Gwasanaeth Ynni
Energy Service

Llywodraeth Cymru
Welsh Government

Technical advice note

Building Fabric

Introduction

This guide introduces the main energy saving opportunities through improving building fabric, with the aim of disseminating knowledge to estate and energy managers, allowing public sector organisations in Wales to identify opportunities to upgrade and improve building fabric across their estates. This will result in reduced costs, increased staff and visitor wellbeing and contribute to meeting climate change targets.

Fabric-first approach

Taking a “fabric-first” approach is fundamental to improving the energy performance of a building as it first seeks to address a reduction in building energy usage before installing other decarbonising technologies. In some cases, fabric improvements may even be a prerequisite of installing low carbon heat measures. This guidance note focuses on building fabric which refers to the roof, walls, windows, floors and doors of a building. However, there are many other energy efficiency measures that should be investigated alongside looking to improve building fabric such as upgrading building controls, replacing aging or inefficient equipment such as belt drives on air handling units (AHU).

Improving a building’s thermal efficiency by upgrading the fabric leads to:

- Reduced heat and cooling demand for internal spaces and corresponding lower energy bills and carbon emissions.
- Reduced maintenance costs.
- Compatibility with low carbon heat generation: In poorly performing buildings it is essential that fabric improvements are made to ensure the efficient operation of some forms of low carbon heating such as heat pumps.
- Better temperature control and thermal comfort for occupants.
- Improved productivity: Output and morale are enhanced through reducing draughts, solar glare, overheating, colder areas, as well as noise.
- Lower capital expenditure: A more efficient, well-insulated building require smaller heating and cooling systems.
- Good investment: Better insulation or well-maintained/modified building fabric can increase a building’s value and aesthetics.
- Compliance with regulation and contribution of climate targets: The government stipulates a minimum efficiency requirement for both new build and existing buildings.

Fabric measures

The primary aim of any fabric upgrade project is to improve a building’s ability to retain heat. The amount of heat a building loses is dependent on three factors: the thermal performance of each building element, air-infiltration, and thermal bridging.

Thermal performance of a building element is known as its U-value. This is a measure of the amount of heat that a building will lose through a specific area of an element at a given difference in internal and external temperatures.

Some typical proportions for heat loss through the various building elements are shown in Figure 1. A lower U-value equates to less heat loss through a specified area, therefore the aim of any building fabric measure should be to reduce the U-value of a building element through insulating. Insulation measures can range from low-cost, ‘quick wins’ such as loft insulation, to high cost, high impact measures such as external wall insulation (EWI). The specific measures suitable for a building will depend on factors such as the building’s construction and age.

Air infiltration relates to the unintentional flow of outdoor air into a building through cracks, gaps, and other openings, leading to energy losses and reduced thermal comfort. High levels of air infiltration can be felt and observed through draughts around door and window openings, or a pressure test can be conducted (but in most non-domestic buildings, this is too costly and impractical).

Thermal Bridging refers to areas or components within the building envelope that conduct heat more readily than the surrounding materials, resulting in localized heat loss or gain, reduced energy efficiency, and potential condensation issues. High thermal bridging can be observed where there are areas of damp around openings, and at junctions in building fabric such as where a joist meets the external wall.

