Designing for Impact

Enhancing Building Performance
Through Early-Stage Analysis

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Introduction

As the global climate crisis intensifies, the performance of buildings has become a critical focus in efforts to reduce carbon emissions. The built environment currently accounts for 37% of global carbon emissions, making it one of the highest emitting sectors. Enhancing the efficiency and overall performance of buildings is therefore essential to meeting climate targets and creating a more sustainable future.

Against this backdrop, architects are having to adapt their design processes as they rise to the challenge of zero carbon buildings. Thousands of firms have committed to ambitious zero carbon pledges such as the AIA 2030 Commitment and RIBA 2030 Climate Challenge. However, to deliver on these, they need to embed building performance evaluation throughout every stage of their design workflows, from pre-design through to operation. They must continuously track progress and assess the impact that design decisions will ultimately have on a building's energy performance and whole-life carbon output.

IES and Chaos, respective leaders in building performance simulation and visualization technologies, have joined forces to highlight the significance of early-stage analysis in optimizing building performance across the lifecycle of any building. This whitepaper explores the importance of incorporating energy modeling from the earliest design phases, as part of a whole-life building performance approach, to ensure buildings meet high performance and efficiency standards throughout their lifecycle. This is a key step in delivering spaces which are better for the environment and for the people who use them.

Delivering spaces which are better for the environment and for the people who use them.

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The Challenge

Buildings contribute significantly to global carbon emissions across their lifecycle. While optimizing the whole-life performance of a building is a continuous process, which involves many different stakeholders, identifying ways to mitigate these emissions early in the building lifecycle is a vital first step in delivering buildings which are more energy efficient, low-carbon, comfortable and cost-efficient to operate.

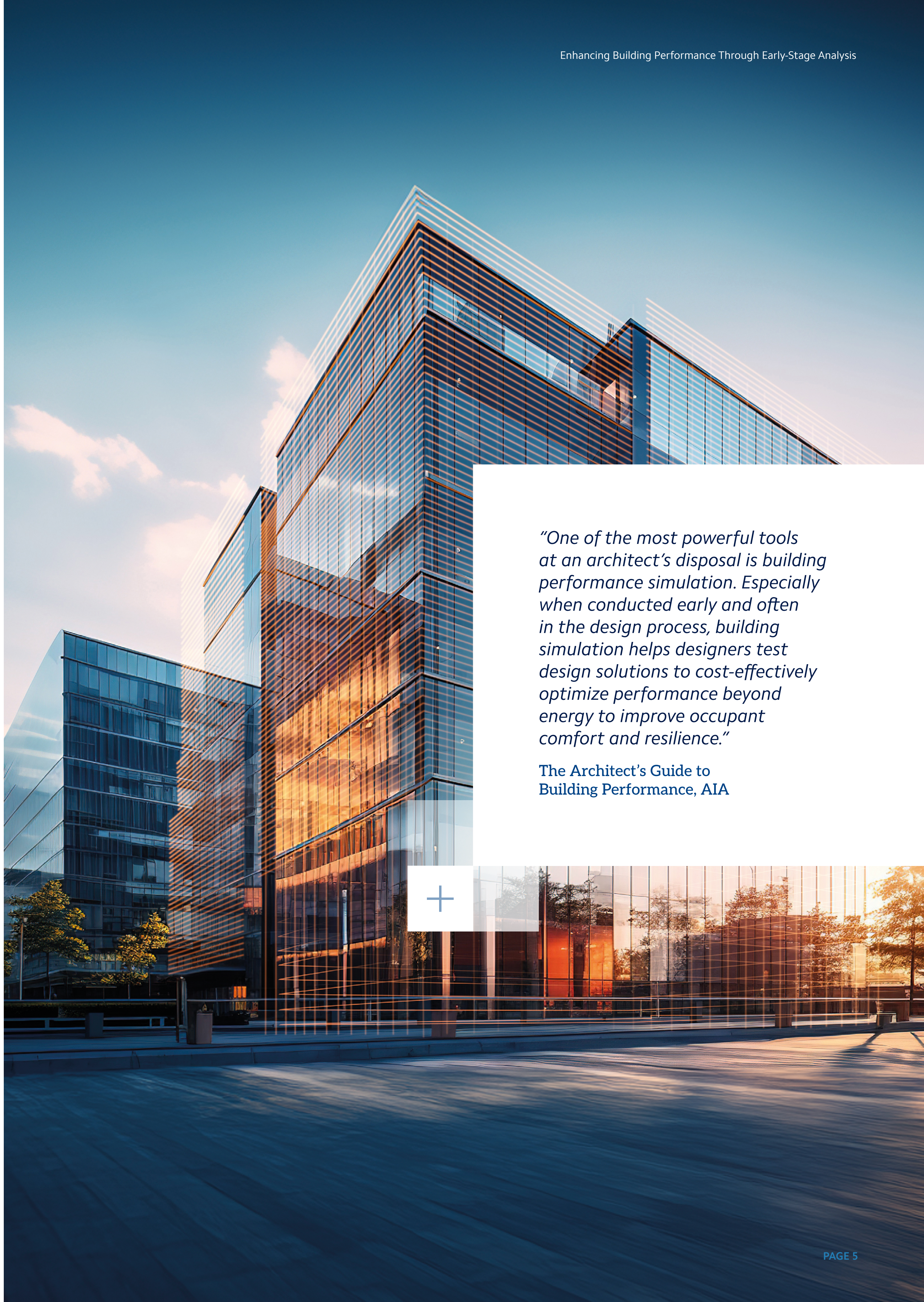
This is because decisions made during the early design stage – everything from site selection and building orientation, down to the lighting strategy and materials used – have profound implications on a building's overall energy use and carbon impact. It is therefore important that architects and design teams consider these factors early on to more accurately predict and enhance how a building will perform across its lifetime.

