Design for Performance: Lessons from the NABERS UK Independent Design Review Process

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Abstract

The Design for Performance (DfP) Agreement is a process whereby building owners and developers commit to the achievement of a post-occupancy NABERS UK rating target while still in the design phase of a new building process. As part of this, an independent detailed energy efficiency design review is undertaken to assess whether the building design appears capable of achieving its target NABERS rating. A review of the building simulation determines whether it makes a plausible theoretical case for achievement of the target and a review of the design seeks to understand the practical issues and opportunities associated with the achievement of the target.

Based on experience from over 10 such reviews of UK commercial office developments, this paper provides an overview of the following key findings:

- Design team and project owner motivations, comprehension and attitudes concerning DfP Agreements
- Integration of the DfP process into the RIBA Plan of Work from stage 2 onwards, including the timing of building simulations and independent design reviews
- Major risks inherent in the UK design, construction and building operation processes that threaten the achievement of the NABERS targets for new developments or major refurbishments with DfP Agreements.

The paper aims to provide an experienced-based briefing to assist project teams in developing the capacity to understand and manage these issues and risks.

Keywords Energy efficiency, Design for Performance, Building Energy, NABERS UK

1 Introduction

Reflecting the NABERS Commitment Agreement framework in Australia, Design for Performance (DfP) is '*the process whereby a developer or owner commits to design, build and commission a new office development or major refurbishment to achieve a specific NABERS base building Energy rating'* (1). The associated NABERS UK energy rating scheme launched in November 2020 and provides the mechanism for calculating a building's rating based on metered energy use over a year and for the verification and public disclosure of the achievement of the original target (2).

The DfP process is an industry-led initiative developed to close the performance gap between building design and operational performance. From its inception, it was supported by the Better Buildings Partnership and funded by DfP Pioneers and the Usable Buildings Trust. To a certain extent, this performance gap is exacerbated by the ‘design-for-compliance’ culture in the UK (2). Building Regulations and Energy Performance Certificates (EPCs) and existing green building tools such as BREEAM play an important role to incentivise better practice building design; however, they lack a similar framework to ensure that buildings are operated efficiently throughout their life in accordance with the design intent. DfP and the NABERS UK rating scheme are administered by BRE.

In brief, the two pioneering elements of DfP are detailed dynamic energy simulation modelling of the proposed building, notably including its building services systems and associated controls from concept design to achievement of a target measured rating and the Independent Design Review (IDR), which is an independent peer review of the design and simulation with a view to identify risks and opportunities in relation to the achievement of the proposed base building operational target.

Based on experience from over 10 such IDRs for UK office developments conducted across two to three years (2019-21), this paper provides an experienced-based briefing on stakeholder motivations, timing and integration of the IDR within various RIBA stages and common issues and risks – both technical and non-technical. Parallels are drawn to the Australian experience, alongside observations regarding similarities or differences.

1.1 The DfP Process

DfP is suitable for buildings that are under development or are going through a deep refurbishment. Although the principles of the process are applicable to any building type, it is currently focused on offices because the associated mechanism of a NABERS UK Energy rating has been developed in the UK so far only for offices.

Officially, the DfP process commences with the registration of the commitment to a NABERS Energy target. This triggers a limited license which allows the Development to promote the target rating using approved wording by BRE. To obtain the full licence for target rating promotion, the process first requires the developer or owner to conduct a compliant building energy simulation to estimate the design’s NABERS performance. Secondly, the simulation report and building design must be critiqued by an independent design reviewer, to assess confidence in the estimated NABERS rating and likelihood of achieving the target rating during the operational phase. The IDR report provides a stronger indicator of the expected performance outcome in the form of the recommended ‘Design Reviewed Target Rating’.

2 Motivations

2.1 Stakeholder engagement

Stakeholders have varying motivations and drivers to participate in DfP. These are mapped in Figure 2-1. This mapping is not intended to be comprehensive; instead, it is indicative of engagement levels based on the author’s observations at the time of writing. This mapping could change over time as the DfP program matures.