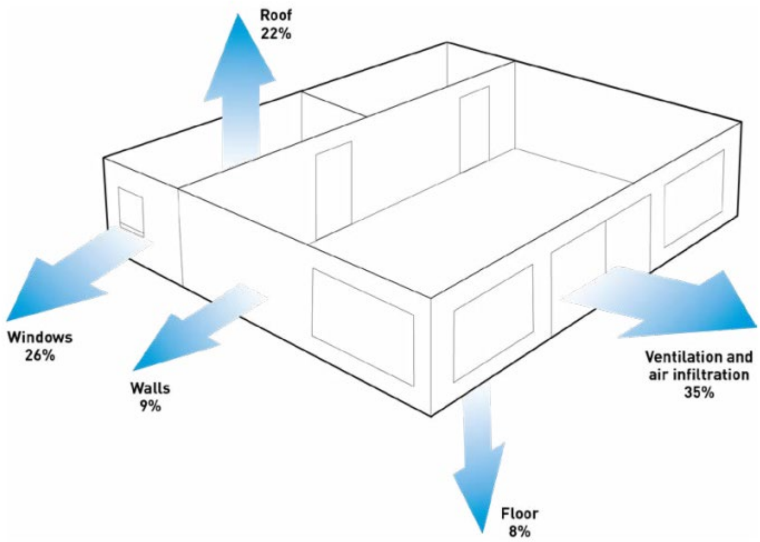

Figure 1 Typical heat loss through building elements

For the vast majority of buildings, reaching net zero will require heating systems to move from fossil-fuel fired boilers (mostly natural gas) to some form of electric heating (heat pumps, direct electric heating or storage heaters). When transitioning a building to electric heating, best practice is to first reduce the heating demand of the building as far as possible to reduce both the required size of heating equipment, and the heating consumption of the building.

This in turn will reduce capital cost of equipment and reduce operational running costs as less electricity will be required. With the current disparity between gas and electricity prices, this is especially important to keep future running costs on a par with existing costs. Therefore, when looking to convert any building to electric heating, fabric measures should always be considered prior to, or alongside heat electrification.

Opportunities

A list of potential insulation measures for each building element, including their relative cost, ease of installation and potential savings have been included in the table below.

Wall Insulation

Insulation Measure	Cost	Installation difficulty	Potential savings	Description
External Wall Insulation (EWI)	£££	High	High	Application of insulation boards or panels, which are then covered with a weather-resistant render or cladding. Structural surveys and planning consent are often required.
Internal Wall insulation (IWI)	£££	High	High	Insulation boards installed on inner walls and covered in plaster/plasterboard. Can be disruptive to operations and reduces Gross Internal Area (GIA).
Cavity Wall Insulation (CWI)	£	Low	Medium	Injection of insulating material into cavities, through drilled holes. Only applicable to buildings with cavity walls.

Roof Insulation

Insulation Measure	Cost	Installation difficulty	Potential savings	Description
Flat Roof Insulation	££	High	High	Application of insulation boards or panels, which are then covered with a waterproof membrane or other weather-resistant material. Various systems (hot roof, cold roof, inverted roof) depending on construction.
Roof cavity Insulation	££	Low	Medium	Installation of insulation material such as batts, rolls or loose-fill insulation in the roof cavity.

Floor Insulation

Insulation Measure	Cost	Installation difficulty	Potential savings	Description
Solid Floor Insulation	£££	High	Medium	Installation of insulation, such as rigid foam boards, beneath the floor of a building.
Suspended Floor Insulation	££	Medium	Medium	Installation of insulation such as batts or rigid boards, between the floor joists or beneath the floorboards of a suspended or raised floor structure.

Windows and doors

Insulation Measure	Cost	Installation difficulty	Potential savings	Description
Double/Triple Glazed windows	££	Medium	Medium	Multi-glazed windows offer better thermal performance with lower U-values and reduced draughts.
Insulated Doors	££	Medium	Medium	Much the same as double/triple glazing, Highly efficient doors can reduce energy loss through a building's openings.
Blinds/ Shutters	£	Medium	Low	Installing blinds and shutters can help to reduce cooling requirements in summer.
Draught Proofing	£££	Low	Medium	Draught proofing involves sealing gaps, cracks, and other openings in windows, doors, and other areas of a building's envelope to prevent the infiltration of cold air and the escape of warm air.
Revolving Door/ Draught Lobby/Air Curtain	£	High	Medium	A draught lobby, also known as an airlock or vestibule, is a small, enclosed space located at the entrance of a building that acts as a buffer zone between the outdoor and indoor environments. It is designed to minimize the infiltration of outside air and the loss of conditioned indoor air when entering or exiting the building.

Risks

Overheating and increased ventilation requirements must be considered when improving building fabric. Improved insulation and air-tightness can reduce the natural ventilation and airflow within a building, which can lead to increased indoor temperatures during warm weather conditions. This can result in discomfort for occupants and may even pose health risks. To mitigate this risk, it is crucial to consider the building's overall thermal performance, employ effective shading strategies, and incorporate appropriate ventilation systems, such as mechanical ventilation with heat recovery (MVHR), to maintain a healthy and comfortable indoor environment while still improving energy efficiency.