Building performance simulation tools have existed within the industry for some time, providing much needed insights into how different design decisions will ultimately impact the final operation and whole-life carbon impact of a building. However, traditionally such tools have remained in the hands of specialists, meaning crucial opportunities for optimization are often missed during early concept design.

This has resulted in a fragmented approach to sustainability when it comes to buildings. And while many projects focus on sustainability during the documentation and construction phases (in terms of reducing waste, using sustainable materials and ensuring speedy delivery), further education is required to ensure the impact on the final operation of the building is also given full consideration during early design iterations.

Fortunately, awareness of the issue is growing within the AEC sector, and many professional bodies, green rating systems, codes and voluntary standards are now advocating for the integration of energy modeling early, and throughout the design process. The American Institute of Architects (AIA) argues that "building performance simulation is no longer just a good idea for some architectural practices; it is an essential part of building design and delivery." However, in spite of this growing recognition, it is still reported that only 41% of AIA members currently use building performance simulation to improve the energy performance of their designs.

That isn't to say that the industry is not taking strides in the right direction. Guidance, such as AIA's Architect's Guide to Building Performance, has been developed to help architects and design teams better integrate building performance simulation into their design processes. Meanwhile in the UK, the Royal Institute of British Architects (RIBA) present their own set of recommendations, including their Sustainable Outcomes Guide, which outlines key performance metrics and design principles for architects and project teams to follow, clarifying the absolute targets for a sustainable future. However, the industry still has a way to go to fully embed these practices.



"One of the most powerful tools at an architect's disposal is building performance simulation. Especially when conducted early and often in the design process, building simulation helps designers test design solutions to cost-effectively optimize performance beyond energy to improve occupant comfort and resilience."

The Architect's Guide to Building Performance, AIA

Understanding the Performance Gap

> *"An outcomes-based design approach will help resolve the now well-known gaps between design intent and in-use performance across a range of metrics by reinforcing the feedback loop between briefing and outcomes, leading to a more sustainable built environment."*
>
> Sustainable Outcomes Guide, RIBA

In most countries, building energy design is driven by a need to meet minimum regulatory standards or codes. Compliance modeling uses thermal energy models to calculate the energy consumption of a building under standardized operating conditions. However, there are often significant discrepancies between compliance predictions and the actual measured consumption of buildings in operation – a phenomenon known as the performance gap.

While the performance gap can vary significantly from project to project, some studies have indicated that in-use consumption can be as much as 2 – 5 times higher than compliance predictions would suggest. Reducing the performance gap is therefore critical if high-performance, zero carbon and net-zero energy buildings are to become the standard.

There are two main reasons why the performance gap occurs. The first is that many code compliance and regulatory standard calculations do not take account of all energy uses in a building, meaning many unregulated loads. For example, IT equipment and other small power, escalators and external lighting, can be overlooked. However, this energy use can be substantial. In some building types, unregulated loads have been shown to account for as much as 50% of total energy use.