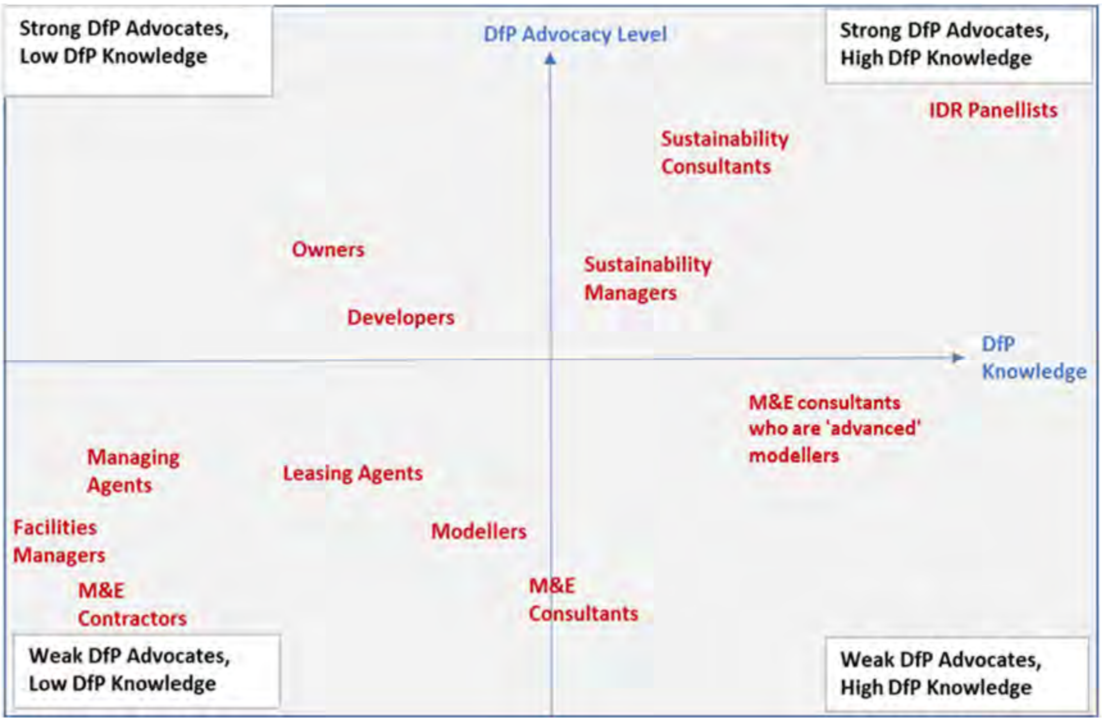

Figure 2-1. Mapping of stakeholders' DfP advocacy levels (motivation or drive) and knowledge.

Earlier projects reviewed were commissioned by the DfP Pioneers, market leaders who are already invested in green building design and determined to close the performance gap. Design and client sustainability teams were already highly knowledgeable as to the benefits of DfP. Stakeholders were self-driven and interested parties. That said, these traits were still observed to be championed by client-side sustainability managers. While sympathetic to the DfP cause, the commercial realities of the leasing market and tenant's limited recognition of the performance gap were still deeply ingrained within other parts of the business, such as the leasing, marketing and facilities management teams.

Following the DfP launch and the Department for Business, Energy & Industrial Strategy (BEIS)'s proposal to introduce mandatory energy efficiency performance-based ratings for office buildings consulted on in 2021 (4), interest in DfP across all stakeholders increased noticeably:

- Owner-developer interests were predicated on the marketing of DfP target ratings to gain leasing or reputational advantage for the property. This was both a rose and a thorn for DfP. The rose is that there is buy-in for DfP as an objective, which empowers design teams; the thorn is the level of optimism and pressure to register a high target rating despite being assessed to be very risky.
- Leasing and managing agents are guided by owner objectives but are entrenched in the business of leasing a building. Predicted ratings are interpreted as how close the building is to a better rating, as opposed to the more conservative Australian practice of committing to the "guaranteed" performance level – the lower rating threshold, with internal stretch targets to achieve the higher rating. The less mature environment in the UK drives a

strong pressure is to reap marketing rewards in the present[1], leaving any building under-performance as a risk management exercise by the respective teams. This is understandable – there are fears that by committing to a lower rating, market perception would be that the property is inferior compared to other available properties by the time the building is built and ready for occupation in 2- to 3-years time.

- Motivations for modellers, M&E consultants and contractors are also led by the client objectives and briefs, as well as budget. In general, these parties are highly knowledgeable in design aspects but may not be accustomed to being challenged or critiqued as part of the DfP review process. When DfP reviews are engaged too late in the process, there is general reluctance to make any changes as it could understandably create ‘more revision work’ which were not within the original scope. Here it is observed that the level of knowledge of the DfP process and its principles is an important differentiator. IDR panellists or M&E consultants with ‘advanced’ modelling expertise were less defensive of the original design position, and more prone to accepting DfP as a constructive and collaborative process.
- Facilities management teams are not typically engaged as part of the design process. However, the DfP process forces early interactions with such stakeholders through the preparation of the DfP Rating Achievement Plan. These important stakeholders may face some of the most substantial institutional culture change – disruption in maintenance contract structures, tenant interactions and harder enforcement of landlord expectations. As “recipients” of performance targets with as yet no empirical evidence of how easily they can be achieved, these stakeholders are wary of being strong DfP advocates with little experience of the DfP principles they will be expected to adopt - they are largely guided by the client brief.

2.2 Understanding modelling margins

In Figure 2-2 shows the modelling margins and target ratings for nine projects reviewed by the authors through IDRs. It can be seen that some target ratings were assessed as risky despite seemingly high modelling margins due to non-technical risks (management issues such as control and visibility over base building equipment within tenancies, or, unclear accountability and responsibility for operational rating achievement) or due to idealised simulations that do not reflect real operation when the building is in-use. It should also be observed that target ratings reviewed as '*achievable’* have modelling margins *higher* than the minimum levels recommended in the DfP guide. This is because:

1. The larger a building is, the higher the risk of deviant in-use operation and thus excess building energy consumption.
2. As the target rating inches towards a 6-star rating, the same modelling margin expressed in percentage terms decreases in absolute terms. A 6,000m^2 building with a 25% modelling margin can use an additional 29 kWh$_e$/m^2 energy for a 4.5-star target, but only 17 kWhe/m^2 extra for a 5.5-star target. For the same building, the 5.5-star target could easily be compromised by a handful of large pumps operating 24/7 unbeknownst to anyone for a short period.

[1] In contrast, Australia’s experience of the commitment process over the past 20 years seems to have fostered a mentality more accepting of reaping marketing rewards in the future when the building over-performs its target.

The above modelling margin risks should be carefully considered by the client and design teams before the commitment and marketing of an exceptionally high target rating.

