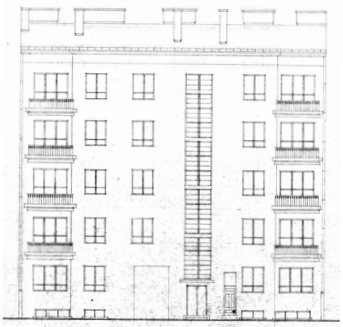
Strategies for masonry building retrofitting



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Strategies for masonry building retrofitting

Suitable bio-based materials and associated challenges.

What can be done to improve the energy efficiency, humidity conditions, and occupant comfort in masonry brick multi-family buildings? How can renewable bio-based materials be used optimally in various scenarios?

This booklet will give an overview on those issues.

Refer to the “Bio-based Material Catalogue” for more information on specific materials mentioned in this guidebook.

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Introduction

For whom is this guidebook?

The knowledge here can be of use for anybody starting work on improving brick buildings, be it thermal retrofitting, simple insulation, or whole adaptive reuse with future-proofing. It can be helpful to architects, homeowners seeking funding, or investors considering options for property improvement.

What can you learn?

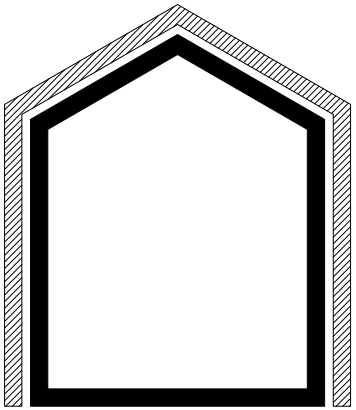
Here you can find basic information on strategies that can be used on various building parts to improve their performance. Depending on the context, different solutions might be preferable, and with them different issues might arise that has to be taken into account, eg. moisture management. The guidebook suggest strategies that can be realized using renewable materials, and examples or those are provided.

Structure of the Guidebook

The guidebook is divided into sections, covering the most common areas of intervention, like Walls, Roofs, Floors, or Basement. In each section you can find various recommended approaches to improving the building envelope. For each intervention there are also suggested examples of renewable bio-based materials that can be used, divided into three categories: insulation, structure, and finishing. Those can be found with detailed data in the additional “Bio-Based Material Catalogue”.

Walls and Windows

Exterior Insulation



Insulating the exterior side is a much more preferred way in terms of moisture control, durability, and overall building physics. It also means that occupants are not disturbed much and can stay in their homes for most of the time. The masonry wall, after insulation, becomes a part of the warm interior and can also act as thermal mass, perfect for managing interior comfort.

The feasibility of this approach depends on how much thickness can be added to the façade, what local laws dictate regarding façade preservation and styling, and other situational factors such as property boundaries and aesthetic regulations. Early consultation with local authorities or heritage expert may be necessary to ensure compliance.

Exterior insulation can be applied in various ways:

1. Insulation boards with external protection: Boards are applied directly to the main wall using adhesives and bolts, followed by a layer of plaster or other protective coating. This approach is cost-effective and straightforward, suitable for a wide range of building types.

2. Substructure with ventilated insulation: A supporting framework is installed, allowing soft or rigid insulation boards to be placed between the structural elements. This assembly is then covered with panels, cladding, or other protective and aesthetic façade elements. The ventilation gap ensures moisture is managed effectively.

3. Enclosed substructure with loose-fill insulation: Insulation materials, such as cellulose or wood fibers, are blown into a sealed cavity within the new structure.

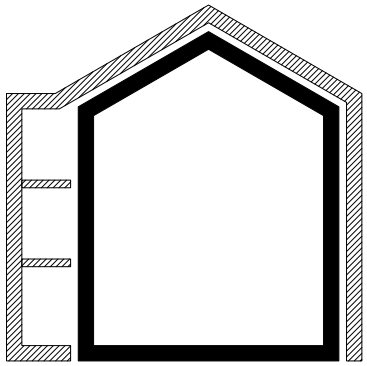
The exterior insulation must be protected from direct water exposure while preferably still allowing the entire wall assembly to “breathe” or dry out freely and quickly. Bio-based materials are a perfect fit due to their natural vapor permeability and capillary action, which help in managing moisture levels effectively. However, covering products like plaster and paint must also be vapor permeable to avoid creating a moisture trap.

