools such as CIBSE *TM22:2006* are not

*Pitstopping* reality-checking routine. CIBSE *TM63:2020* recommends that the performance model be progressively populated with design stage assumptions, intents and targets, as well as operation stage performance and modifications as they become known.

Information Exchange Gateway 2 aligns with scheme design reality-checking (as defined by BSRIA *BG27:2011 Pitstopping*). BSRIA *BG27* advises a project team to identify a small number of performance-critical systems for ongoing detailed sensitivity checks at key points in a project timeline. Note that under the *SCIM*, *BG27:2011 Pitstopping* is a formal requirement.

## BREEAM

Where BREEAM is adopted, Information Exchange Gateway 2 should be informed by the outputs of BREEAM Ene01: Workshop on Operational Energy.

## OpEC Information Exchange 3 (RIBA Stage 3: Spatial Coordination)

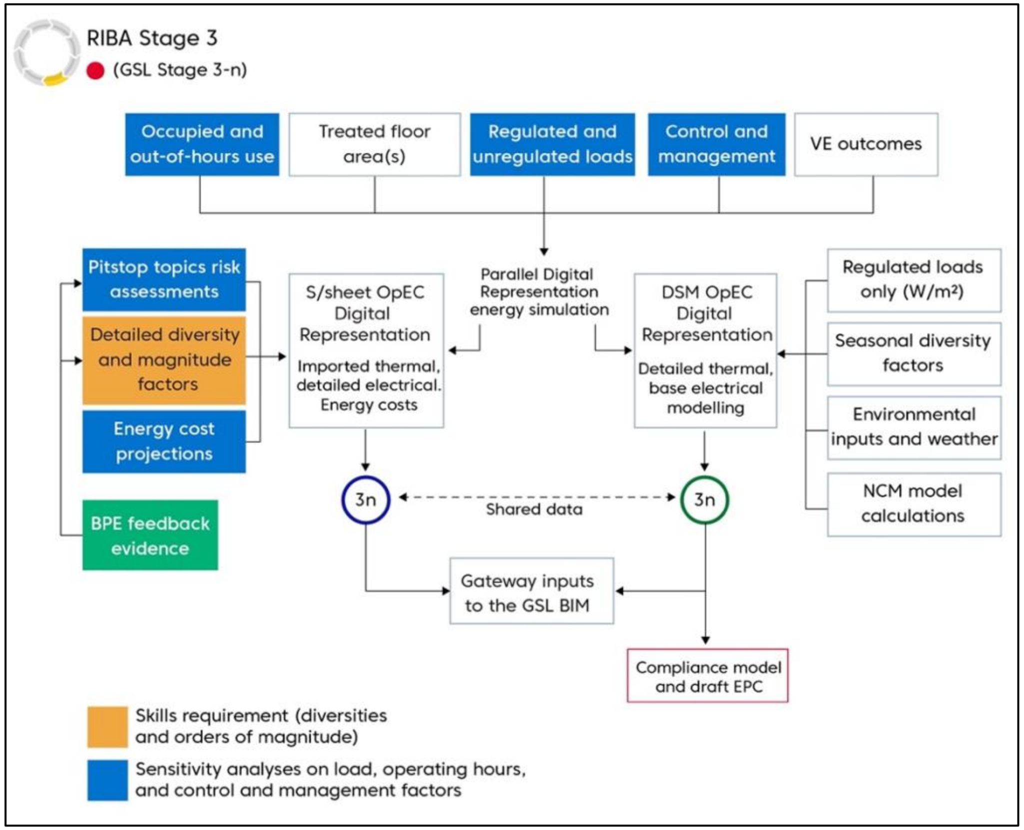



*Figure 6. Project teams are required to ensure that the skills and expertise are available in the team for conducting sensitivity analyses and calculations of diversities and orders of magnitude. The GSL champion should ensure that feedback evidence from building performance evaluations (BPE) is a formal input into the OpEC digital twins.*

The energy and emissions OpEC Information Exchange Gateway 3 aligns with Stage 3: Spatial Coordination of the 2020 RIBA *Plan for Work* and Stage 3: Definition of the BIM Framework (*BS 8536-2*). It also aligns with Stage 3: Developed Design Model of BSRIA *BG6:2018*. As with OpEC Information Exchange Gateway 2, OpEC Information Exchange Gateway 3 in the *BG54:2014* and GSL structures is an intermediate information exchange, as it does not align with any defined stage gateways.

The OpEC Information Exchange Gateway 3 matches the creation of the draft *BRUKL* document and Energy Performance Certificate (EPC). These are generated from the DSM OpEC digital representation, based on calculations performed using the National Calculation Methodology (Figure 6).

If the spreadsheet-based digital representation approach shown in Figure 6 is not deemed suitable by a project sponsor, the NCM-based DSM will need to be split into regulated and non-regulated power load models (i.e. one for regulatory compliance purposes and the second for total operational energy purposes). The practicalities of this separation will need to be discussed with the project sponsor (see box item: Parallel OpEC digital representations)

### RIBA *Plan for Use Guide*

The 2021 RIBA *Plan for Use Guide* suggests energy performance iterations (with allowable approximations) between RIBA Stage 3: Spatial Coordination and Stage 5: Manufacturing and Construction. These points are analogous to Information Exchanges 3–5 of Figure 2. In terms of allowable approximations on operational energy and emissions, BSRIA *BG6:2018* suggests that a ±15% level of precision in energy modelling could be achieved by the end of RIBA Stage 3. The *Plan for Use Guide* quotes levels of confidence. At RIBA Stage 3, the allowable approximation is ±85–90%. As with previous stages, CIBSE *TM54:2013* merely advises users to calculate thoughtful margins of error for their energy and emissions calculations, commensurate with the amount of knowledge and detail (and degree of engineering certainty) known about diversities and potential run-times.

## Government Soft Landings

GSL requires modelling and testing evidence to ensure that the developed and constructed design will deliver the promised operational targets. It asks for a review of all construction and installation details, in addition to the identification of any aspects that will have a negative effect upon the actual performance relative to the required performance.

For Information Exchange Gateway 3, GSL requires environmental targets to be set and the requirements and assessment criteria to be embedded into tender information. The targets should cover both regulated and unregulated electricity loads. Note that GSL stipulates values as kWh/m$^2$ per annum gross internal floor area (GIFA). However, treated floor area (TFA) is a more appropriate measure. Gross floor area may include unlit and unheated areas, and also spaces and/or loads that can be justifiably categorised as separables in an OpEC calculation.

### *Scottish Capital Investment Manual*

Cost reporting for projects working to the *SCIM* will also be intermediate OpEC digital representation information exchange reporting points for Information Exchange Gateway 3, as denoted by the hatched information exchange circles in Figure 2. These may become OpEC information exchanges for GSL projects where cost is a specific performance metric. They may also be stipulated depending on the nature of a non-GSL project and a client's requirements.

For NHS Scotland Soft Landings projects, the NHS Scotland Design Assessment Process (NDAP) requires both the NCM model and "accurate…energy models (DSMs)" to be created. This is typically required for planning. It is also an input into the BREEAM assessment process to help establish targets.

At RIBA Stage 3 the *SCIM* requires an accurate thermal and energy dynamic simulation model (termed the outline solution model) as part of the *BS 8536* series. The *SCIM* does not specify or recommend a particular methodology.

Project teams may choose to adopt the approach to modelling defined in CIBSE *TM63:2020 Operational Performance: Building Performance Modelling*. *TM63:2020* requires the designers to create a design performance model and to populate it with design stage assumptions, intents and targets.

Note that the NHS Scotland Design Energy Performance (NDEP) procedure calls for the modelling of bespoke kWh/m$^2$ targets. These are not likely to emerge solely from the NCM calculation procedures, thus requiring a methodology for calculating operational energy, including both regulated and unregulated loads.

### *Net Zero Public Building Standard*

A scheme design report is required to demonstrate the design is on track to acheave the project objectives in regards to energy performance, supported with energy modelling that assess the impact of design decisions upon the acheavment of relevant targets, applying iterative adjustment and remodelling to optimise them and verify success.

Also included should be an outline measurement and verification plan relating to metering strategies cross referred to the energy modelling studies.

## OpEC Information Exchange Gateway 3 – intermediate data

Figure 2 provides subsidiary OpEC digital representation information exchanges for RIBA Stage Gateway 3. These are characterised as Information Exchange Gateway 3*n*, arranged as additional drops prior to each stage's completion gateway.

The number and location of OpEC digital representation modelling iterations up to the Stage 3 Information Exchange Gateway will depend on a variety of factors, including project complexity and phasing, the elapsed time between stage gateways, and whether a project involves a single entity or multiple assets on one site (such as a campus development, possibly served by a shared energy centre). The actual number of subsidiary OpEC digital representation information exchanges will therefore be context-dependent and a matter of choice by a client and its project team.

The precise location and number of OpEC digital representation information exchanges aligned with RIBA Stage 3 may be dependent on the point at which appointments are made and the design is finalised. For design and build projects, a Stage 3 OpEC digital representation information exchange for energy and emissions might be 3*n*. For traditional procurement routes, however, the substantial energy reporting into the OpEC digital representation may occur before Information Exchange Gateway 4 (i.e. 4*n* in Figure 7), where intermediate reporting is required, for example, for BREEAM activities.

### BREEAM

Where BREEAM is specified on a GSL project, an OpEC digital representation information exchange may occur at one of the intermediate information exchange points (i.e. 3*n* to Information Exchange Gateway 3). For example, an additional 3*n* OpEC digital representation information exchange may be driven by the reporting requirements of BREEAM Ene04: Passive Design Analysis, and energy and emissions outputs from BREEAM Ene04: Low and Zero-Carbon Technology Feasibility Study. Irrespective of whether or not BREEAM is adopted, a project team still needs to ensure that the sub-metering strategy is developed to enable energy to be measured by end use. Where BREEAM is adopted, it will be the assessor's responsibility to show that good practice has been followed. This should be reflected in an OpEC digital representation information exchange. Ideally, individual systems would be assigned a notional end-use sub-meter (or zone meter) in line with the energy metering strategy, and in order for the apportionment to be reported and updated as necessary at subsequent information exchange gateways.

## OpEC Information Exchange Gateway 4 (RIBA Stage 4: Technical Design)

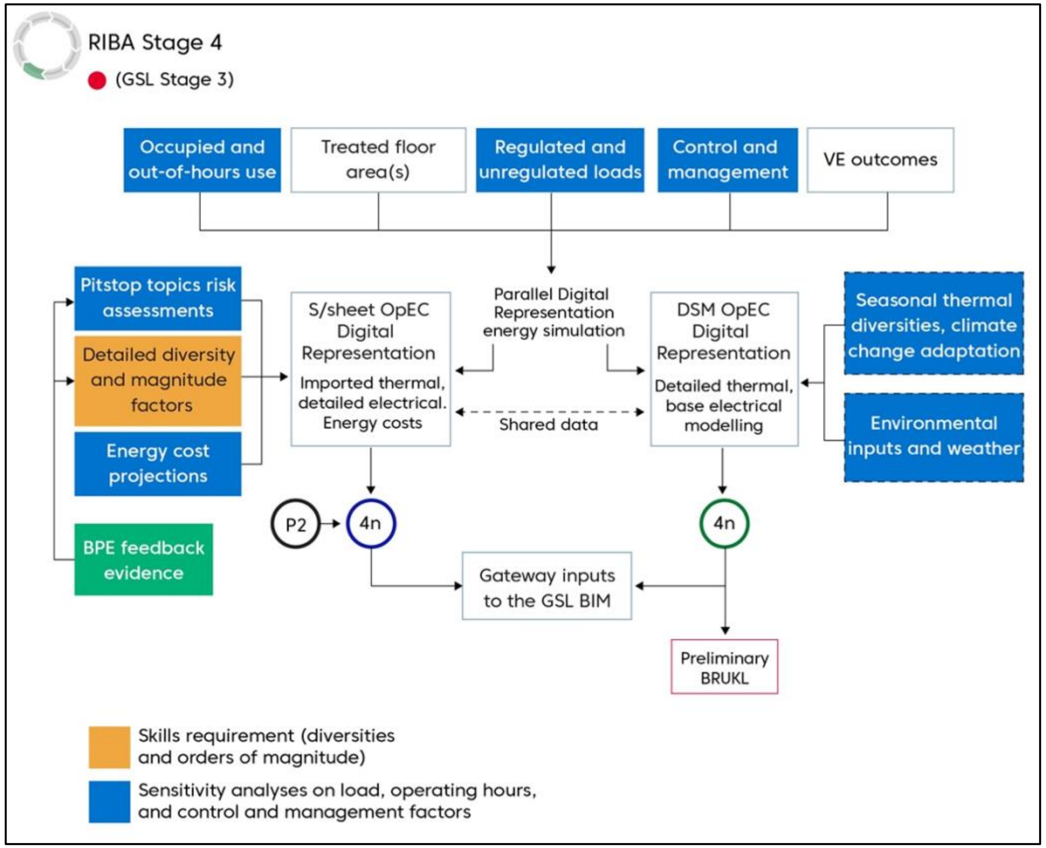



*Figure 7. The adjustment of the OpEC digital representation(s) requires energy-related inputs from BSRIA BG27:2011 Pitstopping reality-checks (a mandatory procedure for projects procured under the Scottish Capital Investment Manual). Note that seasonal diversity factors, climate-change adaptation and weather inputs may have been largely completed by RIBA Stage 4, with adjustments to inputs from outcomes of sensitivity analyses and reality-checks (shown as hatched boxes).*