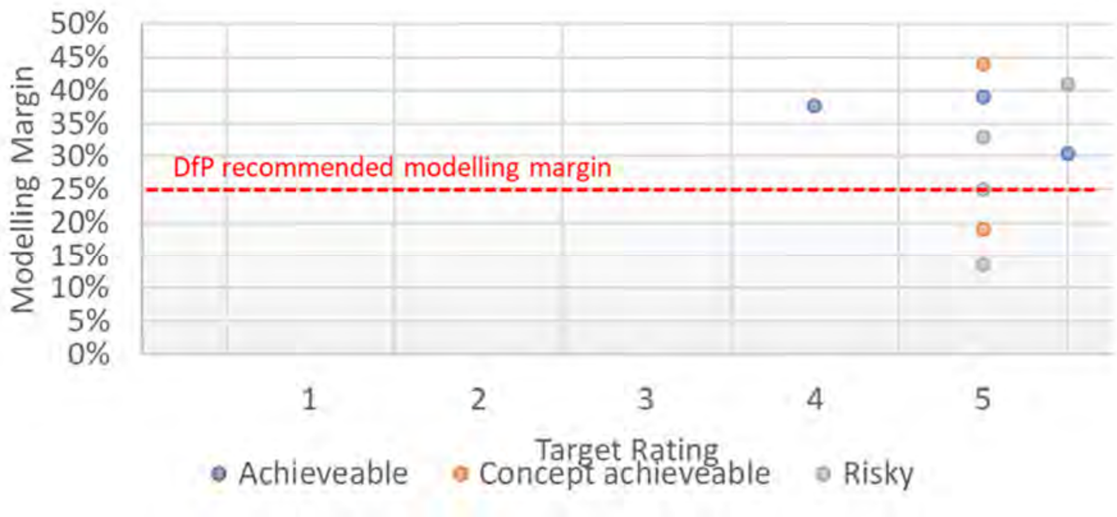

Figure 2-2. Target rating, modelling margin and IDR risk assessment

3 Timing and Project Integration

3.1 When should an IDR be conducted?

IDRs have been sought at all stages of the project – the authors have reviewed design and energy simulations at stage 2 through to stage 4 of the RIBA Plan of Work.

The assessed risks of achieving the target rating are substantially higher at earlier RIBA stages. As such, the earlier the RIBA stage, the less suitable a single snapshot IDR is to support a formal DfP Agreement. This is corroborated by the DfP Guide that recommends for the IDR to be conducted during Stage 4 *to ensure there is sufficient documentation and design detail for the Simulator to produce a credible Simulation and for the Reviewer to produce a detailed review* (3).

In Australia, regardless of whether a project goes through a NABERS Commitment Agreement (the DfP-equivalent program), many projects enlist the assistance of a peer reviewer at the concept, 60-70% design and 90% design (typically referring to tendered design) stages as a risk management exercise.

To harness the benefits of a peer review at all RIBA stages, multi-stage IDRs are increasingly sought by various projects from the authors' experience. This is the exact opportunity noted within the DfP Guide (3), which acknowledges considerable value-add if the reviewer can provide input to larger-scale design decisions in earlier stages as these could be difficult to change at Stage 4.

3.2 When should the simulation be conducted?

As with the IDR, advanced building energy and thermal simulation models can be conducted at any stage. However, the earlier the simulation is conducted, the more experienced the modeller needs to be as the design detail is scarce at earlier stages. For the model to be useful as a design tool, it would need to be guided by a good understanding of how the plant will likely be operated and reasonable model input parameters for equipment (including where to source the information).

Some examples of how the model could be used as a design tool, for a given building location and geometry, include:

1. Which HVAC system design is more efficient and is the difference material?
2. Is there an alternative façade design and/or amount of glazing that should be considered to minimise operational energy use?

The model should be updated and revised in parallel with the design as it progresses from stage 2 to stage 5. At each stage, the model should be integrated within the feedback loop to the design team to inform evidence-based design decisions. At stage 5, the focus of the simulation should be preparation for post-construction monitoring and tuning - providing predicted appropriate sub-system monthly energy targets, mapped to sub-meters, are important in this regard.

Some of these activities and modelling already occur as part of BREEAM and Part L investigations. Essentially, the same activities could be retained albeit with a greater focus on the simulation model being realistic and detailed using DfP principles and co-ordination with the metering plan and specification.

3.3 Multi-stage IDRs and simulations

IDRs and simulations should be viewed along a continuum to de-risk performance issues. Observations from reviews conducted at the various stages are discussed in this section. The benefits and focus of the design review at each stage differs and could be applied differently depending on the needs of the specific project.

3.3.1 Stage 2

At Stage 2, the review focuses on key design concerns that should be considered as the design and project budget is developed in later stages. The benefit of a design review conducted at this stage has been largely to educate the client and design team regarding the DfP process, how the NABERS UK base building rating works and the role of simulation in testing alternative design concepts.

Simulation models at this stage are indicative at best, with the simulations reviewed using simplified HVAC models as well as assumed equipment and controls. Designs tend to be conceptual: for example, the design reviewer can expect hydronic schematics illustrating the intent to use ground-source heat pumps in conjunction with a free-cooling chiller, without any detail regarding interlocking valves or controls. Many contractual relationships are not in place, or even considered at this stage.

