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Multi-Benefit Decision-Making Process for Historic Buildings: Validation of the CALECHE HUB Conceptual Model Through a Literature Review

Noëlle-Laetitia Perret [1,*], Elodie Héberlé [2] and Laure-Emmanuelle Perret [3]

1 Institut Arthur Piaget, J.-L. Pourtalès 10, CH-2000 Neuchâtel, Switzerland
2 Center for Studies and Expertise on Risks, Environment, Mobility and Urban and Country Planning (Cerema), 25 Avenue François Mitterrand, F-69500 Bron, France; elodie.heberle@cerema.fr
3 LMNT Consultancy, Bureau du 111, Place Numa-Droz 2, CP 2511, CH-2001 Neuchâtel, Switzerland; laure@lmntconsultancy.ch
* Correspondence: nlp@iapiaget.ch

Abstract: The CALECHE project, fundSby Horizon Europe, is pioneering sustainable renovation practices for historic buildings that balance energy efficiency with heritage conservation. While this study primarily focuses on energy efficiency in the context of historic building renovation, it also considers aspects of holistic sustainability, such as the use of sustainable materials and adaptive reuse strategies. Through a comprehensive literature review, this study validates the CALECHE HUB conceptual model, emphasising multi-benefit decision-making processes. Key areas of focus includes the assessment of cultural and social values, economic benefits, and environmental sustainability. The analysis explores adaptive reuse strategies and decision support systems (DSSs) to harmonise heritage conservation with energy retrofitting. Using four European demonstration sites as a proof of concept, the findings highlight the need for holistic approaches that respect historic integrity while promoting contemporary functionality. The study underlines the urgency of bridging research gaps, particularly in the integration of new technologies and LCA, to ensure that historic buildings remain vibrant, sustainable, and socially inclusive assets for future generations.

Keywords: historic building renovation; energy efficiency; cultural heritage; multi-benefit decision-making; CALECHE HUB

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1. Introduction

The CALECHE (Coherent Acceptable Low Emission Cultural Heritage Efficient Renovation) project, funded by the European Union under the Horizon Europe programme of research and innovation actions (101123321), is a pioneering initiative. It focuses on developing innovative methods to improve the energy efficiency and environmental sustainability of historic buildings, while respecting their cultural and historical significance. This interdisciplinary project brings together architects, engineers, historians, scientists and industrialists from across Europe, all united by a common goal: to make Europe's historic buildings more liveable, accessible and environmentally sustainable. This approach aligns with Sustainable Development Goal 11 (SDG 11), which emphasises making cities inclusive, safe, resilient, and sustainable, including the protection of the world's cultural heritage.

Historic buildings, comprising approximately 25% of Europe's building stock, are vital to cultural heritage and identity. These structures are not only architectural masterpieces;

they serve as living monuments, embodying historical narratives and fostering a sense of continuity and social cohesion within communities. However, these buildings face modern challenges that require a delicate balance between preserving their aesthetic and historical integrity and improving their energy performance. These challenges are closely aligned with the objectives of the Energy Performance of Buildings Directive (EPBD) [1] and The New European Bauhaus initiative [2], which aim to integrate energy efficiency and heritage preservation.

The renovation of historic buildings involves recognising and balancing multiple values: cultural, social, economic, and environmental. These buildings serve as tangible links to history, helping current generations to connect with their heritage and fostering social cohesion. Renovation can also bring significant economic benefits, such as job creation, tourism, and urban regeneration. In addition, the integration of energy-efficient technologies contributes to environmental sustainability and ensures that these structures meet contemporary standards without compromising their historic integrity. The CALECHE project addresses these challenges through adaptive reuse, a process that revitalizes historic spaces to meet contemporary needs. This approach ensures the continued relevance of these buildings by transforming them into active centres for social gatherings, cultural events, and educational programs, all while significantly improving their energy efficiency. CALECHE's methodology provides a model for sustainable renovation practices that integrate energy efficiency with heritage conservation, thereby addressing both modern environmental and social challenges.

A key component of the project involves the selection of four demonstration sites across Europe:

1. The former Musée-Bibliothèque de Grenoble, France;
2. The municipality of La Chaux-de-Fonds in Switzerland;
3. Villa Matarazzo, Ercolano, Italy;
4. Donner House, Visby, Sweden.