The OpEC Information Exchange Gateway 4 (Figure 7) aligns with the RIBA *Plan of Work* Stage 4: Technical Design, and Stage 4 of BSRIA *BG6:2018* Coordinated Specific Design. It also aligns with completion of the full business case required for projects procured under *SCIM*. As with Information Exchange Gateway 3, the complexity and/or length of a project may require intermediate iterations and information exchanges on operational energy and emissions, with changes captured in the choice of OpEC digital representation – DSM or spreadsheet-based.

As GSL combines the design and construction phases into a single phase, Information Exchange Gateway 4 occurs at an intermediate point in the GSL structure (defined by the red dots in Figure 2).

The OpEC digital representation information exchanges are therefore more dictated by the gateways defined by the 2020 RIBA *Plan of Work* and 2021 *Plan for Use* procedures, the BIM Framework (*BS 8536-2*), BREEAM and BSRIA *BG6:2018*.

Figure 7 incorporates the technical reality-check of BSRIA *BG27:2011 Pitstopping*, held within RIBA Stage 4: Technical Design. It should occur when enough information on the technical design is available for risk assessments to be performed. Figure 6 incorporates the outputs of the P2 Pitstop with the sensitivity analysis inputs to a spreadsheet-based OpEC digital representation. (Note that the reality-check Information Exchange Gateway P2 aligns with BSRIA *BG6:2018* Stage 4a: Feasible Generic Design.)

### RIBA *Plan of Work*

The 2020 RIBA *Plan of Work* calls for operational energy and emissions to be reflected in drawings, details, specifications and strategy drawings. Furthermore, the RIBA Stage 4 gateway requires the professional designers to ensure that contractors set out asset information clearly in tenders and specifications. This covers digitisation as electronic asset tagging or the use of integrated BIM.

At RIBA Stage 4, the preliminary *BRUKL* document will be submitted for approval. Assuming no improvements or changes are requested by building control, the DSM underpinning the *BRUKL* may be signed off as complete. Subsequent

OpEC iterations may be confined to the spreadsheet-based OpEC digital representation. DSM modellers may be retained on contract throughout the project to maintain the DSM for advanced energy modelling, for example, to fulfil the requirements of Design for Performance certification (Figure 2). CIBSE *TM63:2020* recommends that a DSM-based digital representation be used to develop a virtual representation of the building in-use, calibrated to actual energy use, with simulation inputs able to be linked to actual operating conditions after building handover.

Irrespective of whether operational energy-consumption iterations in RIBA Stage 4 are done with an advanced DSM-based or spreadsheet-based OpEC digital representation, the 2020 RIBA *Plan of Work* requires architects to ensure that operational energy and emissions are calculated with outputs reported as $kWh/m^2$ per annum and $kgCO_2/m^2$ per annum, respectively, to allowable approximations. BSRIA *BG6:2018* suggests that a ±5% level of precision in energy modelling could be achieved by the end of RIBA Stage 4. The RIBA *Plan for Use Guide* quotes a level of confidence at Stage 4, in the band ±90–95%. As with previous stages, energy and emissions models constructed to CIBSE *TM54:2013* merely recommend thoughtful margins of error commensurate with known levels of detail about powered systems and the hours they will run.

## BIM Framework

At Information Exchange Gateway 4, the *BIM Framework* requires the project team to undertake model-based simulations of operational energy use and emissions, and to identify any changed operational requirements necessary in order to meet the energy performance target(s). Mindful that value engineering will be conducted at Stage 4 (and beyond), the BIM Framework also requires alternative proposals to be judged for optimising energy consumption and minimising emissions. The BIM Framework therefore calls for the onus to be placed on suppliers and manufacturers to report the energy consumed by their components and parts, and for that information to be recorded in the BIM.

## Government Soft Landings

In line with the requirements of the *BS 8536* series, GSL requires the project team to identify and confirm any unavoidable changes in design that might give rise to a change in the performance of the asset/facility in question. GSL projects that opt to use the energy and emissions modelling approach in CIBSE *TM63:2020* will be able to amend an advanced OpEC digital representation during design and construction so that the representation can evolve to represent the projected or intended performance of the building.

## Reality-checking

BSRIA *BG27:2011 Pitstopping* recommends an optional pitstop for performance-critical items prior to tendering to ensure that the tender documentation covers the risk issues identified during the earlier reality-checking procedures. Such checks are vital for certain items. For example, controls of various kinds may be required to possess a specific level of functionality, maintainability and usability. It is not unknown, however, for controls suppliers to interpret requirements to suit their off-the-shelf products. Such products may not satisfy the performance-critical outcomes of the pitstopping process, such as operational outcomes, physical performance characteristics and user interfaces. Tightly written tender documents will help to ensure that the controls specification is met exactly as required.

The optional pitstop is shown in Figure 2 as “Po”. The product outcomes can be checked at Pitstop 3: Tender Stage Reality-Check(s).

## *Net Zero Public Building Standard*

A technical design report is required to demonstrate the design is on track to acheave the project objectives in regards to energy performance, supported with energy modelling and a detailed measurement and verification plan.

## OpEC Information Exchange Gateway 5 (RIBA Stage 5: Manufacturing and Construction)

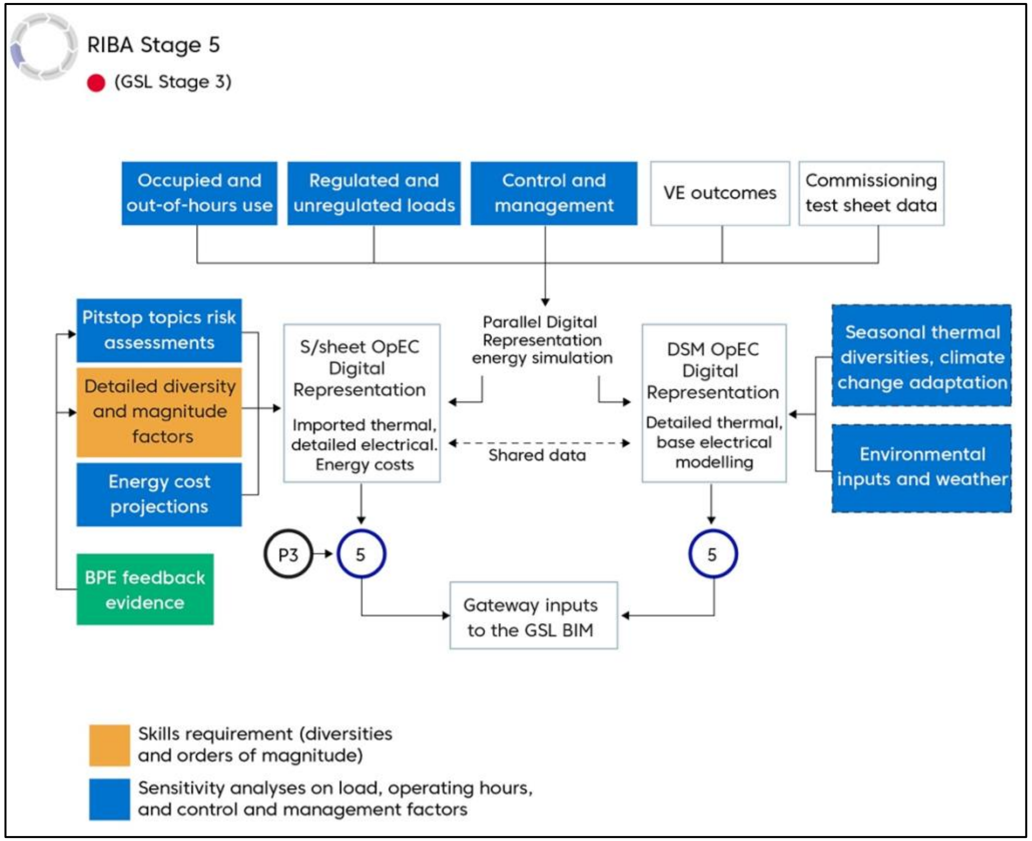



*Figure 8. The adjustment of the OpEC digital representation (s) requires energy-related inputs from BSRIA BG27:2011 Pitstopping reality-check P3 (a mandatory procedure for projects procured under the Scottish Capital Investment Manual). Note that seasonal diversity factors, climate-change adaptation and weather inputs should have been largely completed by RIBA Stage 4. Adjustments to the OpEC digital representation may nonetheless come from continuing sensitivity analyses and reality-checks (shown as hatched boxes), such as refinements to climate-change adaptation measures.*

Figure 8 shows the data requirements for the OpEC digital representation information exchange for the 2020 RIBA *Plan of Work* Stage 5 gateway.

As shown in Figure 2, the OpEC digital representation gateway aligns with the end of GSL Stage 3 “Design and Construct” (and with most other plans of work) prior to handover.

Note that the Stage 5 version of the OpEC digital representation should have been informed by the outputs of the BSRIA *BG27:2011 Pitstopping* tender stage reality-checks (Pitstop P3 in Figure 2 and Figure 8), with particular respect to the energy and emissions consequences of as-installed systems and products. Commissioning test sheets can be used to refine data entries in the OpEC digital representation, such as measured specific fan power. Airtightness test results can similarly be used to refine an asset’s likely thermal performance. In most other respects, OpEC digital representation Information Exchange Gateway 5 is a continuation of Information Exchange Gateway 4 requirements, albeit with increasing accuracy of energy and emissions projections to at least a ±5% level of precision in energy modelling, in accordance with BSRIA *BG6:2018* (or ±90–95% in the RIBA *Plan for Use Guide*). This requirement aligns with GSL and the BIM Framework, both of which oblige project teams to provide evidence that the energy and emissions calculations are peer-reviewed and verified. The asset’s owner will also need to be advised of any changes that might affect the required performance. Evidence must be provided to ensure that design details prepared by specialist contractors, suppliers and manufacturers have been reviewed to check that the required performance can be achieved.

The requirement for increasing accuracy of energy and carbon dioxide emissions also aligns with the requirements of BSRIA *BG6:2018 A Design Framework for Building Services.* A project team is required to prepare accredited as-constructed energy-consumption information in compliance with *Building Regulations* energy performance certification (the as-built EPC).

## Government Soft Landings

For buildings procured using GSL, the Stage 5 gateway and OpEC digital representation information exchange gateway will coincide with the draft as-built EPC.

Project teams working on GSL projects that adopt the procedures of CIBSE *TM63:2020* are required to identify and categorise technical issues caused by construction, commissioning, operations and controls issues as they emerge, and for the OpEC digital representation to be adjusted. Calibration of a CIBSE *TM63:2020* OpEC digital representation is required for a full year's operation (Information Exchange Gateway 7, below) using monthly data at a minimum. Simulation models that focus on specific systems should be calibrated to system-level data.

