Rapid Review No.1 - Summary

Addressing the discrepancy between as-built and as-designed in Australian energy efficient buildings

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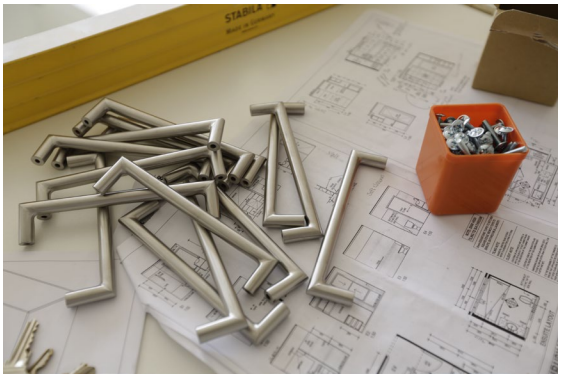
Objectives of this rapid review

Energy efficient buildings are viewed as one of the solutions to reduce carbon emissions from the built environment. However, case studies worldwide indicate that there is a significant gap between the set building energy targets and the actual measured building energy consumption post-occupancy. This phenomenon, known as the regulatory energy performance gap (EPG), is a concern as it hinders the global energy conservation efforts.

Underlying causes for the regulatory EPG have been identified at all stages of the building life cycle. Whilst the role that occupants play in building energy consumption has been widely researched, the influences on the EPG relating to the construction and commissioning stages has been the subject of only 7.9% of studies. Some of the issues relating to the pre-occupancy stages are well-known amongst building practitioners, but in Australia there are still no provisions to address them.

The successful implementation of energy efficient buildings in Australia depends on a deeper understanding of the root causes for the regulatory EPG, in particular, the causes for the gap between as-designed and as-built. It is important to understand how this problem can be addressed effectively based on international evidence-based research. To assess the discrepancy between as-designed and as-built, post occupancy performance measurements are required.

The aim of this rapid review is to examine international literature on the EPG, focussing on the gaps relating to the construction and commissioning stage of energy efficient buildings; and collate information on how to address this gap.



Plans (photo by Kathy Johnson)

Key findings of this rapid review

The review found nine studies, published between 2014 and 2019, that fulfilled the selection criteria for inclusion in the analysis. These studies collectively reviewed over 500 articles reporting results from Asia, Europe, North America, Africa and Australia.

Causes for the gaps between as-designed and as-built

The average discrepancy between the predicted energy use based on as-designed models and the measured energy use in as-built buildings is +34%.

Despite the limited number of articles addressing the research question, all articles agreed on the main factors for discrepancy between buildings' as-designed and as-built. These are described below for each of the relevant building life stages.

Design stage

> *The average discrepancy between predicted and measured energy use is +34%... poor commissioning can cause a gap of up to 20%*

Root causes for the as-built/as-designed gap originate in the design stage, when the design team might propose a design that is too complex for the builder or does not take into consideration practical limitations of the building site. This leads to changes during construction that are not fed back to the design team.

Moreover, there is generally a lack of clarity in design documentation, in particular, how different layers of the building (fabric and services) are supposed to be integrated in practical terms.

> *… Issues relate to lack of knowledge and skills, lack of communication between stakeholders and lack of accountability for building performance post-occupancy*

Procurement stage

During procurement, the emphasis is often placed on cost rather than skills or quality. This results in the engagement of contractors without knowledge of energy efficiency and related skills.

Change orders often occur at this stage, either for cost reduction or site constraints not accounted for during design. The consequences may be lower quality equipment and materials or a complete change in design that affects energy efficiency. Building owners, who often have inadequate knowledge of energy and construction, endorse the changes.

Construction stage

During the construction stage, building fabric is incorrectly constructed due to poor building techniques. Houses have on average 2.29 to 28.3 defects. Complex designs make mistakes more likely to occur. Hidden faults, such as gaps in insulation, are hard to uncover and fix once the building is finished. The impact of these faults may not be uncovered until the building is occupied.

Commissioning stage

Up to 20% of the EPG is due to poor commissioning. Building technologies and services are incorrectly modelled, sized and installed due to lack of skills possessed by contractors.

Reflective insulation (photo by Josh Byrne)

Testing and verification

Building performance testing is often not completed due to time and/or budget constraints. When verification of the built form is carried out, testing protocols are not always followed, and energy efficiency is not prioritized. This results in discrepancies between as-designed and as-built only being uncovered during the post-occupancy stage, when addressing these issues is more difficult.

In summary, most issues relate to lack of knowledge and skills, lack of communication between stakeholders and lack of accountability for building performance post-occupancy. There is usually no designated person responsible for the overall building quality and energy efficiency. There are no integrated delivery methods and no common platform for information recording and transfer.

Addressing the gaps

Key recommendations are classified under the four main themes of training, communication, performance accountability and standards. These are presented below.

Training

All new and current industry professionals should be trained and upskilled. Only adequately qualified professionals should be able to conduct building energy modelling, assessments, testing and building performance verification.

> *… recommended that buildings are rated according to their actual energy performance post-occupancy rather than their predicted performance*

Communication

Greater communication standards need to be put in place between stakeholders to ensure comprehensive design detailing is performed early to avoid changes during the construction process.

Appointing a sustainability champion to oversee the construction would enable close monitoring of the building quality as well as facilitate communication and close feedback loops between the different stakeholders.

Performance accountability

It is recommended that buildings are rated according to their actual energy performance post-occupancy rather than their predicted performance. Project owners would have to agree on performance guarantees, including mandatory plans for how commissioning would be done.

It was also suggested that high operational energy use should be penalized, through an environmental tax. In contrast, pay-for-performance programmes were suggested as an approach for incentivizing savings achieved over time.

Post-occupancy energy performance data should be made accessible to not only ensure the transparency of the rating process, but also to provide feedback to design and construction teams and gather further evidence on the EPG. This feedback loop is essential to enable accountability, provide learning opportunities and ensure future compliance.

As part of ensuring building quality and compliance, testing should be made mandatory during the construction process.

Standards

To ensure building compliance and quality, a number of articles suggest the development of new guidelines and standards. These include developing standards for residential building monitoring and verification. Guidelines for common construction processes, equipment maintenance and commissioning should also be developed to ensure as-built performance.

Verification with a thermal imaging camera (photo by Darcy Hodgkinson)

Addressing the gaps in Australia

None of the articles used in this rapid review specifically discussed the Australian situation. However, the recommendations mentioned above are based on international research that include Australian case studies. Given the general nature of the recommendations, they could be adopted by policy makers in the Australian context.

As a next step it is recommended that these solutions are discussed and validated with professionals in the construction industry across the various Australian states and territories, as well as with policy makers to determine whether these are viable for implementation in the current context.

Studies reviewed

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Disclaimer

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