These sites serve as proof of concept for CALECHE's innovative approaches, demonstrating the viability of sustainable renovation methods that respect and preserve the historical significance of these invaluable cultural assets. This aligns with strategies such as Europe 2020: A strategy for smart, sustainable, and inclusive growth [3], which emphasise the importance of adaptive reuse in achieving broader EU sustainability objectives.

The CALECHE project therefore seeks to establish a multi-benefit framework for the renovation of historic buildings. De la Torre [4] underscores the importance of integrating diverse value systems—cultural, social, economic, and environmental—into heritage renovation decision-making processes, providing a foundation for CALECHE's framework. This approach synthesises knowledge about the different values associated with such renovations—including cultural, social, economic, and environmental benefits—and examines how these values are prioritized in decision-making processes. Studies such as those by Rypkema and Cheong [5] illustrate the economic benefits of heritage conservation in promoting sustainable urban development.

This article is organized as follows: First, the methodology for the literature review is presented, outlining the search strategy, inclusion and exclusion criteria, and the approach used to synthesise the collected sources. This ensures a comprehensive and systematic foundation for understanding the key themes in heritage building renovation. Next, the discussion focuses on the main values identified in the context of historic building renovation, with an emphasis on cultural identity, social cohesion, economic growth through urban regeneration, and environmental sustainability achieved through energy efficiency and life cycle assessments. The analysis then examines various methods for assessing these values, highlighting how multi-criteria approaches can balance the diverse benefits of historic building renovations. Finally, the conclusions provide recommendations for future research and practical applications, offering strategies to guide sustainable and heritage-sensitive renovation practices in different contexts. This integration of sustainability and conservation sets the stage for exploring the key values and methodologies that underpin successful renovation strategies for historic buildings.

Our project aligns with the European Union's broader goals of heritage conservation and sustainable development by integrating energy efficiency measures with the preservation of historical and cultural values. The European Framework for Action on Cultural Heritage [6] emphasises the need for cross-sectoral approaches to ensure the sustainability of cultural heritage initiatives, which aligns closely with the CALECHE project's objectives. By analysing the literature on multi-benefit decision-making processes for historic buildings, the CALECHE project deepens our understanding of how to prioritize and balance the different values associated with historic renovations. The project's emphasis on sustainability, combined with its respect for heritage, positions it as a leading example of how to address the pressing environmental and social needs of the present without compromising the rich historical legacies of the past. The Berlin Call to Action [7] strongly advocates reinforcing the link between cultural heritage and sustainability, a principle that underpins the CALECHE project's methodology.

To ensure clarity and consistency in the terminology used throughout the article, the following Table 1 summarizes the key concepts and their variations that are central to this study. These terms are crucial for understanding the multi-dimensional aspects of historic building renovation and energy efficiency within the context of cultural heritage preservation.

Table 1. Main Keywords and Their Variations/Synonyms.

Main Keyword	Variations/Synonyms
Historic building renovation	Heritage building renovation, sustainable renovation, historical rehabilitation
Energy efficiency	Energy performance, energy retrofit, energy technologies
Cultural heritage	Built heritage, heritage preservation, cultural heritage protection
Multi-benefit decision making	Multi-criteria decision making, integrated decision model, multi-dimensional value assessment

2. Material and Methodology

The CALECHE project uses a systematic approach to the literature review to ensure comprehensive coverage of relevant topics. This involves a structured search of academic databases and grey literature, using keywords related to the refurbishment of historic buildings and multi-benefit approaches. The selected literature is critically appraised and synthesised to inform the methodology and objectives of the project.

2.1. Search Strategy

The search strategy for the literature review of the CALECHE project is comprehensive and precise. It includes access to academic databases such as JSTOR, ScienceDirect, and the Avery Index, supplemented by grey literature sources such as OpenGrey and European Commission databases. Keywords are carefully chosen to encapsulate the broad scope of the project, with terms such as "historic building renovation", "sustainable heritage management", "energy efficiency in cultural heritage", and "multi-benefit approach to conservation". The initial search yielded 350 sources, of which 120 were selected for detailed analysis after the application of inclusion and exclusion criteria. This comprehensive strategy ensured that the literature review was based on a well-established body of knowledge, providing a solid foundation for advancing the goals of the CALECHE project. Sources like Energy Efficiency and Historic Buildings by Historic 4d [8] provided a technical basis for improving energy performance without compromising heritage integrity.