## *Scottish Capital Investment Manual* and *Net Zero Public Buildings Standard*

Projects procured to the *Scottish Capital Investment Manual* (*SCIM*) are required to provide regular updates on the project's out-turn environmental performance. The OpEC digital representation should be populated with performance data that will enable the reporting function to be satisfied. Note, however, that neither *SCIM* nor the *Net Zero Public Building Standard* provides specific Soft Landings guidance on energy and environmental reporting, beyond brief mentions.

## OpEC Information Exchange Gateway 6 (RIBA Stage 6: Handover)

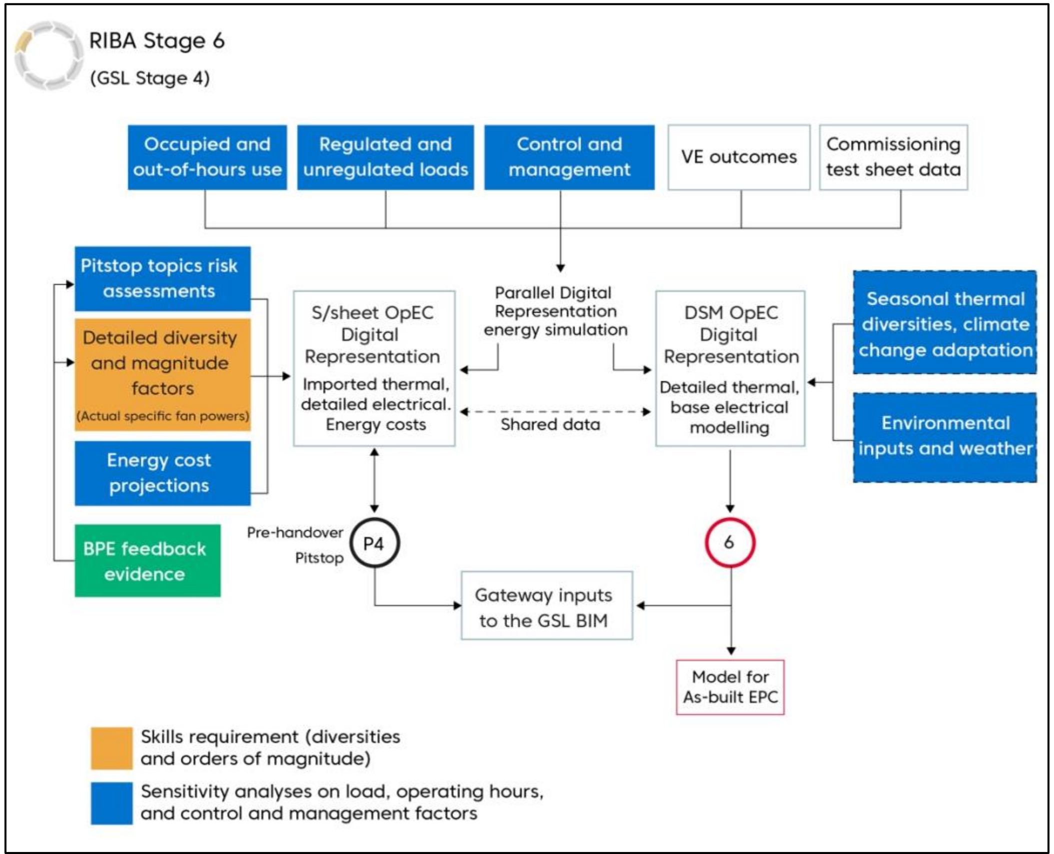



*Figure 9. The adjustment of the OpEC digital twin(s) requires energy-related inputs from BSRIA* BG27:2011 *Pitstopping reality-check P4 (a mandatory procedure for projects procured under the Scottish Capital Investment Manual).*

OpEC digital representation Information Exchange Gateway 6 is a continuation of the requirements of Information Exchange Gateway 5, culminating in the submission of the as-built Energy Performance Certificate (EPC) at project handover. Both the OpEC and the as-built EPC should take into account verified changes that have occurred during construction, including changes to the client's intended hours of operation (and out-of-hours use).

The 2020 RIBA *Plan of Work* Stage 6: Handover calls for the as-built energy model (i.e. the DSM and/or a spreadsheet-based OpEC) to be calibrated to the commissioned building for the purposes of comparing planned energy use with actual energy use.

It is good practice for non-regulated electrical loads not known at previous stages of design and construction (such as servers, distributed catering and vending machines) to be included in the OpEC digital representation. All variables that apply to the energy and emissions calculations should be checked and verified (i.e. treated floor areas, electricity and fossil-fuel unit costs for day and night operation, and the carbon factors for each fuel). Control and management factors for each load should also be revisited. Factors applied to all energy-consuming systems should be checked, updated and verified by site inspection.

### *Scottish Capital Investment Manual*

The *SCIM* calls for a pre-handover Pitstop 4 review to be conducted in its Construction and Commissioning stage, with FM staff in attendance, and for protocols to be tested in their presence. However, more properly, this activity should be conducted in 2020 RIBA Stage 6: Handover, when all systems are installed, fully commissioned and ready for demonstration. Note that seasonal diversity factors, climate-change adaptation and weather inputs should have been largely completed by RIBA Stage 4. Adjustments to the OpEC digital representation may nonetheless come from pre-handover sensitivity analyses (shown as a hatched box in Figure 9), such as refinements to climate-change adaptation measures.

The *BIM Framework*, BSRIA/UBT *BG54:2014 The Soft Landings Framework* and GSL all call for the project delivery team to ensure that individual metering systems are functioning accurately, adequately labelled according to end use, and that meters are reconciled to within ±5% of the fiscal meters prior to handover. Sub-meters should be zeroed prior to handover when construction work that may draw energy from metered circuits is finished. Note that power consumed during client fit-out activities (e.g. server installations) may inflate post-handover meter readings. If meters on such circuits cannot be easily re-zeroed, any energy consumed by installation contractors should be noted and subtracted from in-use data.

OpEC digital representation models devised to CIBSE *TM63:2020* are required to be set at a baseline, with the purpose of reflecting actual operating conditions. This requires the OpEC digital representation to be continually refined during the design and construction phases (and altered to reflect any changes to functional needs). CIBSE *TM63:2020* calls for the model to retain the original technical design intent where possible.

*Net Zero Public Buildings Standard*

The *Standard* recommends a delivery stage report be produced ahead of validation and commissioning.  This report should include a strategy for reporting how the target requirements will be reported during a Verify Performance and Continuous Improvement stage.  This should include finalising the measurement and verification plan for third party verification of performance versus energy targets.

## Reality-checking

The OpEC digital representation Information Exchange Gateway 6 should reflect the findings of Pitstop 4: The Pre-Handover Reality-Check (Figure 9). This should aim to ensure that all operational risks identified at earlier pitstops have been either acted upon and resolved or otherwise reflected in the likely load factors for the energy-consuming items entered into the OpEC digital representation.

Outstanding items and uncertainties identified in Pitstop 4 need to be taken forward for monitoring and fine-tuning in the initial post-completion operational phase. Observed deviant operation of those items (and any other systems, where noticed) will need to be resolved during the GSL and BSRIA Soft Landings aftercare periods (Information Exchange Gateways 7a–7c, below).

Project teams should remain open to performance evidence that indicates how systems may actually behave in practice. This knowledge can be used to modify performance estimates in the OpEC digital representation. However, it is unlikely that project teams will have the time and resources during handover to use building performance evaluation evidence. The OpEC digital representation is more likely to be refined as a consequence of the BSRIA *BG27:2011 Pitstopping* activities applied to a few performance-critical items. GSL champions should encourage their professional teams to model energy and emissions scenarios that reflect how the building will perform after handover.

The setting up and familiarisation of user controls will be crucial during this stage. The effectiveness and usability of user controls can have a major effect on an asset's out-turn energy consumption.

## BREEAM

Under BREEAM, the requirements of BREEAM Ene01: Final As-Built *BRUKL Documents* will apply. For projects procured to *SCIM*, a National Digital Engagement Programme (NDEP) energy certificate is required.

## OpEC Information Exchange Gateway 7 (RIBA Stage 7: In-Use)

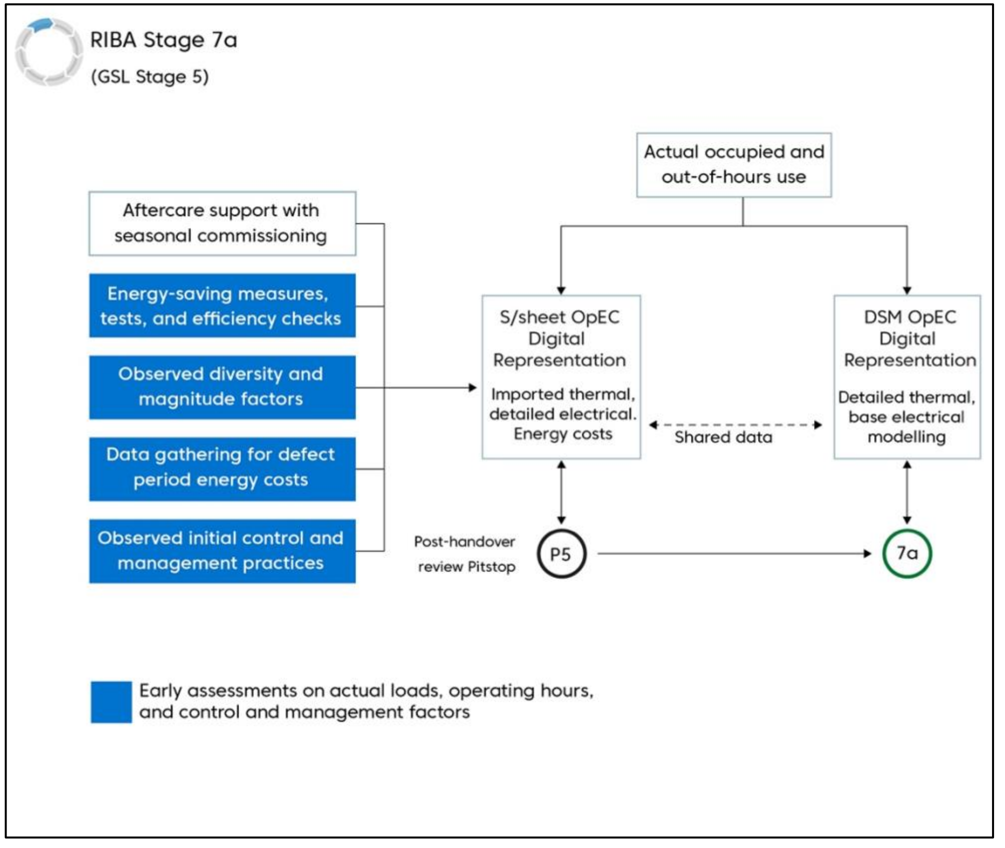



*Figure 10. This reflects the activities required for the OpEC digital representation at Stage 7a. Where a final post-handover pitstop review of critical systems is held (P5), the meeting could be used to run through the OpEC digital representation and refine the loads and their diversity factors.*

Information Exchange Gateways 7a–c are the energy and emissions measurement points for the three-year Soft Landings aftercare period defined in *BG54:2014 The Soft Landings Framework*. For the purposes of the OpEC digital representation Information Exchange Gateway 7a, this guidance is based upon the fundamental requirements of *BG54:2014*, with operating cost as an additional metric to meet the requirements of GSL and the *SCIM*, both of which cover cost as a specific metric.

*BS 8536-2:2016* calls for a review of “early energy use for comparison with predictions” as part of a formal post-implementation review (PIR) of the asset’s performance against the agreed outcomes and/or targets and applicable benchmarks. This is to be repeated at the end of each year of the three-year Soft Landings aftercare period.

The focus of a Soft Landings aftercare team during the initial 12-month operating period should be on monitoring energy use and periodically refining the parameters of the OpEC digital representation. Excess consumption should be investigated and the causes either corrected or verified as normal. Asset managers should be trained to use the OpEC digital representation as an energy measurement and verification system after the Soft Landings aftercare period has been completed. The costs of this activity should be included in the preliminary costs of the consultant or the main contractor.

Figure 9 reflects the activities required for the OpEC digital representation at Stage 7a. Where a final post-handover pitstop review of critical systems is held (P5), the meeting could be used to run through the OpEC digital representation and refine the loads and their diversity factors.