Accordingly, the review identifies design detail that should be considered in later stages, especially if the architectural design could be reimagined to enable more efficient services design and operation, facilitating intellectual discourse regarding any red flags identified and identification of potential future risks that the design could pose during the operational phase.

Reviews conducted at this stage tend to have the highest chance of being incorporated into the overall design due to the project being at its concept stage, and the opportunity for the NABERS UK performance target in client briefs to be incorporated to set the expectations of all parties within the supply chain.

3.3.2 Stage 3 or 4

Many of the earlier design reviews considered by this paper were conducted at stages 3 or 4. This is partly due to the DfP process "landing" in the UK when many of these projects were already at these stages. Clients and design teams also appreciated more information would be available for critique via the IDR.

At the time of writing (January 2022), the UK's DfP scheme's public web site does not differentiate a preliminary target rating from a design reviewed target rating, despite their different license rights. Registered initial targets are not locked down and if applicable have been revised up or down after the stage 4 design review, rather than showing these two targets separately.

At Stage 3, MEP reports tend to have explored multiple options to optimise BREEAM ratings and Part L compliance. Architectural detail such as layouts and coordination schematics are generally well laid out, but the level of detail for façade construction and thermal performance differs between projects. Hence, **the review focusses on design elements and is more critical about the veracity of the simulation report results and modelling margin.**

Arguably, a stage 3 design review is one of the most important stages as it also brings to light non-technical risks that affect the recommended modelling margin for the target rating. In some cases, the review assessed that the 25% modelling margin[2], despite being suggested as a minimum in the DfP guidebook, is extremely risky. This could be due to simulation omissions, poor representation of actual building operation (such as thermal inertia, lack of load diversity *etc.*, unrealistic controls due to lack of control or authority over tenant equipment operation), or if design documentation does not reflect the arrangements modelled (typically control strategies in are not codified in design detail at this stage).

In some projects reviewed, the modeller simulated equipment or controls that were not (yet) specified to inform the design team as to what equipment or controls should be specified in the subsequent design stage. This strategy is acceptable so long as the simulation report states that this is the case.

In theory, the **stage 4 design**, being 'for-tender' documentation, should be more advanced compared to the previous stage. However, like observations from stage 3 reviews, the level of detail within design documentation differed between the projects reviewed. There is less flexibility in changes to the architectural and façade design at this stage, as such, the focus is often on the MEP design. The overall MEP system design is also at a more advanced stage and therefore challenging to change at this stage. Accordingly, **the focus of the design review is inclined towards equipment**

[2] Calculated as the ratio of predicted energy intensity minus the target energy intensity to the predicted energy intensity.

selection (particularly part-load performance), the intended control strategy and the tenant fit-out brief. The efficiency of the proposed equipment selections by the MEP consultant and the intended control strategy for the building is assessed:

- For CAT-A designs, the review suggests enhancements to HVAC system control strategies that align with equipment selections or intended building usage.
- For shell-and-core designs, the review identifies gaps between landlord and tenant equipment demarcations – where risks of poor building energy performance are driven by the lack of detailed instruction to the tenant regarding equipment selection, maintenance and control within the tenant fit-out brief.

The best value for the design review is derived when stage 4 documentation is reviewed just before the issue for tender, or before the tender phase is complete. This is because any opportunities identified as part of the design review process can still be incorporated within the return tender pricing without the need for contract variation or for contractor pricing to be provided for alternative designs for the value management process.

The transition between stage 3 and stage 4 is sufficiently early for any contractual, leasing, post-construction maintenance and property management contracts to be structured and discussed. Before the design is locked in, the client team - developer/owner/property managers – should consider the implications of the design and planned tenant mix on operational energy performance. The 2018 DfP Pilot Programme Technical Report (10) relates how the prevalence of shell-and-core design in the premium office market leads to split incentives between landlord and tenant, leading to major issues in energy efficiency. To overcome this, consider introducing:

- a centralised building management system for all building equipment material to central HVAC performance, including those within the tenant demise; or
- CAT-A services design instead of a standard shell-and-core within building NIA.

3.3.3 Stage 5

Stage 5 designs are the most advanced as these are ready for construction and installation. From a snapshot IDR perspective for the formal DfP agreement, documentation in this stage is closest to actual building operation as equipment selections would be those ordered by the contractor, any workshop drawings and design detail show valves or dampers that are used for control as well as commissioning. Notably, the most advanced element within stage 5, one that is weakly represented in previous stages, is often the metering and HVAC control strategy design. This is because most MEPs in the UK are not accustomed to a detailed specification of HVAC control sequences[3] and Australian and American resources (AIRAH DA28 and ASHRAE Guide 36 respectively) may not be easily accessible by the broader market.

A Stage 5 review would focus on the metering and BMS functional description

[3] While this is largely due to the lack of UK-specific published resources, the authors are aware of efforts to revamp for this purpose the 2009 version of CIBSE Guide H: Building Control Systems.

reverse brief by the contractor to ensure alignment with the DfP model assumptions.

Assuming that the simulation is updated based on the stage 5 design and equipment selections, the IDR will likely profess high confidence in the predicted rating. That said, it may be too late for the building to make any changes should the review outcome be that the target rating is not achievable. In this case, the only option is for the owner/developer to revise the target rating in the DfP agreement to reflect the design reviewed rating. This is typically the least favourable outcome as it has flow-on consequences on leasing and marketing activities.