2.2. Criteria for Inclusion and Exclusion

To ensure the relevance and quality of the reviewed literature, the CALECHE project implemented explicit inclusion and exclusion criteria. Inclusion criteria focused on peer-reviewed articles, reports from credible organisations, and studies on the refurbishment of historic buildings within the EU sustainability framework [6]. Recent publications (within the last 15 years) were prioritised to reflect current practice and thinking. Exclusion criteria excluded sources that were not peer-reviewed, general media articles, and literature that did not specifically address the link between cultural heritage and energy retrofitting. Publications older than 15 years were excluded unless they were seminal works [9] that provided essential context or foundational knowledge.

2.3. Synthesising Information Across Sources

Our approach to synthesising information for the CALECHE project involved a thematic analysis of the collected literature. We categorised the sources according to key themes relevant to historic renovation and sustainability, such as economic impact, historic and cultural value, environmental benefits, and conservation methods. For example, studies such as those by Broström et al. [10] provided insight into the integration of energy efficiency measures in heritage buildings. This synthesis highlighted the breadth of research and understanding in each area. It facilitated the extraction of good practices [11], innovative approaches, and areas for further exploration. The process was iterative, with the synthesis evolving as more literature was reviewed, ensuring a nuanced understanding that accurately reflected the multi-dimensional nature of the project's scope. As mentioned above, the European Cultural Heritage Summit's Berlin Call to Action highlights the importance of integrating sustainability principles into heritage conservation, which aligns with the CALECHE project's objectives. Digital tools, such as Historic Building Information Modelling (HBIM), were identified as critical in synthesising data and visualizing interventions while ensuring heritage conservation aligned with modern sustainability needs [12].

2.4. Historical Building Renovation: Values and Benefits

The CALECHE project's focus on the renovation of historic buildings is a journey through the intricate web of cultural, social, economic, and environmental values. The renovation of historic buildings is not just about preserving bricks and mortar; it is about preserving the soul of our heritage and identity as Araoz highlights [13]. These buildings are custodians of history, and their rehabilitation brings many benefits. From a cultural perspective, historic buildings embody the artistic and social traditions of past generations. Their refurbishment allows us to present heritage sites within evolving paradigms, respecting their unique characteristics while meeting contemporary conservation and sustainability objectives. Araoz highlights how this process ensures the integrity of heritage places under a new paradigm, bridging the past with the needs of the present. Beyond aesthetics, the renovation of historic structures has a profound social impact, revitalising community spaces, promoting social cohesion, and often transforming these sites into focal points for educational and cultural activities [14]. This approach not only preserves the historic fabric but also strengthens the social fabric of communities, promoting a balance between heritage conservation and adaptation to modern needs.

Economically, the restoration of historic buildings can stimulate significant growth. They often become major tourist attractions, contributing to the local economy. The renovation process is a catalyst for job creation, particularly in specialised trades, and can lead to increased property values. From an environmental perspective, the renovation of historic buildings often improves energy efficiency. This aspect is consistent with broader sustainability goals, such as reducing carbon footprints [15]. Contemporary renovations balance the need to preserve authentic character with the integration of modern amenities and green technologies [16].

3. Results

3.1. Cultural and Social Values

Heritage buildings are more than architectural masterpieces; they manifest historical narratives and cultural identities. As Araoz [13] points out, it is crucial to reinterpret these heritage sites within new paradigms that highlight the dynamic relationship between communities and their historical landmarks. This reinterpretation brings new perspectives and strengthens communities' ties to their historical roots, as highlighted by Perret and Schmidt [17]. These buildings are more than just relics of the past; they actively engage with the present, providing continuity and a sense of belonging. They argue that heritage buildings serve as tangible links between the past and the present, embodying collective memory while also providing opportunities for reinterpretation and adaptation to contemporary needs. Their research highlights the role of these structures in preserving not only architectural value but also the socio-cultural narratives they contain, ensuring that they remain relevant in an evolving societal context. The memory aspect of heritage buildings is profound. They embody collective memories, telling stories of times and people's pasts. These structures act as tangible links to history, allowing current generations to experience a direct connection to their ancestors and the historical events that shaped their community. This connection fosters a sense of identity and continuity that is essential for social cohesion and community resilience.