Information Exchange Gateway 7a is likely to be the point at which an asset’s managers decide which version of the OpEC digital representation they wish to use as a measurement and verification tool moving forwards (in line with CIBSE *TM63:2020 Building Performance Modelling and Calibration*). On projects where the *BS 8536* series has to be used for asset management, the OpEC spreadsheet or DSM-based OpEC needs to be stored within the BIM and made accessible to those who will manage it. GSL specifically asks for comparison of actual performance versus theoretical targets, with the updating of energy models in light of operational information and data. This task will fall to those legally responsible for operating the building, with the GSL aftercare team working in support.

As spreadsheets are not ideal for calculating thermal loads, space-heating energy and emissions data may be calculated in the OpEC DSM and imported into the spreadsheet OpEC as a single-line entry of values (load plus diversity). However, if a client has opted to use a DSM-based OpEC during building operation, the spreadsheet OpEC may either be discontinued or used purely as a post-occupancy assessment tool (perhaps by POE specialists external to the project team who may not possess DSM skills). Amended values obtained during the POE(s) can subsequently be uploaded to the DSM for ongoing asset management.

### Post-occupancy evaluation requirements

Users of Government Soft Landings and GSL-related documentation need to be aware that there is considerable variation in how published guidance prescribes energy assessments in the first 12-month post-handover period. The 2021 RIBA *Plan for Use Guide*, for example, recommends so-called "light-touch" post-occupancy evaluation (POE) during the defects period (see box: Judging building performance during the defects liability period). Conversely, *BG54:2014 The Soft Landings Framework* recommends formal POE only once an asset has operated for at least one heating and cooling season, that is, in years two and three post-handover.

The *Scottish Capital Investment Manual* (*SCIM*) calls for three months of initial user support and aftercare followed by nine months of asset monitoring, working alongside the building's owners and managers. The 12-month defects period is then followed by 2 years of periodic support and performance monitoring.

The *Net Zero Public Buildings Standard* asks for a verification stage report with at least 12 months of monitoring from handover, or representative operational use, gathering information on occupancy patterns, weather data, contextual information and other drivers for energy use to determine whether the building is used as anticipated by the energy model.  Energy modelling should then be

### Judging building performance during the defects liability period

The monitoring of systems and their energy use during the defects liability period (DLP) can be helpful in spotting deviant or wasteful operation. However, clients and project teams may be keen to verify a project's energy use and emissions when defects are still being resolved. Rushing to judgement is not without risk. Hasty performance evaluation in year 1 may be compromised by many of the following:

- Outstanding defects may cause some engineering services to operate sub-optimally. Energy use verification during defects may not reflect an asset's true long-term operation.
- An asset's heating and cooling systems will not have completed their first full operating seasons, leading to missing data and thus a partial picture of an asset's true annual energy needs and emissions.
- Initial client fit-out works (scheduled, delayed or impromptu) will add to an asset's power needs, potentially distorting energy and emissions measurements.
- Partial or phased occupation in the first year of operation may mean systems operating at a lower intensity and/or lower operating hours than will be the case for longer-term operation. A relative performance gap may be perceived to occur in the first full year of operation.
- Reporting energy and emissions during defects might lead to a judgement on the delivery team and not on the building's operational performance. This may trigger claims against the contract.
- Energy sub-metering systems may initially misreport data and will need to be recommissioned, reconciled and zeroed before any data they report can be trusted (this may also apply to renewable electricity imports and exports).
- Evaluating energy and emissions while trying to resolve defects may lead to conflicts within the project team. This will not be conducive to collaborative working and risk-sharing.
- So-called "light-touch" POE in the DLP might be the only analysis ever conducted. If the results aren't flattering contractors will not be motivated to remain involved beyond the DLP
- Extreme seasonal conditions that vary significantly from the weather file used for thermal simulations may combine with the above factors, further complicating operational measurements during the DLP.

For these reasons it usually pays to hold off from evaluating an asset's performance until after the DLP. This will also help to maintain relationships that are conducive to collaboration. A performance gap (of any size) found in year 2 will also present fewer contractual risks to a project team. It will also allow fine-tuning to be conducted, with a lower risk of performance shortcomings being falsely (or tactically) classified as defects.

adjusted and updated to reflect usage patterns and a new assessment with corrective actions reported.

After this 12-month period a continuous improvement period is entered into where if operational energy is increased by 20% over the operational energy target, then a ‘non-compliance’ status should instigate further investigations.

The *BIM Framework* requires more formal energy assessment at the end of the first year of operation, with an annual analysis on operational requirements and required performance outcomes and/or targets, as set out in the *Framework’s* Stage 0: Strategy, and Stage 1: Brief Work stages, “subject to any subsequent, agreed modification”.

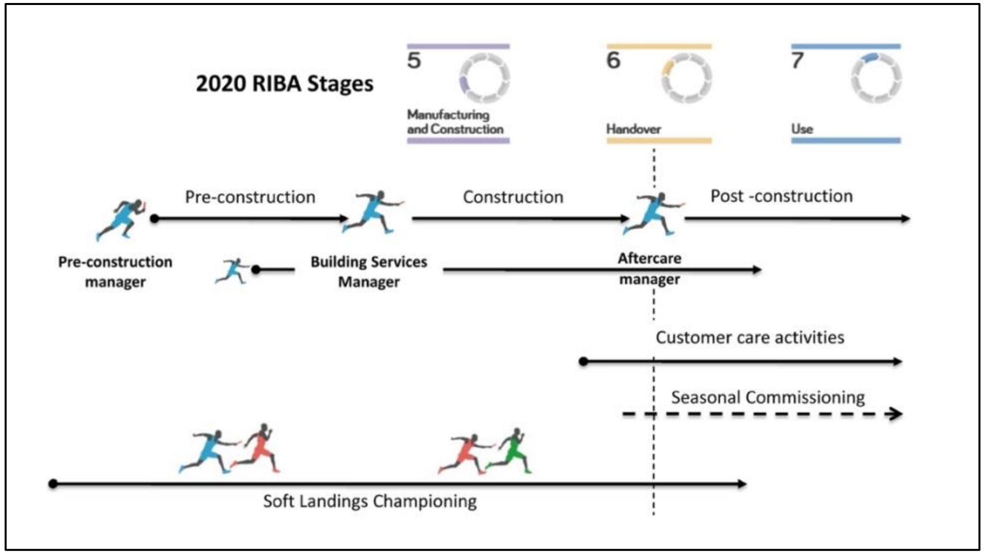
*BS 8536-2:2016* calls for a review of “early energy use for comparison with predictions” as part of a formal post-implementation review (PIR) of the asset’s performance against the agreed outcomes and/or targets and applicable benchmarks. This is to be repeated at the end of each year of the three-year Soft Landings aftercare period.

For the reasons given in the box item “Judging building performance during the defects liability period”, project teams should proceed with great caution when attempting to fulfil a project team’s expectations for early performance evaluation, where actual values are required to be compared with defined outcomes and targets. It will be more prudent for GSL aftercare teams to focus on checking for sub-optimal operation during Information Exchange Gateway 7a, only using that data to correct errors and fine-tune systems. It is in everyone’s interest for early energy data not to be used in judgement – either of the asset or of the project delivery team. This cautious approach will help to create the best environment for both Soft Landings and GSL to succeed beyond year 1. (Note that CIBSE *TM63:2020* recommends measurement of actual metered energy use of a building once its operation is stable and steady. Typically, such stability is only achieved after a couple of years of occupancy, and certainly not in year 1.)

For projects procured to the *SCIM*, a National Digital Engagement Programme (NDEP) energy certificate is required annually.

## *BS 8536* series POE requirements

The *BS 8536* series requires the project sponsor to implement post-implementation reviews to establish if an asset is “performing as expected”. This includes measurement of actual operational performance against the required performance with regard to all individual energy sources and their emissions. This may include analysis of half-hourly energy demand profiles. The resulting data must be compared with benchmark(ed) data. This requires the energy sub-metering system to perform as intended.




Roles can change personnel during procurement and construction. The graphic illustrates a change of personnel in the construction relay race, particularly the disjointed roles of the main contractor and the building services contractor. Handover of the Soft Landings baton needs to happen without it being dropped. Even the relatively continual soft landing championing role may pass from a procurement client to an operational client at a crucial stage in the project, where the operational outcomes are about to become real. Although Government Soft Landings require a Soft Landings champion (possibly in the form of a central government property asset manager), the role may be held by different people at different stages of the project. Consistency in energy performance modelling requires sustained support and focus from the client side all the way through the project, and particularly in the period leading up to handover.

Where the *BS 8536* series has been adopted, the as-constructed information should be processed through the status gates of the common data environment (CDE) in the project information model (PIM). This is to enable a review by the operator, operations team or asset manager. Any deviation from the expected performance should be identified, recorded and shared within the respective teams.

Before a project has completed its first 12 months of operation, the energy and emissions OpEC digital representation should ideally have been reduced to a single operational model. Some organisations will be able to monitor energy consumption using a DSM within an inherited BIM, such as professional asset managers or outsourced energy management specialists. Others with fewer skills in BIM and/or energy management (and with no experience with DSM) are likely to fare better using a generic spreadsheet-based digital representation.

Note that by the end of year 1, an asset will be managed solely by the asset's owner and not the Soft Landings aftercare team. On a GSL project procured by a central government, it is possible for project ownership to shift from a delivery client to an operational client. Where this happens, the GSL responsibilities need to be taken on by the operational client and not lost in the transfer. This may include sustained effort by a GSL delivery team during the initial phase of aftercare to ensure that the OpEC digital representation is complete, accurate, and well-curated in the asset's management systems (e.g. a facilities BIM). It will also need to be in a state that is usable by the ultimate asset managers for ongoing use in energy and emissions assessments, seasonal commissioning and optimisation of energy performance during Soft Landings investigations and fine-tuning interventions. If the OpEC digital representation is not finished off well and working to the satisfaction of the asset managers, it is likely to fall rapidly into disuse.

Where the *BS 8536* series has been adopted for use by asset managers, operational energy and emissions records will need to be passed through the status gates of the common data environment (CDE) in the project information model (PIM). Once verified, the energy data should be allowed to transition through a "verified gate" to the "published section" for subsequent use. *PAS 1192-2* provides detailed guidance for this activity.

## OpEC Information Exchange Gateway 7 (RIBA Stage 7: In-Use)

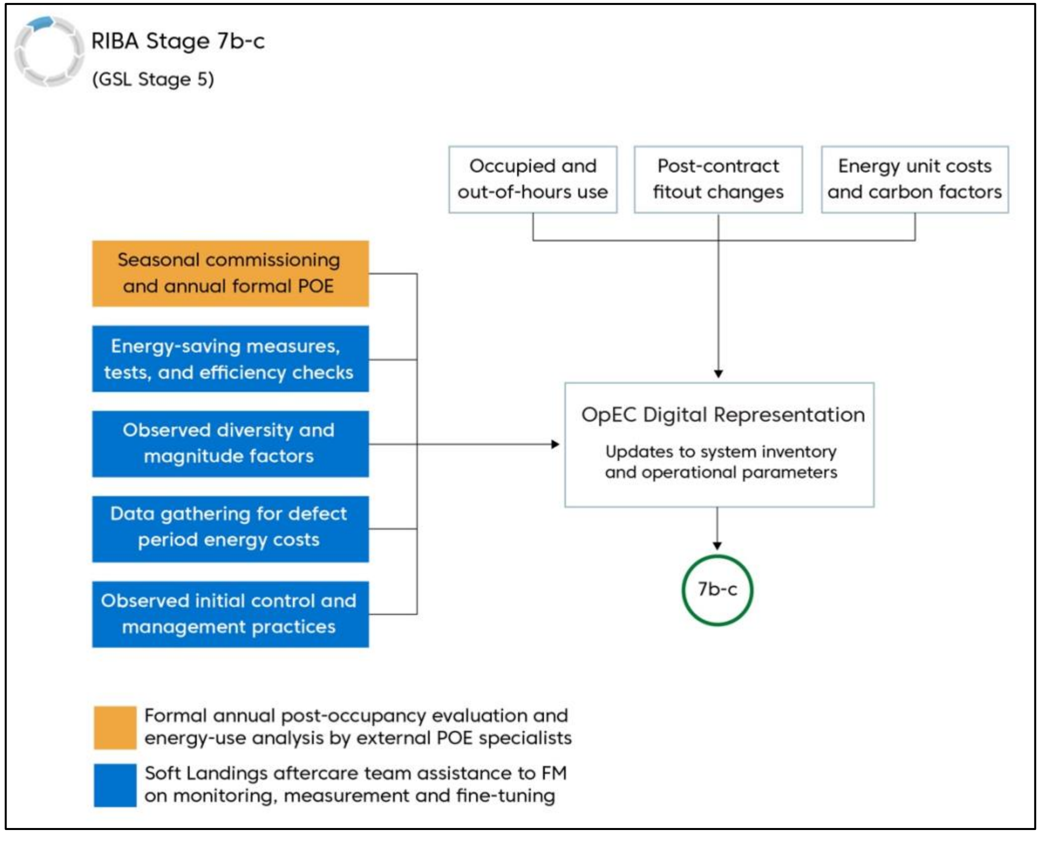



*Figure 11. This reflects the activities required for the OpEC digital representation at Stages 7b and 7c. By Stage 7b the energy and emissions OpEC digital representation should ideally have been reduced to a single operational model.*

At RIBA Stages 7b–c, the asset managers (aided by the Soft Landings aftercare team) should be comparing the as-built OpEC digital representation with the actual measured data, identifying any disparities and resolving them. Activities can include refinement of loads and run times, as well as identification and resolution of performance gaps, typically caused by wasteful or parasitic operation. The as-built digital representation model should be revised as the operational regime develops in order to create a more refined as-operated model.