Poor workmanship can be a particular issue when installing fabric measures. It can include a wide range of issues such as improper installation of insulation, gaps or overlaps in materials, inadequate sealing of air barriers, uneven application of coatings or finishes, and other work-related errors or oversights. Poor workmanship can compromise the effectiveness and performance of fabric measures, leading to reduced energy efficiency, increased heat loss or gain, air leakage, moisture problems, and overall diminished building performance. It can be a particular issue when installing insulation measures, as they are often hidden within building elements. It is therefore crucial to ensure proper training, supervision, and quality control measures are in place to minimize the risk of poor workmanship and ensure that fabric measures are implemented correctly and according to industry standards and best practices.

Supply chain risks in the context of fabric measures refer to potential challenges or disruptions that may occur during the procurement, production, or distribution of materials and components used in the construction or retrofitting process. In general, the risks include delays in material delivery, shortages, price fluctuations, quality issues, or dependence on a limited number of suppliers. However, when installing fabric measures, there is a particular risk in the lack of skilled contractors available who can deliver fabric improvements. Supply chain risks can impact project timelines, increase costs, and potentially affect the availability and consistency of materials required for fabric measures. To mitigate these risks, it is essential to have a well-planned procurement strategy, maintain good relationships with suppliers, diversify the supply chain where possible, and have contingency plans in place to address any unforeseen disruptions.

Best practice standards

To mitigate the risks, it is important to adhere to standards that specify 'best-practice' throughout the project life cycle, such as PAS 2038. PAS 2038:2021 Retrofitting non-domestic buildings for improved energy efficiency is a publicly available specification (PAS) created by the British Standards Institute (BSI) which outlines a holistic approach to whole-building retrofit. It is a set of guidelines explaining different roles included in the process, as well as the different standards and competencies required and it sets out a framework for assessing the existing building, identifying energy-saving opportunities, developing an appropriate retrofit plan, and ensuring quality control during the implementation phase. The specification also highlights the need for effective monitoring and evaluation throughout construction and operation to verify the performance and benefits of the retrofit measures. Following the standard could help to maximise the potential cost and carbon savings from upgrading building fabric, and reduce risks through the design, construction and operation phases.

Funding options

It can be challenging to develop a positive economic case for fabric measures, due to the often high capital costs involved, and relatively low economic return. These investments, however, will almost always be financially driven and unlikely to capture elements without considerable return on investment such as the decarbonisation of heat.

An integral part of successful project development is robust financing, and the available options should be investigated as thoroughly as technical options. Public sector organisations in Wales may have different financing options available depending on the nature of their services.

There are a number of financing options to consider if not using the organisations own dedicated capital, such as the Wales Funding Programme (WFP), the Low Carbon Heat Grant, the Public Works Loan Board (PWLB), or apply for third party funding and grants.

All available options should be assessed financially and considered on a project by project basis by the decision maker, as the project may be eligible for other funding streams or could be combined with a larger project.

Delivering fabric upgrade projects

It is important to carefully consider the approach to installing fabric measures to maximise the likelihood of the project being delivered and ensure that the solution delivered is the best option. There are 8 main stages recommended to deliver a successful building fabric project:

1. Governance: Senior management buy-in is essential as this ensures suitable resource is assigned to deliver the project. Fabric measures are necessary but can sometimes be intrusive to install and costly. It is therefore recommended that sponsorship is secured at director level, clear timelines are established, and resources are allocated from the project inception.

2. Previous work: Any previous work conducted will help inform the scope of work for an options appraisal, including building upgrades and extensions. In many cases, reports such as Display

Energy Certificates or Energy Performance Certificates, condition surveys, structural surveys or other building studies may be available, particularly for energy-intensive buildings. It is also important to consider planned works such as scheduled maintenance activities or repurposing or abandonment of the site.

3. Data analysis: The aim of the data analysis stage is to prioritise specific sites and projects for fabric measures, then conduct site-specific analysis to inform options appraisal and feasibility studies.

- **Prioritisation**

Estate-wide energy assessments are a useful way of prioritising the worst-performing sites. Energy data can be compared against benchmarks to highlight where buildings are particularly poorly performing compared to an average building of the same size in a similar location, or, sites can be prioritized depending purely on energy consumption. It is important to liaise with other teams within your organisation to understand if any work has been conducted already or whether there are any changes to the site planned for the future that could impact the timeframe for insulation projects.