Secondly, issues relating to how the building is commissioned and operated can further lead to discrepancies between design stage energy predictions and operational energy use. In many cases, the building in operation is controlled for comfort and changes are made that go against the design intent of the building. For example, set-point temperatures may be increased to react to occupant comfort needs. This of course will take the building further away from its original design intent.

It is for these reasons that building owners must be made aware that minimum compliance standards will not achieve sustainable outcomes and efficient buildings in operation, and that compliance metrics can never be taken as operational targets, or as a true measure of how their building will ultimately perform.

Adopting an outcomes-based design approach, which includes early-stage building performance analysis, can reduce the performance gap by allowing for more accurate energy use and performance predictions to be made. Design teams should work with their clients to include more realistic operational schedules and assumptions into their designs, alongside any unregulated loads.

Of course, for the approach to be fully successful, it is important that in-use or post-occupancy evaluations are also conducted once the building is operational. In many cases, this can be achieved by reutilizing the initial design model, and calibrating this with live data from the building in use, to create a digital twin for ongoing performance tracking and analysis, thus helping to close the gap as part of a whole-life performance approach.

Barriers to Adoption

There are several barriers currently preventing more widespread adoption of building performance simulation in the early design stages.

Despite the recognized potential for increased energy efficiency and other performance gains, the process remains fragmented, with various stakeholders – i.e. architects, engineers, contractors, and building operators – focusing on separate parts of the building lifecycle. This disjointed approach threatens the industry's collective progress towards net-zero targets, as each phase of the lifecycle is often treated in isolation rather than as part of an interconnected whole.

One of the key challenges is when clients take a short-sighted view on sustainability. Often, focus will turn to minimizing capital expenditure and up-front costs, rather than considering the long-term operational benefits and savings which can be achieved over time. This narrow perspective can ultimately prevent a building from achieving its full net-zero potential and result in decisions which may not truly be in the best interests of the building owner, or the environment.

Two further challenges to adopting building performance simulation are cost and time. Traditionally, the process has required specialized knowledge and software which can take time to both learn and to run the analysis itself. This makes the process out of reach for many designers and building projects. In some cases, even if specialist advice is sought, many of the key design decisions will have already been made prior to the analysis being completed, limiting the value of any insights gained and, making it difficult to implement the findings.

Further education is needed to help both design teams and their clients to fully understand the value proposition of embedding building performance analysis from the early stages, and throughout, the building lifecycle. By building a robust business case for sustainability, stakeholders can better appreciate the long-term financial and environmental benefits of energy-efficient designs.

Moreover, the lack of integration between the various tools used by different stakeholders exacerbates the problem. Design teams, contractors, and facilities teams often use disparate tools and systems throughout the building lifecycle, resulting in silos of information and inefficiencies. However, advancements in technology and enhanced interoperability between tools is helping to foster improved collaboration across project teams. This includes emerging tools and platforms, such as **Enscape Impact**, which make it easier and more accessible to adopt a unified approach to building performance simulation.

Benefits of Early-Stage Analysis

Incorporating building performance analysis early in the design process offers numerous benefits, on both the client and practitioner side.

These can include:

Reduced Effort and Cost

Early analysis reduces the need for costly interventions later in the project lifecycle. This means that building performance simulation often pays for itself both in terms of reducing upfront capital costs – for example, by reducing instances of expensive, oversized equipment – as well as lowering operational energy costs over the lifetime of the building.

Fewer Modeling Iterations

Streamlining collaboration between architectural and engineering teams leads to quicker and more efficient design processes, saving considerable time and effort across the design team.

Closing the Performance Gap

Accurate early predictions help in designing buildings that meet performance expectations, and should be used in conjunction with robust post-occupancy evaluations and measurement and verification (M&V) to ensure that the design intent is met in operation.

Higher-Performing Buildings

Optimized buildings are not only better for the environment but also more efficient, comfortable, and cost-effective to operate. When utilized correctly, building performance simulation can help to balance the necessary trade-offs between optimizing a building's energy and carbon performance, against the needs and comfort of occupants.

The industry is making strides to realize these benefits, leveraging building performance simulation to balance energy efficiency with occupant comfort. The collaboration between Chaos and IES exemplifies how technology can enhance design practices, ensuring buildings meet sustainability goals from the outset.