However, long-term use of the as-built OpEC is the responsibility of an asset's managers. The Soft Landings or GSL aftercare team will merely act in support.

Subsequent information exchanges for the digital representation OpEC in Soft Landings and GSL years 2 and 3 focus on ongoing energy and emissions measurement and verification, as explained in BSRIA *BG54:2014*, to the procedures given in CIBSE *TM63:2020* (Figure 10). Note that while CIBSE *TM54:2013* is notionally an energy assessment tool for use during project design, many of its measurement principles are consistent with the needs of post-occupancy evaluation where energy and emissions are disaggregated by end use. Most Soft Landings and GSL guidance are consistent in their energy and emissions reporting requirements. For example, the RIBA *Plan for Use Guide* requires disaggregated energy data, where possible, for zone-by-zone and/or system-by system analysis of energy use and emissions.

### GSL requirements

Under GSL Stage 5: In-use and Operation, aftercare teams are required to monitor systems to establish actual performance versus theoretical targets. Note that under GSL the only comparison that can be made is the in-use consumption compared with the original design intention. There is nothing stated in GSL Stage 3: Design and Construct and GSL Stage 4: Pre-handover for Soft Landings teams to compare performance as it develops during project delivery. GSL teams therefore need to follow guidance in BSRIA *BG54:2014 The Soft Landings Framework*, similar statements covering performance requirements in BSRIA *BG6:2018*, and the requirements in Stages 4–6 of the *Plan for Use Guide.*

GSL requires a Soft Landings team to use a recognised annual energy assessment and reporting methodology for formal post-occupancy evaluations. Although the CIBSE *TM22:2006 Energy Assessment and Reporting Methodology* may be used, it may not fulfil all of the requirements specified by GSL, *SCIM* and

Net *Zero Public Buildings Standard*. Figure 11 reflects the activities required for the OpEC digital representation at Stages 7b and c. By Stage 7b the energy and emissions OpEC digital representation should ideally have been reduced to a single operational model.

### *SCIM* requirements

The *SCIM* requires a project team to have created an in-use validation energy and emissions model by Information Exchange Gateway 5. This requirement refers project teams to the Achieving Excellence in Design Energy Performance Tool (AEDET), a spreadsheet-based stage sign-off system. However, *SCIM* provides no detail about what is required. AEDET's references to energy also extend no further than a tick-box sign-off (at all stages) that confirm the following: "The engineering systems are energy efficient." Nonetheless, energy monitoring under *SCIM* is required to be conducted according to a project monitoring and evaluation checklist (PME).

### *BS 8536* series requirements

The *BS 8536* series states that emissions may be calculated using the methodology required for the Display Energy Certificate (DEC). Note that calculations for the latter may not be at a sufficiently high level of resolution required by a client. A CIBSE *TM22* assessment can deliver the same information to a high level of detail and calculate both electrical and fossil fuel energy use against defined benchmarks. However, it is not advisable to import one set of values from one assessment and another set of values from a different assessment (particularly when calculation assumptions differ) when a single OpEC method can do both better. This guidance therefore links to a free-to-use CIBSE *TM22*-derived OpEC spreadsheet method, tailored to the specific needs of GSL projects (Section 3). The free-to-use version hosted by CDBB is an initial beta version of the OpEC spreadsheet. It will be refined and updated based on user feedback. Users are free to use the beta version at their own risk.

Changes to the OpEC digital representation need to be reflected, where relevant, in changes to the asset logbook with respect to the inventory of loads, operational parameters and the sub-metering installation (electrical and thermal). As with Information Exchange Gateway Stage 7a, where the *BS 8536* series has been adopted for use by asset managers, operational energy and emissions records will need to be passed through the status gates of the common data environment (CDE) in the project information model (PIM). Once verified, the energy data should be allowed to transition through what is termed a "verified gate" to a "published section" for subsequent use.

# 3. Energy assessment tools

This guidance document suggests two routes to creating an operational energy and carbon digital representation (OpEC). The digital representation(s) need to be progressively refined as details of all energy-consuming systems and their operating requirements emerge during procurement. Two routes – run in parallel where necessary – are suggested:

1. A spreadsheet-based digital representation covering a building or asset's emerging electrical energy demands, with thermal energy requirements calculated within a thermal simulation model and imported into the spreadsheet.

2. An OpEC digital representation constructed wholly within a dynamic simulation model (DSM), thus enabling the joint calculation of energy consumption and carbon dioxide emissions from both thermal and electrical sources of power.

Irrespective of the route (conventional spreadsheet digital representation or dynamic simulation digital representation), an OpEC digital representation is required to possess the following core capabilities for assessment during project delivery (i.e. real-time assessment) and Soft Landings aftercare:

- Accurate representation of energy loads and their usage factors in the proposed asset;
- Real-time calculation of energy costs (based upon known or notional unit costs for electrical energy and fossil fuels);
- Real-time calculation of carbon dioxide emissions (based upon specific or notional carbon factors for power sources);
- Functionality in the digital representation to enable changes (e.g. through client variations, value engineering or equal and approved product substitutions) to be captured during project delivery, and their effects on out-turn energy use and carbon dioxide emissions to be calculated and visualised;
- Preferably, for the digital representation(s) to provide an audit trail;
- Capability for modelling seasonal load factors, primarily at a simple level;
- Capability for the energy loads to inform a project's main metering and sub-metering strategies as energy loads and asset-usage profiles emerge during procurement;
- Capability of being adopted as a post-occupancy energy and carbon assessment tool by asset managers or appointed building performance evaluators.

Both DSM and spreadsheet-based OpEC approaches have their advantages and disadvantages, strengths and weaknesses. Clients may stipulate additional functionality of an energy and carbon digital representation to meet the needs of a specific context. For example, buildings with diverse process loads may require those loads to be treated separately. Similarly, assets powered by onsite renewables or heated and cooled from district mains may require more complex modelling.

Individual clients will be able to determine the optimal approach for their project by full consideration of the following factors:

- The individual project context (its type, size, form of procurement and technical complexity);
- Employers' contractual requirements covering energy and carbon dioxide modelling and reporting, in addition to out-turn performance;
- Skills available within the appointed project team for energy assessment and digital representation computer simulation, and the continuing availability of those skills throughout design and construction, and into initial operation of the asset;

- The budget available for energy and carbon assessments during project delivery, whether conducted in-house or outsourced;
- The level of risk to the project of missed energy targets, post-completion (client specified, and/or certification-dependent, e.g. Passivhaus);
- The availability of operational performance data – and the quality of that data – available to energy modellers during a project in order for them to properly calculate and communicate likely energy-use outcomes;
- The amount and quality of reality-checking and sensitivity analysis carried out during a project (in order for modellers to be able to identify and quantify risks to the energy targets);
- Contractual conditions relating to the intellectual property of energy simulations (either spreadsheet or DSM-based) originated by the professional designers, and the ongoing availability of those simulations during the project and after handover;
- The complexity required of the control logic applied to key energy systems (the greater the complexity of a system's control logic, the more the computational power of a DSM will be needed to model a system's operating characteristics – and thus its likely energy consumption);
- The potential for an energy model to perform realistic "dress rehearsals" on outcome performance. A conventional spreadsheet may be able to digitally represent the likely operating characteristics and energy performance and carbon dioxide emissions for a simple project, whereas complex HVAC systems may possess co-dependencies and intricate operating modes that can only be exposed by modelling performance in a DSM-based digital representation;
- The capabilities of an asset's managers to use a digital representation model as an aid to energy management (as above, a spreadsheet-based digital representation may be more appropriate for projects with rudimentary engineering services, and/or projects with non-professional or irregular asset management);
- Note that the greater the level of detail or resolution required in a DSM, the greater the number of assumptions and the more likely that margins will compound to make a DSM digital representation less rather than more accurate. Compounding of errors is a known drawback in energy simulation.

Clients and their professional advisors need to consider these factors carefully before deciding on a preferred route for an operational energy and carbon digital representation. It is likely to be necessary for clients' requirements to address the factors explicitly. Contract conditions and professional appointments should also clearly define the scope of work required, and also the ultimate ownership of any intellectual property related to energy models and their outputs.

# 4. The OpEC spreadsheet

The following guidance applies to the use of the open-source operational energy and carbon (OpEC) assessment spreadsheet. A beta version of the spreadsheet has been provided, alongside this guidance, to enable project teams to assess the emerging environmental cost of a project through procurement and construction. Note that procurement in this context includes specifying actions by building services contractors and sub-contractors during construction, and therefore beyond RIBA Stage 4, GSL Phase 2 and *BS 8536-2* Stage 4.[2]

The procedures described in this section follow the reporting stages for the various plans of work, project sequences and environmental assessment tools presented in Figure 2. As such, the OpEC spreadsheet and guidance is compatible with the building information modelling (BIM) and dynamic simulation modelling (DSM) information exchanges, as specified by the project plans listed in Figure 2.

The beta OpEC spreadsheet is a manual method for tracking changes that occur to power loads in a building or other constructed asset, over a given timeline. It is based upon the CIBSE *TM22:2006 Energy Assessment and Reporting Methodology,*[3] a spreadsheet tool originally designed for post-occupancy evaluation (POE). The method is also consistent with the energy analysis conventions of CIBSE *TM54:2013 Evaluating Operational Energy Performance of Buildings at the Design Stage.*[4] Design estimations made using the *TM54* approach can be used to populate the spreadsheet. Subsequent changes to installed loads (kW), hours of use or intensity of use (kWh) and cost (p/kWh) during subsequent project stages can be tracked and reported as those changes occur during procurement.

Alterations to loads that emerge over time (such as during procurement or construction) may stem from a required increase in installed capacity and/or an increase in planned hours of operation. Changes may also stem from value engineering decisions. While these may aim to reduce capital costs, they can result in a fall in energy efficiency. The beta OpEC spreadsheet is capable of recording and highlighting the cost and energy implications for each iteration. Conversely, improvements to specifications or reductions in a system's hours of operation will be reported as savings.

The spreadsheet is designed to record iterations and to colour-code each change, or batch of changes, for the purposes of tracking and auditing. The details of this process are described below.

The spreadsheet caters for loads subject to statutory compliance with *Building Regulations* (aka "regulated loads"), as well as loads associated with an asset's business use but not covered by statute (aka "unregulated loads"). Regulated loads usually define fixed installations, such as lighting systems. Unregulated loads cover freestanding equipment connected to electrical sockets (aka "plug-in" loads).

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[2] *BS 8536-2:2016 Briefing for Design and Construction. Code of Practice for Asset Management (Linear and Geographical Infrastructure*). BSI. ISBN 978 0 580 92299 2.