- **Site-specific analysis**

Energy audits can then be conducted on the priority sites to assess the current state of the building fabric and help inform an options appraisal.
An energy audit should assess the whole building including age and condition of all building elements, plant and equipment. On fabric specifically, the inclusion of thermal imaging can be a very useful tool in assessing the 'hotspots' where the building is losing the most heat. Notes should also be taken on the building's construction, heating and cooling plant, condition of the fabric, age and condition of openings, whether there is any insulation present already, draughts within the building and any damp around windows.

It is also useful to note the building occupancy hours, usage patterns and heating and cooling strategies, including building management systems.

4. Options appraisal: Typically, there are two approaches to improving the building fabric: whole-building refurbishment, or a single measure approach:

Whole-building refurbishment

This offers the opportunity to make significant energy savings and maximise the cost-effectiveness of upgrading the building fabric. For example, combining the installation of insulation with new windows will enable the design and deployment of an optimised low energy heating, ventilation and air conditioning (HVAC) solution.

Single measures

These are targeted, often opportunistic, interventions and therefore the most common type of building improvement project. These often consist of either roof insulation, wall insulation, new windows or draught-proofing. Whilst this approach can achieve some improvements, it is important to consider how the improvement measure might impact on the function of the rest of the building. For example, adding insulation to a building should always be preceded by a review of ventilation provisions to safeguard against surface or interstitial condensation occurring.

5. Business case: The success of a project relies on a viable and successful business case. A good business case requires a strong understanding of the priorities of decision makers. Until now, most proactive investments needed to show a return on investment (ROI) to be justified, something that isn't always possible with fabric measures. However, Welsh public sector organisations with an ambition to decarbonise by 2030 won't be able to achieve this by reducing energy consumption and adjusting user behaviour alone; the decarbonisation of public services requires investment which may not come with a positive ROI. Therefore, the impact of future carbon emissions should be considered alongside financial performance, particularly as potential future costs may be incurred from a highly competitive carbon offsetting market.
Given ROI is often not possible for fabric retrofit projects, additional capital funding is often essential for fabric retrofit projects. Available funding is explained in more detail in the Funding Options section.

6. Delivery routes: Once the business case has been approved, procurement and delivery routes must be decided on. For many whole-building fabric upgrades, a large capital investment is needed and it is therefore likely that a full public tender process will be required, including the development of technical specifications and associated reviews. Utilising existing frameworks or establishing a new one is the only way to avoid this process, therefore it should be considered what frameworks are available and whether they could be employed effectively. This will have a significant impact on how the project is being managed.

An individual tender will be more resource intensive whilst using an established framework may potentially be more expensive. As with the financial options, there is no 'one-size-fits-all'; each project will depend on many factors such as: technical team resource, the desire for project ownership and attitude to risk.

In general, frameworks and outsourced project management become more feasible where largescale investment is required.

7. Implementation: To make sure the ultimate benefits of the project are realised, it is of the utmost importance to define how the project will be handed over to the users, how the technology will be maintained and how the performance will be monitored. The months or years it takes to generate feasibility studies, conduct stakeholder engagement, complete technical option appraisals and financial modelling as well as all the other elements required can easily distract from the ultimate aim of delivering a carbon reduction project. It is therefore important to know upfront what the anticipated project is expected to achieve in terms of financial and carbon savings and to review whether it does so after implementation. Creating operational guidance and a performance monitoring strategy should therefore be a priority. Some frameworks, especially those including energy performance contracts, have a thorough handover and monitoring procedure in place but this should not be taken for granted. It is best practice to share learnings by producing a case study after each delivered project and making it available for colleagues within the organisation and beyond.

Conclusions

The journey towards achieving net zero carbon emissions in the Welsh public sector may seem challenging, but it presents an incredible opportunity for positive change. By embracing a fabric-first approach, public sector organizations in Wales can make significant strides towards reducing energy bills and carbon emissions. Upgrading building fabric not only aligns with the Welsh Government's ambitious climate change targets but also brings numerous benefits such as reduced energy and maintenance costs, enhanced staff and visitor well-being, and improved productivity.

While the risks associated with fabric measures need to be carefully managed, adhering to best-practice standards like PAS 2038 can help ensure successful project delivery. Additionally, various funding options, including grants and loans, are available to support these vital initiatives. With careful planning, sound governance and a strong business case, public sector organisations can confidently embark on fabric upgrade projects and contribute to the creation of a fairer, healthier, and more sustainable society for all.

Find out more about how the Welsh Government Energy Service can help your community enterprise or public sector organisation:

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