Alongside wall insulation, old windows should be replaced with better-performing ones. These new windows should be installed closer to the exterior, within the insulation layer, to reduce thermal bridging. Proper sealing and attention to detail are critical at this stage to prevent air leaks and ensure a continuous thermal barrier.

Additional considerations include integrating solar shading or reflective exterior finishes to reduce summer heat gain and enhance year-round energy performance. Installing external insulation provides an opportunity to modernize the façade’s aesthetic while improving its thermal properties.

Insulation	Structure	Finishing
Rigid or soft fibre boards or batts; Enclosed cavities with blown-in insulation;	Wooden boards and battens as sub-structure for cladding or soft insulation;	Water repellent but moisture permeable coatings; Wooden or composite cladding protecting the insulation from water.

Second Façade



If conditions like local laws, daylight, and space availability allow, adding a second façade to the existing wall is an interesting option that gives new possibilities. It is a form of external insulation, but with extra steps.

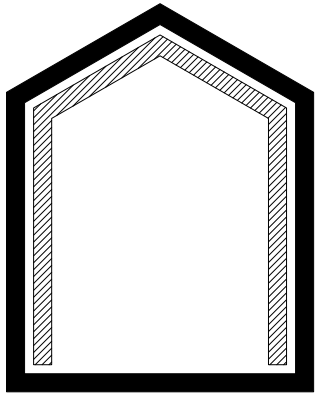
In this case, the existing wall does not need to be changed much or at all, except for some basic repairs, like removing old plaster or repainting. The second façade can be added at a distance while the insulation can be placed either on the outside of the original wall, making the loggias or terraces exterior unheated buffer spaces protecting the wall, or in the new façade layer, making the new loggias unheated (or heated) interior spaces. These can be closed completely, allowing for balconies and terraces to form a kind of winter garden. This approach not only adds more usable space but also allows for significant personalization on a larger scale, moving beyond the current trends of small cluttered balconies. Along personalization, additional features could be installed, like adjustable shading elements that could provide more sun during winters, or more shade during summers. The new façade also offers an opportunity to integrate modern building services like ventilation systems or heat pumps, avoiding any prolonged interior works and enhancing overall building performance.

In terms of materials, the new façade can be made entirely out of structural wood elements that can be prefabricated along with fitting bio-based insulation, windows, or already mentioned preinstalled services. Then in the future, if new improved technologies are more available, the existing systems could be easily replaced or upgraded without much nuisance for the users. Prefabrication further reduces on-site disruption and speeds up the retrofitting process.

Careful attention should also be given to the junctions between the new and existing structures to avoid thermal bridging and ensure the durability of the assembly. Bio-based materials, while sustainable, require protection from prolonged moisture exposure, so detailing and proper drainage are critical.

Insulation	Structure	Finishing
Rigid or soft fibre boards or batts; Enclosed cavities with blown-in insulation; Prefabricated structure-insulation elements;	Wooden or mixed wood-steel elements; prefabricates	Wooden or composite cladding; protective coatings;

Interior Insulation



This is an option when the external façade cannot be altered. It means less interior space for occupants and significant disruption during works, which also have to be performed with best practice and attention to detail to avoid moisture and air penetration problems.

The exterior of the wall needs to be properly treated anyway, meaning removing the old plaster, filling up larger holes and cracks in the brickwork, applying water-resistant coatings, and applying a new layer of plaster or other bio-based low-carbon alternatives. Proper drainage systems should also be inspected or installed to ensure that water does not accumulate near the base of the walls, which could lead to further deterioration over time.

On the interior side, special attention has to be paid to moisture management. Without insulation, the masonry monolithic walls could “breathe” or, in other words, dry rather quickly naturally. Adding insulation will mean a different environment inside; now the main wall is protected from the warmth of the inside, meaning it’s colder and possibly more saturated with water. The warm humid air of the inside could condense water vapor on a cold wall, thus measures to prevent it are needed. One option can be applying a smart vapor barrier properly on the warm side of the insulation in case of insulations that do not bond with the masonry wall. For this option, insulation materials like blown-in cellulose or wood fibers can be used, or other bio-based materials in the form of boards not bonded with masonry. Ensuring a complete seal around edges, joints, and penetrations like electrical outlets is crucial to maintaining the integrity of the vapor barrier.