3.4 A shift in mindset

Comparison between design reviews conducted in 2019-20 during the DfP Pioneer program and ahead of the NABERS UK launch versus those conducted in 2021 showed a distinct shift:

- The former revealed a tendency for Part L compliance models to be partially ‘upgraded’ and reported for DfP purposes. Shortfalls included simplified HVAC models that were inadequate to represent real building operation and equipment performance at partial loading, as well as idealised façade performance that do not reflect true wall-construction layers. The simulation was rarely used as a supporting tool to test the importance of various building design elements and to stress test (via off-axis scenarios) the building design against non-technical risks such as tenant behaviours. Off-axis scenarios tended to be more ‘cookie-cutter’, mainly taken from the NABERS commitment agreement handbook. Little thought was given to scenarios that reflect the risk profile for the building in question, and how using a technical tool like simulation modelling could be used to inform criticality of tenant management, services control and monitoring, and how post-handover contracts should be structured. This revealed another manifestation of the mindset stemming from the need to ensure compliance with Building Regulations. The issue of unrealistic input parameters in modelling being a causal factor for the building energy performance gap is well documented (6)(7), albeit published case studies for commercial offices are thin on the ground due to an absence of commercial building performance disclosure in the UK, to date.

- The latter revealed more sophisticated simulations, including the use of advanced dynamic HVAC modelling programs (which are typically an add-on to standard simulation software, such as the ApacheHVAC module by IES and TAS Systems by EDSL, and also require more modelling inputs). The energy modellers seem to exhibit greater awareness of simulation software limitations, transparently reporting any compromises and the level of risk such treatment in the model poses to estimated building performance. Off-axis scenarios are used to stress test impacts of such compromises and deviations from intended control such as tenant equipment operating 24/7 or inability of landlord central plant pumps to turn down due to poor valve control by tenant equipment. In some cases, simulation was used to inform design (via off-axis scenarios), such as the impact of different glazing selections, significantly oversized plant capacity that should be designed with more modular plant or require a thermal buffer tank to avoid plant short-cycling, or benefits of specifying an alternative control strategy.

In essence, there has been a clear shift towards using the simulation model as a design tool. Complementing this also revealed more realistic building simulation models at the design stage, narrowing what Bordass *et al* (5) described as the ‘credibility gap’ – unrealistic assumptions that lead to modelled outcomes that bear no resemblance to actual fuel consumption. This attests to simulators’ increased appreciation of how real buildings and HVAC controls should be modelled instead of idealised comparison to a reference building using Part L compliance models and NCM profiles. Mounting confidence in the realism of simulation models also aid acceptance of dynamic energy models as a design tool, as demonstrated in latter reviews completed[4].

3.5 A holistic approach for change

A change in context during 2019 was triggered by a relatively sudden mainstream acceptance of the “Climate Emergency”, manifested by the government amending the UK’s Climate Change Act and by the UKGBC producing operational performance targets for commercial offices which referenced NABERS UK ratings (15). This shift in mindset, especially for the type of developers who were spearheading DfP, largely overcame the barriers mentioned earlier represented by the traditional commercial realities of the leasing market and lack of tenant interest in the performance gap. At a practical level, the change was complemented by several events, which played an important role in the observed industry upskilling process:

- **The formal launch of the NABERS UK rating scheme and DfP framework released public documents that practitioners could reference.** These documents included guidance on modelling parameters, default operation profiles and internal gains and introduced the concept of modelling off-axis scenarios.

- **Delivery by the BBP of the independent design reviewer training and examination to establish a panel of experts.** As part of the DfP program launch, customised training was delivered to candidates, educating them on the design review process, common pitfalls and using a real project as an example, tested the candidates on the application of concepts taught.

    - The training emphasised the importance of the design review process as a conduit for educating and expanding the design team’s horizons regarding issues and solutions to achieve operational performance. The training further recognised the role of the design reviewer as a ‘*change agent’*, challenging all parties to make this a constructive process, encouraging teams to accept recommended solutions where appropriate, and collaboratively brainstorm or propose better solutions as part of the process. Setting the right culture and mindset from the get-go has been critical in ensuring the success of the building industry

[4] As opposed to a compliance check box that is ignored once ticked.

towards achieving highly efficient building performance.
  - The IDR template[5] is used by the reviewer and shared with the design and client team – indirectly educating and upskilling the industry. Because the same template includes all trades (architectural, MEP, simulation) and non-technical aspects related to management such as the rating achievement plan, it breaks down silos in the design process. It provides all stakeholders with an appreciation of issues and risks that affect efficient building performance including how technical and non-technical decisions can have impacts that reverberate across the value chain.

- **Launch of the NABERS UK Assessor training by BRE.** A key role of the energy simulator is to predict the NABERS UK energy rating that the building will likely certify at. Before the launch of the NABERS UK Assessor training, most design teams and modellers were unfamiliar with the coverage of a base-building NABERS UK energy rating. This lack of understanding led to common errors such as the omission of HVAC equipment energy (such as tertiary pumps or fan coil motors) within tenant net internal area (NIA), failure to identify sub-metering risks or consider alternative methods for mechanical services within NIA, lack of awareness regarding complexities of apportioning and sub-metering requirements for shared thermal energy plant and artificially boosted predicted ratings by fully claiming on-site renewables to discount base building energy consumption. Launching the NABERS UK Assessor training has significantly improved the industry's broader understanding of the rating coverage and a better grasp of associated risks, and thus, improved design responses.