"By adopting sustainable practices at all stages of the life cycle, we can reduce our reliance on finite resources, generate positive and restorative impact, and improve quality of life for people in all stages of the value chain."

Beyond the Business Case, World Green Building Council

The Approach in Action

Monklands Hospital

The new, state-of-the-art University Hospital Monklands is the first hospital in Scotland to be designed from the outset to be fully Net Zero for both the build and operation phases. The project followed the Dynamic Simulation Guide developed by IES Consultants as part of the Net Zero Public Sector Buildings (NZPSB) Standard, and presents a significant step forward in terms of modeling detail at early-stage design and stakeholder collaboration; measures necessary to support accurate predictions of net zero carbon operation and in-use verification. Dynamic simulation involves the entire project team, so everyone involved in the design, construction and management of the building inputs knowledge into the building model, not just the mechanical engineers.

IES supported NHS Lanarkshire's design team to provide complete operational energy and Indoor Environmental Quality (IEQ) modeling at the Outline Business Case stage. Typically, full building analysis wouldn't be considered until the Full Business Case has been proven, essentially at the Technical Design Stage (RIBA Stage 4). However, for this project, IES consultants were able to use performance modeling prior to the Outline Business Case, utilizing the Dynamic Simulation guide as the template. The modeling was designated the 'critical path' to support operational energy and Net Zero reporting. The findings placed the design team in a proactive position towards a successful project and verified the decision to commence detailed modeling at an early stage.

University of Glasgow

IES have been working in partnership with the University of Glasgow since 2015, using their digital twin technology to improve building performance across the campus and support the university's net-zero by 2030 target.

In 2019, they embarked on a collaboration with the university, HLM Architects and Sciencescope, through the Innovate UK funded R&D project, eDigit2Life. The project succeeded in evolving basic compliance models of a number of the campus buildings into operational/live digital twins to help close the performance gap and optimize the whole-life performance of some of the university's most intensely used student buildings. This involved developing design stage dynamic simulation models of the buildings and calibrating them with real operational data from the building management systems (BMS).

One of the key findings was the need for ensuring operational performance is considered at the very beginning of the new building or building renovation project conception. It was confirmed that early energy and compliance analysis during initial concept design, and starting the fit-out design during technical design development, can inform better system sizing and greatly reduce the performance gap between design intent and actual operation. In using the early-stage design models to create performance digital twins of the final buildings in use, operational performance can be monitored on an ongoing basis to ensure the design intent of the buildings is met.

The project developed a proposed methodology, aligned to the RIBA Plan of Work *(outlined in Figure 1)* to ensure that operational efficiency is considered during all stages of the building lifecycle. Interoperability between tools and technologies and improved stakeholder collaboration throughout the process, from the very initial pre-design conversations, were noted as key requirements to achieving these goals.