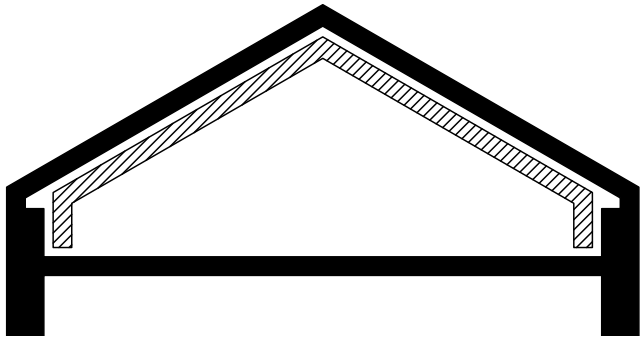
Another option is to take advantage of bio-based natural materials and their properties and bond the insulation material with the masonry wall, forming a homogeneous, slowed-down flow of humidity and temperature between interior and exterior. In this case, a vapor barrier is not needed. Bio-based materials that can be bonded to the masonry with special plasters or clay will work perfectly in this case. Those include organic fiber boards (e.g., wood, hemp, flax) of various densities, or also a hempcrete mix. Careful consideration of the thermal conductivity and capillarity of these materials is important to ensure they are suitable for the specific climate and wall type.

Special attention also must be paid to window replacement and proper insulation to avoid thermal bridges or leaks. Window frames should be aligned with the insulation layer to minimize thermal bridging. Furthermore, detailing around junctions, such as wall-to-floor and wall-to-ceiling interfaces, should be addressed to ensure continuity of the insulation and air barrier. Using bio-based insulation wedges or preformed thermal break elements can help achieve this.

Insulation	Structure	Finishing
Breathable fibre boards bonded with brick wall; vapor protected blown insulation in cavities;	Plasterboards on wooden sub-structure;	Clay based or other natural plasters; vapor permeable or retardant depending on solution;

Roofs

Interior Insulation



If the roof cannot be replaced fully for any reason, and it can be assumed there are no water penetration problems that cannot be fixed, it can be insulated from the inside in a similar way walls can be.

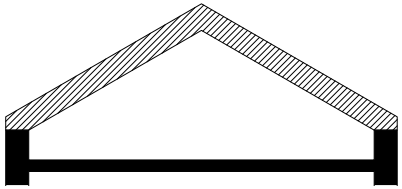
If it is meant to be an unheated space, insulation can be laid out on the floor as on a flat roof. It can be either more rigid insulation boards, or a loose insulation like wood fibre, cellulose, or perlite. In that case the attic should be ventilated, with air intakes placed in a rain protected area around the roof edges, and outlets best positioned on top of the roof ridge, also well protected from any water penetration. The vents must be installed so they last long, and no animals can destroy them to get inside. To avoid that, additional animal habitats could be installed around the protected facade area to let birds choose a better option instead of trying to breach inside roof space. The insulation should also be continuous with the wall insulation to avoid a thermal bridge on the edges of the facade, where it meets the roof edges.

Another option is to close the roof space so it's semi heated. This includes insulating the roof structure itself with boards, batts, or cavity-enclosed blown-in insulation, taking care of any possible water penetration issues, and making sure no humidity or condensation issues occur. In this case, the roof could even be remodeled to a usable space for any purpose, for example a small apartment, office or a social space.

It needs to be stressed that this option is possible only when the roof structure does not pose any problems and can be trusted to be waterproof and sturdy enough to last another couple of decades. If additional actions can be reduced to external layers replacement and no structural improvements are necessary, then this still might be a viable option instead of complete roof replacement.

Insulation	Structure	Finishing
Soft tightly packed fibre boards; Loose insulation if applied to the floor;	Wooden elements for insulation support;	None; natural plasters if space is occupied;

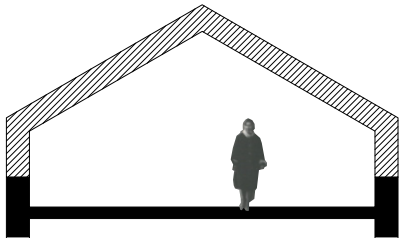
Complete Roof Replacement



Complete roof replacement with a modern structure and technology is mostly the best option. It can achieve the best results in terms of building performance, and allows for including the attic as a future usable space, generating additional profit for the building association, It will be a more expensive option than simple upgrades, but also the one that avoids unexpected moisture problems and other issues present with old elements, prolonging the service life of the building after the upgrade. A brand-new roof will also enable for services like solar hot water or photovoltaics to be installed easily and optimally.