- **Commissioning of design reviews within the industry.** Many independent design reviewers were themselves experienced energy simulators or M&E consultants. The process of critiquing simulations and designs by others in the role of a design reviewer, or being subject to the design review process by a third party, also assisted in further enhancing their (or their supervised staff) own simulations, designs and appreciation of the non-technical issues that can impact real building energy performance.

- **Delivery of the CIBSE advanced simulation modelling for DfP training.** The training course (8) was aimed at upskilling the MEP community in the theoretical approach to simulation modelling when targeting an operational rating. Modellers were trained on the practical application of advanced simulation principles to reflect realistic building operation and input parameters that need to be modelled as part of dynamic energy modelling. This course was vital to address the issue of low building energy modelling skills in the industry (10).

3.6 Early involvement and discourse amongst stakeholders

While the IDR process is a highly technical exercise, it would be folly to ignore the

[5] The IDR template is a comprehensive spreadsheet that systematically and transparently prompts the reviewer by asking questions about each type of specified equipment/control, enabling the reviewer to offer suggestions for (without dictating) possible efficient design responses.

importance of stakeholder engagement and communication across the full building lifecycle and value chain. It is true that building operational performance is contingent on good design and accurate simulations reflecting in-use building occupancy profiles and facilities management; however, the success of target achievement is highly dependent on stakeholder activities post-handover of the building (9).

This reinforces the importance of risk assessments stretching far beyond the design-only phase – the review assesses the inherent risks across the full operational lifecycle of the building from client brief development, design, leasing, construction, maintenance to post-construction monitoring and tuning.

The 2018 DfP Pilot Program Technical Report (10) identifies a long list of stakeholders ranging from investors, developers, leasing agents, managing agents, facilities managers, occupiers, contractors, MEP consultants, modellers and many more. Therefore, the IDR process should endeavour to engage with the different stakeholders, as many of the non-technical issues that impact building operational performance fall outside the sphere of control of the design team. This issue is raised by Bannister and Cohen (14) who reported on the dilemma of designers heavily constrained to deliver systems that conform to industry commercial norms, and developers that feel obliged to deliver to tenant expectations.

The process adopted for the completed IDRs endeavoured to engage with stakeholders across the lifecycle, noting that this was not always possible with all projects reviewed due to commercial considerations.

- **The briefing workshop is important as scene-setting to encourage a collaborative instead of a combative environment**. This workshop always involved the architects, MEP design engineers and energy modeller. But in some cases, the owner/developer and sustainability consultant, if engaged, were also present. The briefing workshop was key to getting a basic understanding of the development/refurbishment project brief so it was clear which building elements were to be retained and which are new, allowing the design engineers to describe any projects constraints that led to certain design decisions or compromises. This workshop is key to setting up a constructive environment instead of being combative or defensive – the design team is encouraged to identify any challenges or elements that could benefit from additional perusal by the reviewer to provide input. As the DfP process is new to the UK market, it was necessary to reiterate that an extensive list of IDR recommendations is not a fault-finding exercise. Conversely, these should be considered as a shopping list of prioritised suggestions, many that could or should be adopted for the project in question; and others for integration within the next project.

- **The rating achievement plan, including the tenant fit-out brief, must be front and centre of the DfP process.** In early reviews, a separate workshop was required to educate the owner/occupier regarding the rating achievement plan. Different approaches have been observed – (a) some projects with the MEP being the driving force coordinating the several workshops with a large stakeholder group including the M&E contractor, managing agent, leasing agent, owner/developer, (b) other projects with a dedicated sustainability consultant or ‘NABERS champion’ advising the owner with the engagement process with other stakeholders largely opaque to the reviewer, or (c) projects where the owner is actively engaged in the process with the independent design reviewer to discuss implications of the rating achievement plan and how to set up contractual relationships such as maintenance contracts, performance contracts for the main contractor, a structure for post-construction monitoring and tuning contracts and interactions with facilities management or the tenant.

4 Common Issues

The common issues and major risks identified from the IDRs are summarised in this section.

4.1 Technical risks

4.1.1 Common technical risks for HVAC systems

The following technical risks are common for the various HVAC system types reviewed and benefited from being modelled as an off-axis scenario in the DfP simulation.

- **Heat recovery VRF system.** Zonal thermal diversity tends to favour heat recovery VRF systems. With smaller VRF buildings delivered as a shell-and-core base building design, stress test poor design by the tenant by removing the diversified internal zone loads.
- **Water-to-air heat pumps.** Unless enforced via tenant leases or a CAT-A HVAC design, any condenser water valves for the compressor units are likely to be open for long durations, leading to the pumping system acting as a constant flow instead of variable flow system. This risk is mitigated if continuously modulating condenser water valves linked to compressor load is specified.
- **Air-to-air heat pumps.** Where a single heat pump serves both interior and perimeter zones with terminal reheats, the high efficiencies of heat pumps in heating mode is not capitalised[6] and reheat energy will be high. Where this result is not observed in the simulation results, revisit how the air transfer between HVAC thermal zones is modelled by the simulation software engine or consider adding internal partition walls to ensure this is modelled correctly by the software. From a mechanical design perspective, this system should be designed with separate perimeter and interior zone heat pumps.
- **Centralised cooling and heating plant.**
  - Standard designs seem wedded to the use of plate heat exchangers at each tenancy for hydraulic separation. This practice is advantageous to enable tenant fit-outs without affecting the broader hydronic network and pseudomonas risk-management. However, this is at the expense of pressure losses[7] across the heat exchanger and more notably, restricts execution of temperature resets[8] that increases chiller and

[6] This is because the heat pumps will always operate to satisfy the warmest zones, leaving any colder zones to be reheated using terminal reheats.
[7] Typically between 10kPa to 40kPa per heat exchanger.
[8] Relaxed temperatures (higher for chilled water, CHW; and lower for hot water, LTHW) decrease thermal efficiency of heat exchangers which could be specified to be anywhere between 80 and 95% efficient.

heating plant efficiency during building partial loading. As a result, the system regresses to operating as a constant temperature system, which can perpetuate the '*low deltaT*[9]' syndrome. While uncommon, some projects did specify a design without plate heat exchangers, suggesting that the alternative configuration without plate heat exchangers, the Australian norm, is possible in the UK context.