[3] CIBSE *TM22:2006. Energy Assessment and Reporting Methodology*. CIBSE.

[4] CIBSE *TM54:2013 Evaluating Operational Energy Performance of Buildings at the Design Stage*. CIBSE.

## Use on Government Soft Landings projects

The beta OpEC spreadsheet is designed specifically for use on Soft Landings and GSL projects. Although GSL was originally designed for central government clients, it is increasingly being specified in public-sector employers' requirements.

Some commercial clients are specifying GSL even though GSL was not written for non-government procurement. In these instances it will be more appropriate for *BG54:2014 The Soft Landings Framework* to be used, and/or the 2021 RIBA *Plan for Use Guide*. Individual clients may require more detailed procedures, citing various standards and guidance documents. Users of the OpEC spreadsheet therefore need to check that its functionality meets those specific requirements.

Project teams have three main options for performing the calculations:

1. All thermal and electrical energy, carbon and cost calculation iterations run within an energy module of the DSM (a DSM-based OpEC digital representation), using equipment and performance data imported from the BIM inventory. This is most likely for very large or complex projects and those projects adopting the Design for Performance (DfP) process and certification. Although an OpEC spreadsheet may not be required, project teams may opt to duplicate the analysis in the tool for reasons of file size, ease of reporting and ease of graphical representation, particularly when communicating energy, carbon and cost outputs to non-technical project stakeholders.

2. Electrical load data exported from the BIM inventory to an OpEC spreadsheet for iterative analysis, with assessment of thermal loads remaining a DSM function. In effect, the OpEC spreadsheet would be a simplified digital representation. Data bi-directionality would be required to ensure that any changes in the spreadsheet can be exported to update the BIM (and subsequently accessible to the DSM for energy, carbon and cost revisions). This option is likely to be most appropriate for larger projects where modelling in a DSM is performed beyond RIBA Stage 4.

3. All thermal and electrical energy, carbon and cost calculations performed iteratively in spreadsheets external to BIM and DSM. The OpEC spreadsheet would therefore be the project's sole energy digital representation. Where a project uses BIM, data bi-directionality will still be required. An OpEC-based digital representation is more likely to be appropriate for small and/or simple projects, whether involving new-build, retrofit or fit-out.

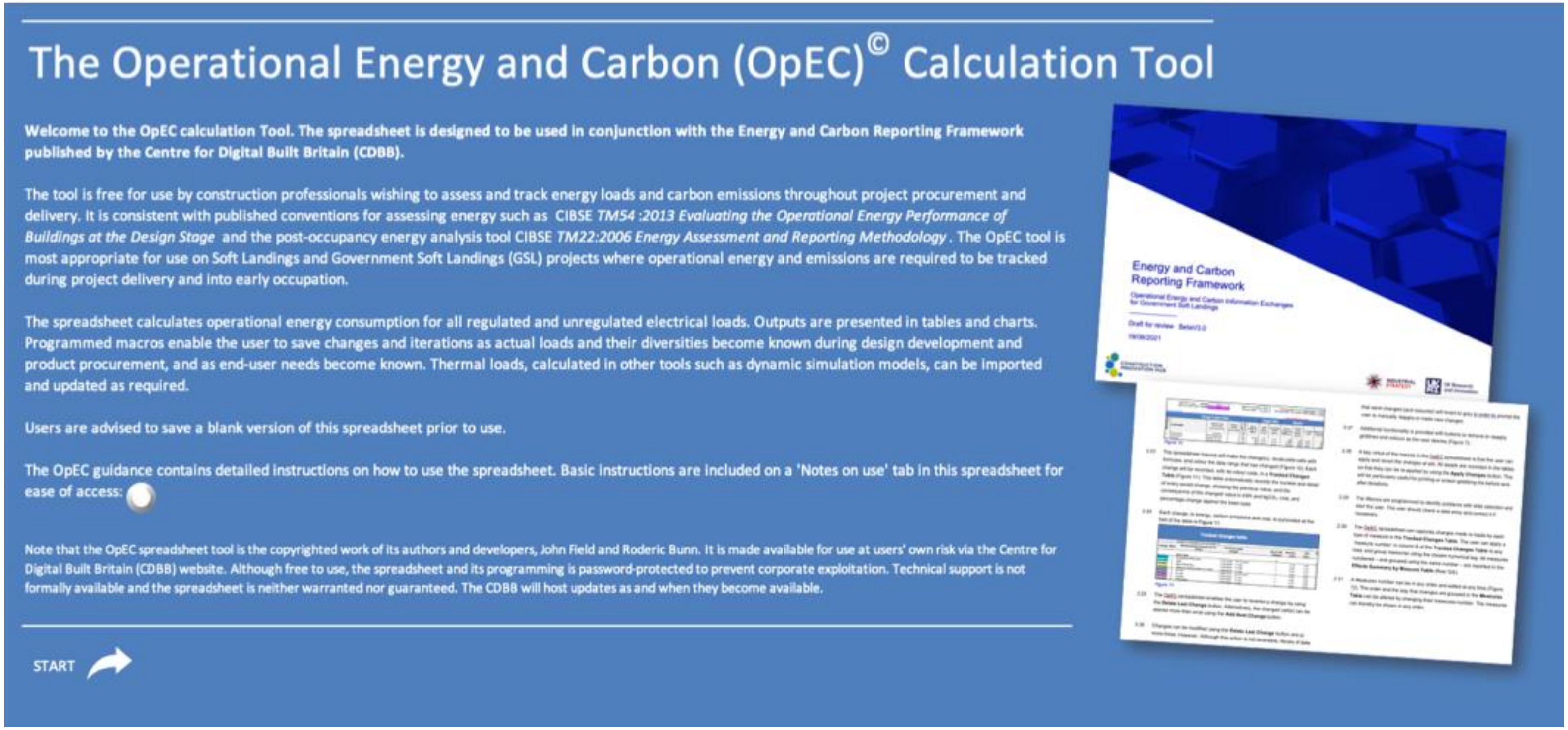
The beta OpEC spreadsheet calculates energy-use iterations using simple Visual Basic macros. Opening the file will present the choice of enabling or disabling macros. You should only do so if you are sure that no harm will come to your computer. Corporate IT departments are usually able to address any concerns. For most users, "enabling macros" will be low or zero risk.

Note that data entry in the beta OpEC spreadsheet presumes some knowledge and experience in how electrical loads tend to operate in practice. Those with some expertise in post-occupancy evaluation will be better able to approximate the load factors for energy end uses. That experience may be biased to particular systems, such as lighting, with less knowledge of other systems, such as refrigeration or vertical transport. Users should always seek help from experts rather than guessing at load factors about which they have little knowledge.

The beta version of the OpEC spreadsheet is free. All cells are unprotected, enabling users to modify or amend the OpEC spreadsheet for their own purposes. Note that the spreadsheet is copyright-protected. It must not be monetised by users, corporately branded or transferred into corporate ownership.

The host may periodically update the beta spreadsheet for reasons of debugging or additional functionality. However, ongoing maintenance or support will not be available. No responsibility for its use is taken or implied.

## How to use the beta OpEC spreadsheet



**Each step on how to use the beta OpEC spreadsheet is numbered for ease of reference**:

1.1 The spreadsheet is consistent with the energy assessment process in *TM54:2013 Evaluating Operational Energy Performance of Buildings at the Design Stage*. Users of the OpEC spreadsheet are recommended to use the procedures in *TM54* for deciding how to apportion electrical loads, and for estimating their load factors and diversities.

1.2 All spreadsheet calculations (and the command buttons for the Visual Basic macros) are contained on a single sheet. All inputs for electrical-loads work require single-line entry of data in the **Energy Loads Table**. No other entries are required for the spreadsheet to calculate a consumption profile for an asset.

1.3 The spreadsheet is designed to enable reconciliation with an asset's annual metered electricity consumption. As consumption data will not be available during design and construction, reconciliation will not be possible until after 12 months of asset operation. However, the relevant cell in the OpEC (Cell E2) can be populated with a design energy calculation, against which modelled electrical consumption can be compared, and as details of the asset's energy profile emerge during procurement.

2 Users are urged to take care about how the design energy calculation is characterised. It is generally imprudent to regard early estimations as hard targets, particularly if unregulated loads are not included in the figure and/or little or no sensitivity analysis has been performed – on both regulated and unregulated loads. On that basis, a figure entered into E2 should be treated as a moving target, with a decreasing degree of approximation in line with prevailing guidance.

For example, BSRIA *BG6:2018 A Design Framework for Building Services* quotes the following increasing levels of precision required by the end of the respective RIBA stages:

- RIBA Stage 2 Concept Design: ±25%
- RIBA Stage 3 Spatial Coordination: ±15%
- RIBA Stage 4 Technical Design: ±5%

The 2020 RIBA *Plan of Work* also includes levels of confidence as the design develops:

- Stage 2 Concept Design: ±75–80%
- Stage 3 Spatial Coordination: ±85–90%
- Stage 4 Technical Design: ±90–95%

The *Plan of Work* confidence levels are broadly the same as the precision figures given in BSRIA *BG6:2018*. The BSRIA guidance notes, however, that estimations for main power, heating and cooling loads calculated in dynamic simulation models may need to be more precise at an early stage of design than a figure of ±25% might suggest.

2.1 The assessment procedures given in CIBSE *TM54* acknowledge that energy modelling is highly context-sensitive. The degree of approximation applied in OpEC input data, and the levels of precision and margins of error decided upon, are therefore a matter of design judgement. Uncertainties would need to be discussed with the client prior to data entry, with notes made in the OpEC spreadsheet "comments" section for the relevant row(s) of data.

## Data entry

2.2 Data entry begins with entering basic details about the building: its name, floor area, unit costs of electricity and notional hours of use (Figure 1). CIBSE *TM54:2013* provides guidance on these input values. As the cells act as look-up values for the energy calculations, the data entries in Figure 1 should be regularly reality-checked.

| | | | | | | | | | Benchmark/Targets | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | kWh/m² p.a. | kgCO2 p.a. |
| **A primary school** | Annual billed (metered) electricity (if known) | 90,000 | kWh | 1,130 | m² TFA | **Energy use kWh/m² p.a.** | 60.21 | m² TFA | 125.0 | 23.75 |
| **Unit cost "in use" (p/kWh)** | 10.05 | | **Hours "in use"/day** | 12.00 | | **Emission factor "in use" ($kgCO_2$/kWh)** | 0.1900 | | | |
| **Unit cost "out of hours" (p/kWh)** | 10.05 | | **Days per week** | 7.00 | | **Emission factor "out of hours" ($kgCO_2$/kWh)** | 0.1900 | | | |

*Figure 1*

2.3 Note that treated floor area (TFA) is a more accurate measure than gross floor area (GFA). Bear in mind that although some spaces, such as plant rooms, may not be heated, they may be electrically lit. Also bear in mind that although buildings such as schools may ostensibly only be used for teaching 40 weeks per year, community use at weekends and during school holidays may increase the hours of operation, particularly for sports facilities and internal areas like changing rooms and showers.

2.4 All known electrical loads (regulated and non-regulated) are entered into rows of the **Energy Loads Table** (D11 to D69). A drop-down list enables loads to be assigned to end uses, such as lighting or refrigeration (Figure 2). The list of end uses is concordant with CIBSE *TM22* and *TM54*. The end-use definitions are also consistent with the requirements of *ISO 12655:2013,* with the refinement that pumps, fans and controls can be disaggregated rather than combined.