A modern roof build-up can be done in a fully bio-based fashion using renewable and recyclable materials that work well together. A wooden structure can be combined with various bio-based fibre insulations in almost any form, be it rigid batts or loose fill in cavities. Interior can be then finished with wood based products like OSB boards and, if the space is to be occupied, natural plasters with low VOC content and air cleaning abilities.

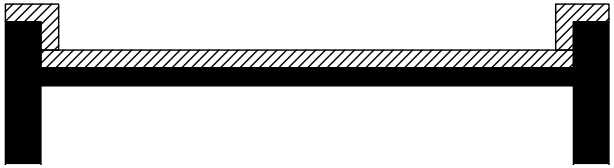
Top-Up



If site specific regulations and structural integrity of exterior walls and floors allow, another fully usable floor can be added on top with brand new walls and roof. This would have similar benefits as replacing the roof, with significant upgrades, the new usable space can be bigger and even more comfortable. That would allow for more revenue for the association. This should be combined with overall refurbishment of the building, preferably adding external insulation or a second façade. Similarly, as with a new roof, everything can be done with lightweight bio-based construction, like wooden frame structure combined with renewable insulation. As with any building work, quality should be of highest priority, with special care put into water and moisture control, especially where brickwork meets with new construction.

Insulation	Structure	Finishing
Soft fibre boards; rigid boards for exterior side; loose fill fibre insulation;	Wooden roof structure with osb or plasterboard covering;	Ceramic roof tiles on the exterior; clay or natural plasters for interiors;

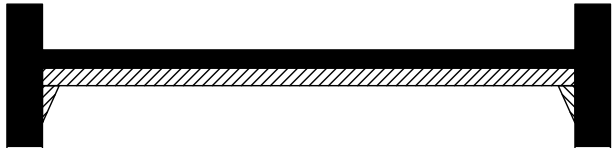
Flat Roofs - Exterior



If the roof is flat, then special care must be taken in terms of preventing water intrusion. Basic fixes like additional waterproof layers or extra sealing can be done immediately with almost no nuisance to the users. However, depending on the situation, more definite actions might be required, for example if the roof is not thermally insulated at all. The roof can be insulated from the exterior, which will perform best in the future, but this will require special construction measures and care to not let water through. Additional possibility is to install a green roof, if the structural integrity of the roof allows for that additional load. Green roofs have the benefit of reducing a heat island effect and retaining water for longer, reducing street flooding during storms. In any case, rigid insulation boards can be used for insulation, like wood fibre or cork, while the green roof usually needs additional layers to prevent roots from piercing waterproofing.

Insulation	Structure	Finishing
Rigid fibre boards like cork or dense wood fibre;	Not needed;	Bitumen waterproof covering; green roof - extra natural layers of gravel, soil, filter fabrics;

Flat Roofs - Interior



The flat roof can also be insulated from the inside, in a similar way as a ceiling, making sure in the first place that humidity will be taken care of properly, similarly to the case of insulating walls form the inside. Water vapor condensing on the cold roof surface will lead to serious problems like meld, rot, and generally less comfortable living environment if not addressed professionally. The new insulation, if bio-based and vapor permeable, can be bonded with the roof structure to form a continuous layer. If, for any reason, roof structure cannot be bonded with the insulation, then vapor barriers need to be placed in front of the insulation, to prevent humidity from reaching the cold roof surface underneath the insulation. Exposed ceiling surface can be treated in many ways, from painted plasterboards to additional aesthetic soundproof boards.

Insulation	Structure	Finishing
Soft o rigid vapor permeable fibre boards;	Montage elements for insulation placement;	Various ceiling coverings like rigid fibre boards, cork, wood composites;

Floors

Floating Floors

The best way to make sure floors will be properly insulated in terms of temperature and sound is to perform a deep remake taking out the whole non load bearing surface of the floors and lay out a “floating floor”. This option of course poses an issue that the occupants must be displaced for the time of works, but everyone will benefit from highly improved sound environment. Additional possibility while redoing the floors is to install a floor heating system to replace standard radiators. This would improve thermal comfort and possibly save some heating energy. Insulating materials in form of rigid boards will serve this purpose perfectly. Examples include dense wood fibre or cork boards.