- Related to the above issue is the practice of domestic hot water (DHW) calorifiers and space heating sharing the same LTHW plant. Space heating demand is seasonal while DHW demand is steady-state across the year. The common issue observed was domestic water temperature requirements[10] restricting the ability for the LTHW temperature to be reset downwards when space heating demand is low. Designs should consider the ability to service the DHW load separately from the centralised plant (e.g., via a separate hydraulic connection to a dedicated heat pump) or at minimum, a separate hydraulic riser for DHW so it is not on a riser shared with space heating.

4.1.2 Alternative approaches to HVAC equipment design within tenancies

Traditionally, HVAC equipment located within tenant NIA is considered 'tenant plant' despite being base building equipment under NABERS UK. Such tenant HVAC plant is included within NABERS UK base building energy coverage because poor design, control and maintenance of such equipment can substantially increase landlord centralised HVAC plant operation (14).

A few observations associated with this issue can be made:

- UK buildings tend to be delivered as shell-and-core, with the tenant designing and installing equipment when the space is let[11]. The predominant UK designs reviewed under the DfP scheme often specified CAT-A lighting design but seem to relinquish mechanical design to tenant fit-out. However, more recent reviews, while still in the minority, show signs of market warming to the concept of a CAT-A HVAC design combined with centralised landlord monitoring and control. The CAT-A HVAC design approach decreases the level of performance risk by increasing:
    - Design team control over the base building systems design and installation
    - Facilities management team control of building in-use operation as well as equipment maintenance.

- From an electrical design perspective, two options exist:

[9] This is a situation where the low temperature differential between supply and return chilled water temperatures lead to increased flow to achieve the same capacity, thereby increasing pumping energy. This is the reason why the relationship between pump power and system flow will not follow the pump affinity laws in practice, and one is more likely to observe a linear or at-best a quadratic relationship between the two variables (11).
[10] Typically 70°C on the primary side of the heat exchanger to achieve 60 to 65°C on the secondary side
[11] This is contrasted with Australian buildings which are typically delivered as 'CAT-A' designs across all services, enabling a tenant to move in and occupy the space as-is if desired with some modifications to communications to suit.

1. to retain existing shell-and-core design but design dedicated mechanical services switchboards for each tenancy for connection of on-floor HVAC equipment only; or,
2. two, to design dedicated mechanical services electrical riser from the landlord main switchboard, with sub-metered tee-off for charge-back to each tenant. This option is the norm in Australia with the associated energy consumption cost typically recovered from the tenant via aggregated building outgoings.

The benefit of the second approach is decreased sub-metering requirements, which reduce the risk of sub-metering failures. Designs reviewed indicate that this model is possible and has been implemented in the UK context; however, it needs to be flagged for early consideration by the owner-developer and leasing teams as part of the client brief in Stage 2.

4.1.3 Outside air AHU design

Outside air AHUs are specified with heat recovery via thermal wheels or plate heat exchangers, usually centralised for large buildings and on a floor-basis for medium to smaller buildings. While conveniently aligned with tenant cost-recovery mechanisms, this configuration is not necessarily the most efficient outcome, especially for buildings with deep floor plates[12].

Two design options exist:

1. Better demarcation of tempered air to the perimeter and interior zones using separate AHUs - an ideal solution to avoid simultaneous cooling and reheat. That way, free-cooling using air-side economy cycle to the interior zones can be applied during temperate or cold weather, without the need for reheat on the perimeter.
2. If the building must proceed with a tenancy-based AHU approach, then at a minimum, VAV boxes should be designed for interior and perimeter zones respectively. Localised heat recovery from the return/relief air stream to the perimeter zone for reheat purposes should be designed. This option will allow airflow to perimeter zones to be dialled back when cooling is not required, and the cool ambient air (during economy cycle) to be reheated using recovered heat.

4.2 Other Non-Technical Risks

4.2.1 Locked in, left behind

A less common issue but an equally noteworthy risk is the issue of locked-in obsolete designs. This usually follows an extended hiatus in development progress due to capital or other unforeseen issues. One project found itself locked into the use of substantive gas heating systems supplying 70/80°C water due to the original

[12] These building types accentuate the thermal difference between year-long cooling dominated interior zones versus the perimeter zone which tracks ambient temperatures.

BREEAM targets being set 10 years ago[13]. As the commitment had been registered, the design team found itself under immense pressure to retain the registered design with condensing gas boilers even though the building is anticipating a completion date in 2024/25. This grates in the context of London's Mayor setting a target of net-zero carbon by 2030 for London (17) and all new buildings must be designed to meet this target by 2025.