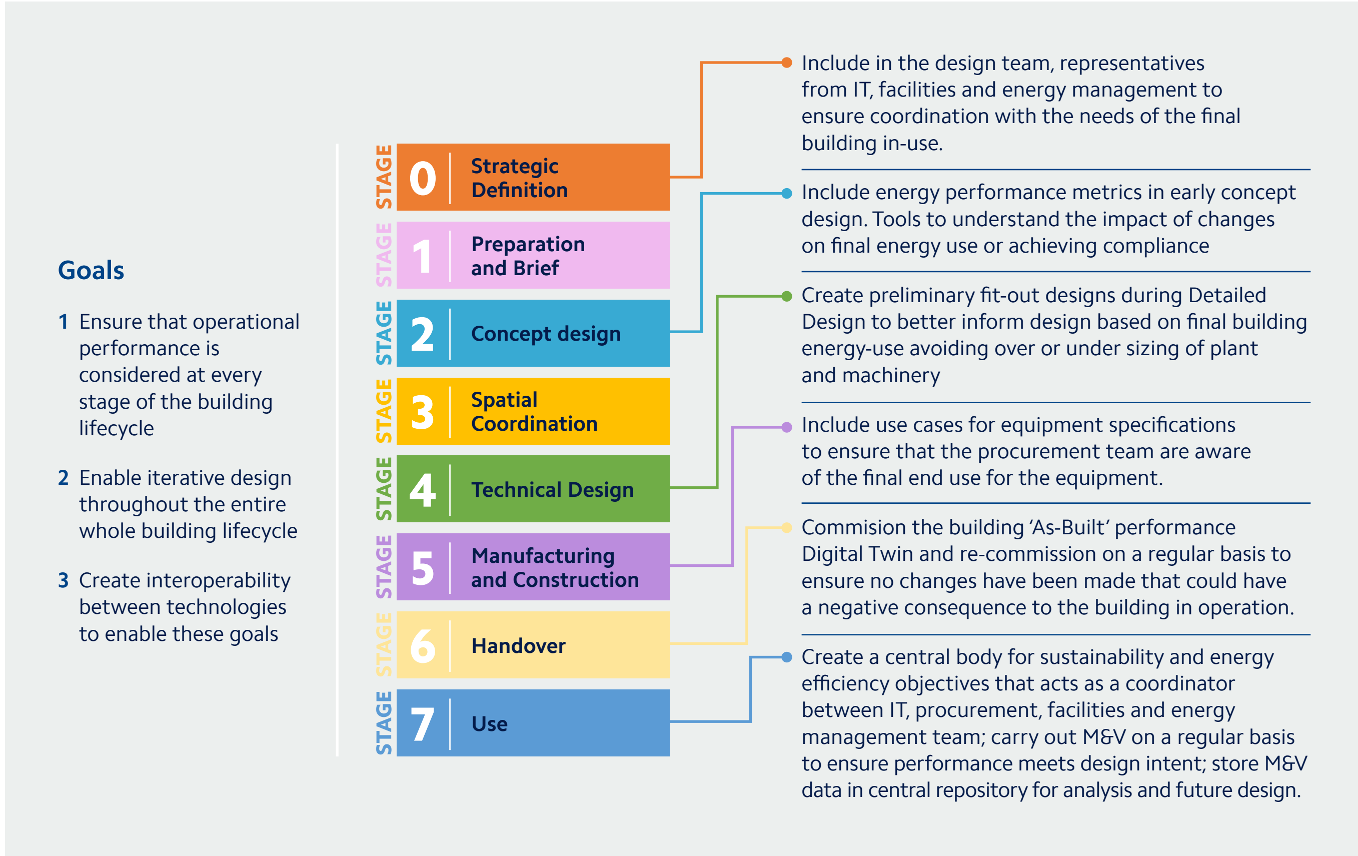


***Figure 1:** Recommendations for a whole-life performance approach aligned to the RIBA Plan of Work*

Conclusion

By focusing on early-stage analysis, the AEC industry can significantly reduce carbon emissions and create high-performing buildings that contribute to a sustainable future.

Through partnerships and technological advancements, the integration of building performance simulation from the beginning of the design process is becoming a reality, offering a pathway to achieve net-zero carbon buildings, close the performance gap and mitigate the global climate crisis.

About Us

IES

IES is a global climate tech company delivering innovative technology solutions and consultancy services to decarbonize the built environment. Over the last 30 years, they have built a solid reputation as the leading global innovator in integrated performance-based building analysis and they are now home to the largest building physics analytics team in the world.

Supporting energy-efficient, healthy and cost-effective built-environments, IES' digital twin technology provides those involved in the design, retrofit and operation of buildings the information needed to make smarter, more sustainable decisions with confidence.

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Chaos

Chaos develops 3D visualization technology for architecture, engineering, construction, product design, manufacturing, and media and entertainment.

They create intuitive and powerful workflows for architects, artists, and designers in any industry. Their research and development is leading the way towards a truly comprehensive end-to-end visualization ecosystem to meet the evolving needs of customers.

Headquartered in Karlsruhe, Germany, Chaos is now one of the largest global 3D visualization companies, with more than 700 employees and offices worldwide.

www.chaos.com

Introducing Enscape Impact

Incorporating building performance analysis earlier in the design process can enable architects to make more informed decisions when they matter most, enhancing the overall project sustainability and efficiency.

Enscape Impact – a new tool developed through a joint venture between Chaos and IES - bridges the gap between energy modeling and design visualization, enabling architects to integrate powerful energy analysis into their creative workflow.

Enscape Impact transforms how architects evaluate their designs' sustainability from the outset. It integrates IES's energy modeling capabilities with Enscape's real-time rendering engine, enhancing visualizations with energy efficiency data, simulated energy use, and carbon emissions indicators to guide early design decisions.

Learn more at **www.enscape3d.com/impact**