Insulation	Structure	Finishing
Rigid boards like cork or dense wood fibre;	Not needed;	Clay based cement screed; Wooden or composite flooring;

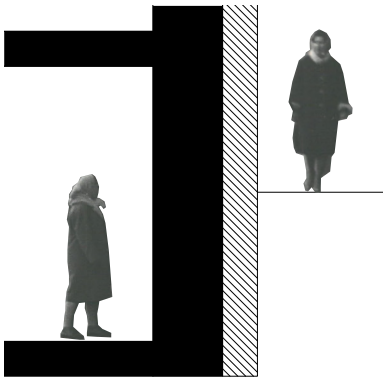
Ceiling Insulation

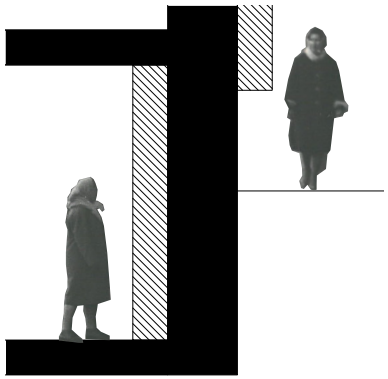
If drastic measures are not possible and minimal nuisance for occupants is preferred, floors can be acoustically insulated from the bottom, in a similar way as faux ceilings are done in offices. This can be done either by attaching rigid board insulation directly to the structural beams or ceiling slab, or using a lightweight substructure holding soft insulation in place, while covering it from the bottom with specifically designed aesthetic elements. In that case all natural fibre, wool, or textile composite boards will suite the needs perfectly. One more possibility is to directly use only stiff acoustic elements that will be exposed as an aesthetic feature. Those include for example cork, mycelium, seaweed, reed, or recycled textile fibre composites. Design possibilities in that case are very broad and can positively influence indoor comfort not only by soundproofing but also visual satisfaction.

Insulation	Structure	Finishing
Rigid or soft soundproof fibre boards or textile composites;	Montage elements for insulation placement;	Various ceiling coverings like rigid fibre boards, cork, wood, mycelium, or textile composites;

Basement

Exterior or Interior Insulation





Strategies for retrofitting basement walls share similarities with approaches used for above-ground walls but require more focus on moisture-related challenges and specialized detailing. Basements are inherently exposed to higher levels of ground moisture and hydrostatic pressure.

If feasible, insulating the exterior side of the basement walls is the optimal solution in terms of building physics. This method retains the maximum amount of usable interior space and includes the masonry wall as part of the dry, warmer interior, using its thermal mass to stabilize indoor temperatures. Additionally, it prevents groundwater from seeping into the walls, protecting the structure from moisture-related damage. However, external insulation requires extensive excavation around the foundation walls to install water-resistant barriers and insulation layers. This process can be both expensive and labor-intensive. Furthermore, in densely built urban environment, retrofitting only one building while adjacent structures remain untreated can lead to persistent issues. Walls connected to untreated neighboring buildings may still transfer moisture, potentially causing internal problems such as efflorescence.

If external insulation is impractical, internal insulation becomes the alternative, but it demands careful execution. For a breathable assembly, bio-based insulation materials can be bonded directly to the masonry wall. This setup allows moisture to diffuse through the wall, preventing condensation issues. Suitable materials include wood fiber boards, hempcrete or hemp-based panels, and other natural fiber batts or boards. While this approach minimizes the need for vapor barriers, it carries inherent risks. The original wall's moisture content and conditions on the exterior side must be well understood. Excessive dampness could saturate the insulation, causing it to deteriorate prematurely or develop mold and fungal growth.

A safer option might involve isolating the original masonry wall from the interior environment. This can be achieved by applying an impermeable water-resistant barrier to the interior face of the masonry, effectively sealing the wall. Insulation can then be applied on the dry, protected interior surface. This strategy ensures the insulation remains dry and effective while preventing moisture from migrating into the used space. Additional measures such as drainage layers or capillary breaks can further enhance the effectiveness of the insulation system.

Insulation	Structure	Finishing
Water and vapor protected rigid fibre insulation or cork; Protected blown-in loose fibre;	Wooden sub-structure for insulation;	Sacrificial plaster layer; clay based or natural plasters;

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