2.5 No data entry is required in grey boxes. As greyed cells are not protected, users should be very careful to avoid inadvertent editing.

| Energy Loads Table | | | | | | Usage data | | Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Row item** | **Load type** | **End-use item** *(Select from drop-down menu)* *Drop down* | **Number present (or m² area)** | **Units or floor area** *Drop down* | **Rated Watts (or W/m²)** | **Load factor "in use"** | **Load factor "out of hours"** | **Annual energy use (kWh p.a.)** | **Annual cost of energy (£ p.a.)** | **% of total cost** | **Emissions ($kgCO_2$)** |
| 1 | Passenger lift | Other (Regulated) | 1 | Units | 20,000 | 1.0% | 0.1% | 566 | £57 | 0.8% | 108 |
| 2 | Indesit freezer | Catering (central) | 1 | Units | 600 | 80.0% | 80.0% | 3,064 | £308 | 4.5% | 582 |
| 3 | Tall fridge | Catering (central) | 6 | Units | 400 | 80.0% | 80.0% | 10,322 | £1,037 | 15.2% | 1,961 |
| 59 | | | 0 | | 0.0 | 0.0% | 0.0% | 0 | £0 | 0.0% | 0 |
| 60 | | | 0 | | 0.0 | 0.0% | 0.0% | 0 | £0 | 0.0% | 0 |
| | | | | | | | **Total** | **68,041** | **£6,838** | **100.0%** | **12,928** |
| | | | | | | | Total unfiltered/unhidden | 13,953 | £1,402 | 20.5% | 2,651 |
| | | | | | | | **Metered electricity copied from Cell E2 for reconciliation** | 90,000 | | -24.4% | |

*Figure 2*

2.6 Cells E11 to E69 of the **Energy Loads Table** offer users a choice: to input either the number of energy-consuming items or the floor area over which a given load will operate. This option avoids the need to itemise multiple units, such as light fittings in an open area like a retail floor. Consequently, in cells G11 to G69 a choice must be made to input either the number of units or a design allocation in watts per square metre. Cells F11 to F69 provide a drop-down "note to self" on which a value has been chosen. Figure 3 illustrates how the option can be used for internal lighting: For example, either 10 W/m² (for a 2247 m² treated floor area) or 100 light fittings at 100 W each.

| **End use item** *(select from drop-down menu)* *Drop down* | **Number present (or m² area)** | **Units or floor area** *Drop down* | **Rated Watts (or W/m²)** |
|---|---|---|---|
| Lighting (internal) | 2,247 | m2 | 10.0 |
| Lighting (internal) | 100 | ✓ m2 | 100 |
| | 0 | Units | 0.0 |
| | 0 | | 0.0 |

*Figure 3*

2.7 The **Energy Loads Table** requires the user to estimate in-use load factors and out-of-hours load factors (columns H11 and I11 onwards in Figure 2). Advice on estimating these factors during a design process is given in CIBSE *TM54:2013*.

| Usage time | | | |
|---|---|---|---|
| Hours "in use" per day | Days per week | Weeks per year in-use | Factor for full load |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |
| 12.0 | 5.8 | 40.0 | 1.00 |

*Figure 4*

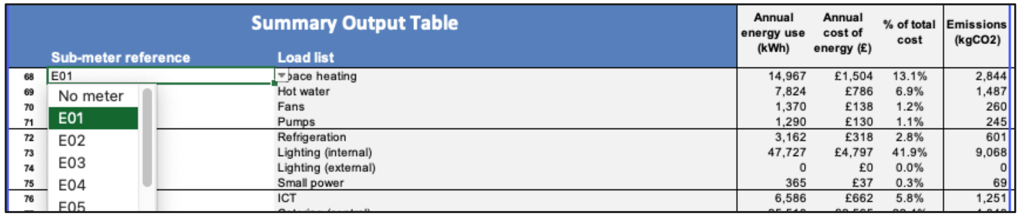
2.8 The user is required to enter the number of weeks per year that an asset will be in operation in the "Usage Time" table, column S (cells S13 onwards - Figure 4) For 12-month operation the default is 52.1 weeks. Some assets may have shorter weeks of operation. The standard occupied hours for schools, for example, is 40 weeks. However, community use of school facilities may mean that some loads, such as sports-hall heating and lighting systems, operate for longer. The spreadsheet gives the user the freedom to cater for extended hours of use by applying specific run-times to each load. (Note that early consideration of run-times for specific zones may inform a sub-metering strategy.)

2.9 The user needs to enter values for "factor for full load" in the **Usage Time Table** as in Figure 4. Guidance on load factors is given in CIBSE *TM54:2013*. Once values have been entered, the spreadsheet will calculate the power demand and running costs, reporting the values in greyed cells.

2.10 Extra rows can be added in the **Energy Loads Table**. However, additional rows must be added between D76 and D89, and not after D89. This rule ensures that macro functionality is preserved. Depending on the project, it may be appropriate to add additional end uses such as "servers" or "fume cupboards". However, an expanded list of end-use profiles may make the energy modelling process unnecessarily detailed. Judicious use of the "other" category may be appropriate for most projects, at least until it is found that loads characterised as "other" begin to vary in their load profiles. At that point the "other" loads could be disaggregated into sensible sub-categories. For example, it may be desirable to separate out "other" into "regulated other" and "non-regulated other" to avoid mixing two types of load. Similarly, it may be appropriate to disaggregate ICT loads into "central" and "distributed". Such decisions are best made on a project-by-project basis.

2.11 The beta OpEC spreadsheet makes no specific allowances for winter and summer operation. For simplicity, the energy use assessment presumes an equal division between heating and cooling seasons. However, users could choose to factor in seasonal variations in their energy-use estimates.

2.12 The characteristics of loads assigned to the end-use profiles backfill to a **Summary Output Table (**Figure 5). This table summates annual electrical energy consumption for each end use (cells D76 to D89) from the data entered in the **Energy Loads Table**. No data entry is required for the summary table. Note that Figure 5 shows the drop-down menu for allocating sub-metering references (EO1, EO2, etc.), which are discussed in Paragraph 1.18.



| | Sub-meter reference | Load list | Annual energy use (kWh) | Annual cost of energy (£) | % of total cost | Emissions (kgCO2) |
|---|---|---|---|---|---|---|
| 68 | E01 | Space heating | 14,967 | £1,504 | 13.1% | 2,844 |
| 69 | No meter | Hot water | 7,824 | £786 | 6.9% | 1,487 |
| 70 | | Fans | 1,370 | £138 | 1.2% | 260 |
| 71 | E01 | Pumps | 1,290 | £130 | 1.1% | 245 |
| 72 | E02 | Refrigeration | 3,162 | £318 | 2.8% | 601 |
| 73 | | Lighting (internal) | 47,727 | £4,797 | 41.9% | 9,068 |
| 74 | E03 | Lighting (external) | 0 | £0 | 0.0% | 0 |
| 75 | E04 | Small power | 365 | £37 | 0.3% | 69 |
| 76 | E05 | ICT | 6,586 | £662 | 5.8% | 1,251 |

*Figure 5*

2.13 The **Summary Output Table** does not require association of loads to sub-meters; nor does it require reconciliation of loads with sub-metered data. However, users can opt to associate loads with a drop-down list of 15-meter references in the **Summary Output Table** (rows C77 to C91).

2.14 Loads attached to the individual sub-meters in the **Summary Output Table** generate data for a **Sub-Meter Report** on a separate tab: **Sub-Meter Report (Optional)**. This table enables a user to see how loads are building for sub-meters, particularly when multiple loads are assigned to one meter (Figure 6). The table calculates annual energy use, annual energy cost and the percentage of the total cost, meter by meter. In a design context this may be useful for informing a metering strategy, such as allocating meters to specific zones for billing purposes. In a post-occupancy evaluation context, calculated loads can be compared with metered consumption to quickly identify whether sub-metered consumption matches data gathered from a field survey. The data from the **Sub-Meter Report** automatically populates graphs on the **Output Charts** tab.

2.15 Users may add additional rows in the **Summary Output Table** between C77 and C91 for associating a given load with a given zone, such as "Lighting: Sports Hall", and for allocating a new meter to that load. An additional 15 meters are included in the drop-down list for this purpose. The **Sub-Meter Report** table will need to be expanded beyond the 15 meters provided. Note that users need to assure themselves that the spreadsheet's formulas still function as rows are added. Rows must be inserted between C77 and C91 in the **Summary Output Table,** and not added.

**Sub-meter Report** A

*Do not adjust grey boxes*

| Sub meter allocation | Annual energy use (kWh) | Annual cost of energy (£) | % of total cost | Location (optional) | Meter type (optional) |
|---|---|---|---|---|---|
| **E01** | 0 | £0 | 0.0% | | |
| **E02** | 2,004 | £241 | 6.3% | | |
| **E03** | 334 | £40 | 1.1% | | |
| **E04** | 376 | £45 | 1.2% | | |

*Figure 6*

2.16 Note that for a wide variety of reasons a building's sub-meters often fail to reconcile with field survey data, fiscal meter readings and data recorded by building management systems. The reasons for this are listed in the **Sub-Metering Problems** tab**.**

2.17 Once data entry rows have been completed, the OpEC spreadsheet will calculate the asset's operational energy. The annual kilowatt hours, energy costs and the percentage contribution of each electrical load are shown in columns J, K and L. Columns O to R will tabulate the **Usage Time** of each load, while columns T to Y will tabulate the **Power Demand**, including total watts at full load, full load hours per year, average power demand in summer and winter, and out-of-hours average demand in summer and winter. The tables show the breakdown by individual load and the totals.

## Tracking changes

2.18 Once all loads have been entered into the **Energy Loads Table**, users can begin to use the change functionality programmed into the spreadsheet. Programmed macros enable users to make changes to any numeric value associated with an energy-consuming load using the macro buttons at the top of the sheet (Figure 7). The buttons must be used with all numerical changes for the spreadsheet to record the change properly.


*Figure 7*

2.19 As each load is entered into the **Energy Loads Table**, the entries populate charts on the **Output Charts** tab. Charts are automatically created for kwh/m$^2$ p.a., kg$CO_2$/m$^2$ p.a. and £cost of energy per annum (Figure 8). The **Output Charts** Tab also captures each tracked change in line graphs showing incremental improvements over the base case.

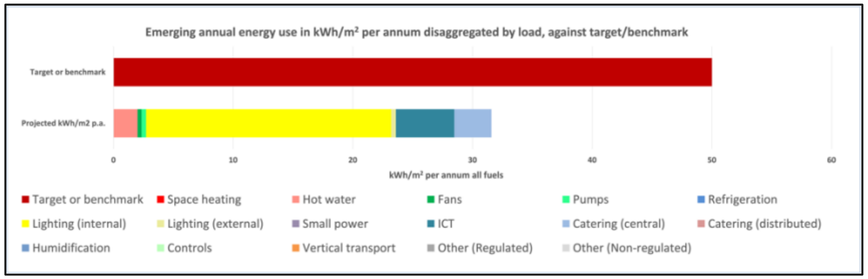



*Figure 8*

2.20 The OpEC spreadsheet does not have unlimited capacity for recorded changes. Users are therefore advised only to make changes to the loads when there is a clear and definite reason for doing so. The design expectations will change as approximations for usage factors tighten, particularly as specifications mature into installed systems and actual products sourced by the contractors. Similarly, power loadings may change as a contractor sources "equal and approved" alternatives, and as value engineering decisions lead to a change in equipment ratings and/or load factors, leading to a notional rise or fall in operational energy use. Changes in proposed hours of use will have a similar effect. The OpEC spreadsheet enables the user to periodically revisit, reality-check and update power ratings and usage factors, and for iterations to be recorded.

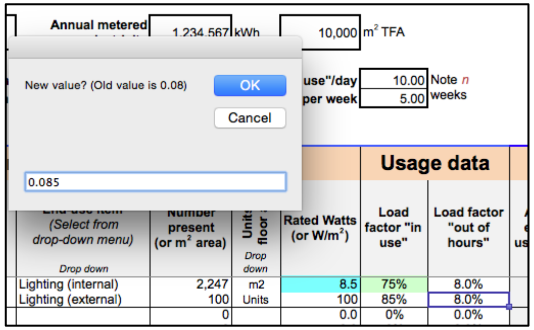



*Figure 9*

2.21 Toggle functions (Figure 7) enable users to store a single change (or a batch of changes) by clicking "**Add Next Change using your selected range"**, and then to highlight one cell – or a range of cells – in a column and enter the changed value, say from 90% "out-of-hours load factor" (0.9) to 70% (0.7). The act of making the change is saved in the spreadsheet and the change(s) highlighted as a random colour (Figure 8). A batch of changes might be a block of identical numeric entries, such as four load factors of 90% altered to 70%. Alternatively, a change might be to the entries for electricity unit cost, once an energy supply tariff is known (or changed to another). The **Add Next Change** toggle will save individual changes.