The NABERS UK rating tool is based on primary energy ($kWh_{equivalent}/m^2$), and therefore the building is disadvantaged from the outset with gas boilers operating at a coefficient of performance (COP) of 0.9 compared to heat pumps with COPs 2.5 or higher. For the project in question, the compromise was to design water-to-water heat pumps and specify controls to stage these units ahead of the gas boilers, though it was challenging to introduce any water temperature set point reset to derive condensing boiler and heat pump efficiency benefits due to the domestic hot water calorifiers located downstream of the LTHW system.

This is a prime example of how a non-technical barrier led to significant technical limitations and building operational performance risk.

4.2.2 Tenant fit-out brief

A tenant fit-out brief is important within the UK context as it sets expectations of the tenant from the outset that may not be common at the time. The fit-out brief should be incorporated within leasing documents, particularly shell-and-core designs. Coverage of the brief should include:

- the base building target NABERS UK rating
- tenant equipment efficiency and design parameters,
- coverage of sub-metering, validation requirements and trend logging requirements.
- the interface of equipment to the landlord centralised building management system, both monitoring and control.
- landlord review and approval process of any tenant fit-outs to ensure that it does not adversely impact the base building target NABERS UK rating
- equipment control sequences that should be programmed.
- maintenance requirements for tenant equipment.
- tenant response and participation in the building tuning program
- after-hours air conditioning request process that is aligned with the NABERS Rules
- dispute resolution process where tenant actions or design is not approved by the landlord[14].

The tenant fit-out brief could be perceived as more prescriptive than usual. The brief must be discussed with the leasing agent for negotiation purposes and for facilities management to be empowered to enforce the tenant fit-out brief during building

[13] At that time, both UK and Australia green building rating tools and building regulations had a penchant for natural gas due to its lower emissions relative to coal-generated electricity. This has rapidly changed in recent times as the electricity grid decarbonises with the uptick in renewable energy generation.

[14] A few options explored as part of the projects reviewed such as update of the simulation model to quantify any adverse impact of the tenant design/operation on the NABERS UK base building energy rating. Financial responsibility for commissioning the model should ideally be disclosed in the fit out brief.

operation.

4.2.3 Maintenance contracts during DLP

The structure of maintenance contracts and management of the defect liability period was identified as another major risk. Designing for building performance has the best chance for success when there is continuity between the original design and construction team through to building operation. This is because building performance is dependent on proactive building tuning and monitoring, which profits from a good understanding of the original design intent.

Existing practice for maintenance contracting is not conducive for performance. M&E contractor engagement is limited to the rectification of equipment defects during DLP and a second M&E contractor, typically unrelated to the project M&E contractor, responsible for service and maintenance of the building. Exacerbating this issue is the tendency for HVAC equipment within NIA to be under direct tenant control – in a multi-let building with 10 tenants, this could end up with 12 M&E contractors responsible for various parts of the mechanical system that impact base building energy consumption, all with split incentives due to engagement by different stakeholders, varying degrees of maintenance or service quality[15] - performance tuning which takes a *system* view (e.g., *all* fan coil units and valves in a building impact centralised plant staging, temperature and pumping control) becomes a logistical nightmare. Furthermore, there is no point in contractually requiring the project M&E contractors to participate in the building tuning process during DLP if they do not have any clout to test or tune setpoint adjustments[16].

The rating achievement plan is the ideal forum for the discourse of these concerns and challenging the institutional status quo, which is why designing for performance and the IDR cannot be limited to the design and construction team. Where the IDR process and workshops involved the owner or facilities management team – alternative contracting methods could be debated. Approaches considered include one that has been successful in the Australian context but requires negotiation with the managing agents: the M&E contractor is engaged for service and maintenance for all equipment within base building energy coverage (including those within tenancies) during DLP, eliminating the issue of split incentives.

5 Conclusions

The Design for Performance (DfP) framework was introduced in the UK to address the building energy performance gap, a step-change in action aimed at helping to meet the UK's net-zero by 2050 legislated target. DfP was modelled upon the 20-years of success in Australia under the NABERS program, which recently reported that an average 42% reduction in base building energy intensity upon a building's 14th NABERS rating (16).

This paper has presented lessons from the NABERS UK independent design review process across the past two- to three-years, reflecting on stakeholder motivations, change in attitudes and skill with time and market activities, and a wide range of

[15] This is not necessarily due to failure on the part of the M&E contractor as these parties could be engaged for different service levels by their end client (various tenants, facilities management team or original developer).
[16] To avoid disputes regarding liability. If anything goes wrong during that process, is the maintenance M&E contractor responsible for rectification or the project M&E contractor?

common issues that influence building energy performance – both technical and non-technical. It reflects on how and when simulation and design reviews could be conducted, and how best to extract value from these tools at each stage to de-risk operational performance.

In 2020, Bannister and Cohen (14) reflected at the CIBSE Glasgow conference that the UK could leapfrog the 20-years of progress in Australia learnt by slow trial and error, by adopting these lessons in the UK ahead of the curve. The UK industry has the right attitude and is well on the track towards delivering high-performing buildings from the projects reviewed within the short two to three-year timeframe.

The challenge will be in changing the status quo and early engagement with stakeholders to address many of the non-technical barriers such as maintenance and tenant engagement during the leasing negotiation and building operational stage. A holistic and collaborative approach to designing for performance is momentous and will require '*NABERS UK/DfP Champions*' within each stakeholder group to advocate the responses to the opportunities and issues identified in this paper.

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