2.22 When changing a value using the **Add Next Change** macro, the spreadsheet will identify the old value and prompt for a replacement. Note that for changes to percentage values, the data must be entered as 0.085 for 8.5% (with no commas), as in Figure 9. Unit cost values are changed in the same manner (Figure 10).

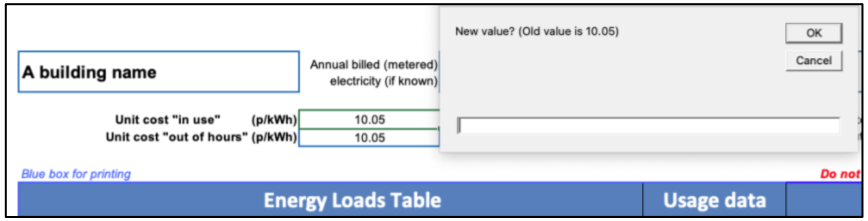



*Figure 10*

Unit cost "in use" (p/kWh) 10.05 | Hours "in use"/day 12.00 | Emission factor "in use" ($kgCO_2$/kWh) 0.1900

Unit cost "out of hours" (p/kWh) 9.25 | Days per week 7.00 | Emission factor "out of hours" ($kgCO_2$/kWh) 0.1900

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| Energy Loads Table | | | | | | Usage data | | Results | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Row item | Load type | End-use item (Select from drop-down menu) Drop down | Number present (or $m^2$ area) | Units or floor area Drop down | Rated Watts (or $W/m^2$) | Load factor "in use" | Load factor "out of hours" | Annual energy use (kWh p.a.) | Annual cost of energy (£ p.a.) | % of total cost | Emission ($kgCO_2$) |
| 1 | Passenger lift | Other (Regulated) | 1 | Units | 20,000 | 1.0% | 0.1% | 566 | £56 | 0.5% | 10 |
| 2 | Indesit freezer | Catering (central) | 1 | Units | 600 | 80.0% | 80.0% | 3,064 | £296 | 2.6% | 58 |
| 3 | Tall fridge | Catering (central) | 6 | Units | 400 | 80.0% | 80.0% | 10,322 | £996 | 8.8% | 1,96 |

*Figure 11*

2.23 The spreadsheet macros will make the change(s), recalculate cells with formulas and colour the data range that has changed (Figure 11). Each change will be recorded, with its colour code, in a **Tracked Changes Table** (Figure 12). This table automatically records the number and detail of every saved change, showing the previous value, and the consequence of the changed value in kWh and $kgCO_2$, cost and percentage change against the base-case.

2.24 Each change, in energy, carbon emissions and cost, is summated at the foot of the table in Figure 12.

**Tracked Changes table**

*Number of Changes in the list below: 7*

| Change | Mea-sure* | IItems(s) being changed (can be edited) | Parameter being changed | No.of cells changed | Previous value | New Value |
|---|---|---|---|---|---|---|
| | | **Base Case** | | **0** | | |
| ChangeA | 1 | Hall lighting | Rated Watts (or W/m2) | 1 | 35.00 | 26.00 |
| ChangeB | 1 | Classroom main lighting | Rated Watts (or W/m2) | 1 | 11.50 | 8.10 |
| ChangeC | 3 | Classroom main lighting | Load factor "in use" | 3 | 0.80 | 0.65 |
| ChangeD | 2 | Classroom displays | Rated Watts (or W/m2) | 1 | 60.00 | 150.00 |
| ChangeE | 2 | Network hub cabinet | Rated Watts (or W/m2) | 1 | 120.00 | 250.00 |
| ChangeF | 3 | Servery | Load factor "out of hours" | 1 | 0.12 | 0.00 |
| ChangeG | 4 | General change | Days per week | 1 | 5.40 | 5.80 |

*Figure 12*

2.25 The OpEC spreadsheet enables the user to reverse a change by using the **Delete Last Change** button. Alternatively, the changed cell(s) can be altered more than once using the **Add Next Change** button.

2.26 Changes can be modified using the **Delete Last Change** button one or more times. However, although this action is not reversible, blocks of data that were changed (and coloured) will revert to grey in order to prompt the user to manually reapply or make new changes.

2.27 If, after tracked changes have been made to the final list of loads, a user discovers that an original load entry was entered inaccurately or a value was missed out (such as its hours of use or load factor), the user must first correct the value then use the **Revert Changes to Base Case** button followed immediately by the **Apply Changes** button (Figure 7). This will ensure the spreadsheet handles the missing or wrongly entered data correctly. Do not treat an error correction as a tracked change.

2.28 Additional functionality is provided with buttons to remove or reapply gridlines and colours as the user desires (Figure 7).

2.29 A key virtue of the macros in the OpEC spreadsheet is that the user can apply and revert the changes at will. All details are recorded in the tables so that they can be reapplied using the **Apply Changes** button. This will be particularly useful for printing or screen-grabbing the before-and-after iterations.

2.30 The macros are programmed to identify problems with data selection and alert the user. The user should check a data entry and correct it if necessary.

2.31 The OpEC spreadsheet can capture changes made to loads by each type of measure in the **Tracked Changes Table**. The user can apply a "measure number" in column B of the **Tracked Changes Table** to any load, in addition to group measures using the chosen numerical tag. All measures numbered – and grouped using the same number – are reported in the **Effects Summary by Measure Table** (Row 124).

2.32 A measures number can be in any order and edited at any time (Figure 13). The order and the way that changes are grouped in the **Measures Table** can be altered by changing their measures number. The measures can thereby be shown in any order.

| Mea-ure* | Summary of the effect of the Changes specified above, grouped by Measure | | Changes included | kWh | Cost (£) | Percent | kgCO |
|---|---|---|---|---|---|---|---|
| 1 | Classroom and hall relamping | Rated Watts (or W/m2) | AB | -3,818 | -458 | -10.8% | -72 |
| 2 | Classroom display upgrades and associated network hub cabinet expansion | | DE | 2,299 | 276 | 6.5% | 43 |
| 3 | Operational changes to classroom lighting and servery equipment | | CF | -3,760 | -451 | -10.7% | -71 |
| 4 | Extended weekend use | Days per week | G | 1,561 | 187 | 4.4% | 29 |
| 5 | - | - | | 0 | 0 | 0.0% | |
| 6 | - | - | | 0 | 0 | 0.0% | |
| 7 | - | - | | 0 | 0 | 0.0% | |
| 8 | - | - | | 0 | 0 | 0.0% | |
| 9 | - | - | | 0 | 0 | 0.0% | |
| | | | **Totals** | **-3,717** | **-£446** | **-10.5%** | **-70** |

*Figure 13*

A minor limitation of the spreadsheet is that the **Summary Table** in Figure 13 will itemise changes under the heading of the first change recorded for a series of changes that are subsequently grouped. The user is free to overwrite the entries in cells C128 to C136 with their own descriptors, as shown in Figure 13. The user is aided by a record of the grouped changes in column I128 to I136 under the heading "Changes Included". The user can track back to the **Tracked Changes Table** using the alphabetic references.

## Creating a new energy spreadsheet

2.33 The user of the beta OpEC spreadsheet can revert to a blank spreadsheet by deleting all changes through successive use of the **Delete Last Change** button. The **Tracked Changes Table** will report a "base case" (i.e. no changes) and display a zero number of changes. The user will also need to delete data in the **Energy Loads Table** (but not in the **Summary Output Table**). The user should check that no extraneous data is retained in the "units" cells, "hours per day" and "week" cells. However, it far better than the user stores a clean, unused version of the OpEC spreadsheet.

2.34 The CDBB website holds two versions of the beta OpEC spreadsheet: a blank version and a simple exemplar version based upon a hypothetical primary school. Users are recommended to study the exemplar version carefully before entering data into the blank version.

# 5. Glossary

**AEDET** Achieving Excellence in Design Energy Performance Tool

**BIM** Building information modelling

**BREEAM** Building Research Establishment Environmental Assessment Method

**BRUKL** Building Regulations UK Part L

**CDBB** Centre for Digital Built Britain

**CIBSE** Chartered Institution of Building Services Engineers

**Data drop** Points at which data is aggregated or assembled for reporting purposes, for example, into a building information model (BIM), as a deliverable for consideration at a project gateway. The term "information exchange" is also used

**DfP** Design for Performance. This initiative, fronted by the Better Buildings Partnership with certification by the BRE, is the UK version of the National Australian Building Environmental Rating Scheme (NABERS), otherwise known as NABERS UK. It is a voluntary energy-efficiency rating scheme for accurate assessment of base-building energy requirements of commercial offices (www.betterbuildingspartnership.co.uk/our-priorities/design-performance)

**Diversities** A level of variability in equipment energy use and emissions as details become known and refined. Diversities are estimated (to increasing levels of accuracy) from known specification details, power efficiencies, operating parameters and subsequent patterns of asset use

**DSM** Dynamic simulation modelling

**GSL** Government Soft Landings

**Magnitude** Magnitude factors are those that multiply energy use and the consequent emissions. Typical factors that may raise energy use by orders of magnitude include higher-system operating hours (particularly outside normal operating parameters), higher fabric air-leakage than assumed at design, and poor control that leads to wasteful operation

**NDAP** NHS Scotland Design Assessment Process

**NDEP** National Digital Engagement Programme

**OpEC** Operational energy and carbon

**Pitstopping** A BSRIA methodology for risk assessment of a small number of asset items that are crucial to outcome performance. See BSRIA publication BG27:2011

**RIBA** Royal Institute of British Architects

**SCIM** Scottish Capital Investment Manual

**UBT** Usable Buildings Trust

# 6. Selected bibliography

**The following guidance documents will assist clients and project teams in applying Soft Landings and Government Soft Landings, and in setting the assessment requirements for monitoring the emerging operational energy consumption and emissions.**


BSRIA *BG6:2018 A Design Framework for Building Services.* ISBN 978-0-86022-762-5. Available from wwww.bsria.co.uk/bookshop

BSRIA *BG27/2011 Pitstopping – BSRIA's Reality-Checking Process for Soft Landings.* ISBN 978-0-8602-693-2. Available from www.bsria.co.uk/bookshop

BSRIA *BG45/2013 How to Procure Soft Landings*. ISBN 978-0-86022-719-9. Available from www.bsria.co.uk/bookshop. (Contains generic clauses for client requirements, with examples for the targeting, monitoring and measurement of operational energy and emissions.)

BSRIA/UBT *BG54/2014 The Soft Landings Framework*. ISBN 978-0-86022-730-4. Available as a free download from www.usablebuildings.co.uk

BSRIA *BG54/2018 The Soft Landings Framework*. ISBN 978-0-86022-76-4-9. (Referenced specifically for its separated design and construction requirements.) Available from www.bsria.co.uk/bookshop

BSRIA *BG61/2015 Soft Landings and Government Soft Landings.* ISBN 978-086022-745-8. Available from www.bsria.co.uk/bookshop

*BS 8536-2:2016 Briefing for Design and Construction – Code of Practice for Asset Management.* Available from https://shop.bsigroup.com/

*BS EN ISO 19650-2: 2018 Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) – Information management using building information modelling.* Available from https://shop.bsigroup.com/

CIBSE *TM54:2013 Evaluating the Operational Energy Performance of Buildings at the Design Stage*. ISBN 978-1-906846-38-1. Available from https://www.cibse.org/knowledge/knowledge-items

CIBSE *TM63:2020 Building Performance Modelling and Calibration for Evaluating Energy Performance In-Use.* ISBN 9781912034765. Available from https://www.cibse.org/knowledge/knowledge-items

*Government Soft Landings – Revised guidance for the public sector on applying BS8536 parts 1 and 2.* DOI: https://doi.org/10.17863/CAM.45315 Available from www.cdbb.cam.ac.uk/BIM/government-soft-landings

*Net Zero Public Sector Buildings Standard.* Scottish Futures Trust, March 2021. Available from www.scottishfuturestrust.org.uk

RIBA *Plan for Use Guide* (2021). Available as a free download from www.architecture.com/-/media/GatherContent/Plan-for-Use-guide/Additional-documents/Plan-for-Use-Guide-2021.pdf

The Construction Innovation Hub is funded by UK Research and Innovation through the Industrial Strategy Challenge Fund

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