Involving local communities in the conservation process is paramount. Mydland and Grahn [18] emphasise the need for participatory approaches that identify and integrate local heritage values, ensuring that renovations reflect the cultural identity and priorities of the community [19]. The perceptions of local residents have a significant impact on the success of heritage rehabilitation projects. Involving communities early in the process ensures that the social and cultural benefits are consistent with local values and strengthens the link between people and heritage [20].

Adaptive reuse of heritage buildings goes beyond mere conservation. It involves redesigning historic spaces for contemporary needs, ensuring their continued relevance and functionality. This approach protects the physical integrity of these structures and revitalises their role as active centres of community life. Often these repurposed buildings become hubs for social gatherings, cultural events, community projects, and educational programmes.

Through adaptive reuse, communities inject new energy into these spaces, preserving their significance and encouraging collective stewardship and pride. This process helps to create vibrant, living heritage that continues to contribute to community life and social cohesion. It is a way of honouring the past while making it relevant and accessible in the present, ensuring that heritage buildings remain a valued and integral part of the social fabric.

3.2. Economic Benefits

The restoration of historic buildings is a multifaceted investment that brings a range of economic benefits that extend far beyond the immediate preservation of the structure itself. One of the most significant benefits is the ability of preserved heritage sites to attract tourists seeking authentic cultural experiences. This influx of visitors often acts as a significant economic driver, boosting local economies through increased spending in hospitality, retail, and other related sectors. Tourism in heritage areas also promotes cultural exchange, fostering links between diverse communities while providing economic opportunities for local businesses [21]. The process itself acts as an economic catalyst, creating employment opportunities in a variety of sectors. Specialised areas such as restoration crafts, heritage management, and conservation engineering benefit from increased demand, which not only supports local employment but also helps to preserve traditional skills and knowledge. Conservation projects often serve as training grounds for the next generation of craftspeople, ensuring that expertise in restoration techniques is passed on and remains viable for future projects [22].

The reuse of heritage buildings significantly increases property values and stimulates investment in the surrounding area. By repurposing historic structures for contemporary use, communities can integrate their architectural heritage into modern urban landscapes, making them more attractive to residents and investors alike. This adaptive reuse is often a cornerstone of broader urban regeneration efforts, transforming blighted neighbourhoods into vibrant cultural and economic centres. Investment in historic city centres often catalyses sustainable development by improving infrastructure, fostering innovation, and encouraging long-term community engagement [23].

The ripple effects of heritage conservation go beyond the immediate economic benefits. Restored buildings often act as anchors for further development, encouraging investment in infrastructure and local services. This revitalisation can transform entire neighbourhoods, stimulating urban regeneration and improving the quality of life for residents. Architectural heritage conservation projects can attract new businesses, stimulate tourism, and promote local economic growth (UNESCO, 2009). The adaptive reuse of Villa Matarazzo, for example, would not only preserve a historic monument but also transform it into a thriving cultural and educational centre, stimulating community engagement and creating local employment opportunities.

The economic benefits of building restoration are both direct and far-reaching. From job creation and skills retention to increased property values and urban regeneration, the positive financial impact reinforces the importance of heritage conservation as a sustainable and strategic investment. These projects highlight the potential of heritage as a driver of economic development, benefiting communities while preserving their historical and cultural identity.

3.3. Environmental Sustainability

The environmental aspect of refurbishing historic buildings is increasingly recognised as essential for sustainable development. Cluver and Randall [16] discuss the challenge of incorporating energy efficiency into historic buildings, highlighting the need to balance heritage conservation with reducing environmental impact. Akande et al. [15] analyse energy use in refurbished heritage buildings, shedding light on the complexities of improving energy efficiency in older structures. Innovative technologies are essential to improve thermal efficiency and address broader carbon footprint concerns in historic renovations.

A key tool in achieving this balance is life cycle assessment (LCA). LCA is a methodology used to assess the environmental impacts associated with all stages of a building's life, from the extraction and processing of materials, through construction, use, and disposal at the end of its life. By considering the entire life cycle, LCA provides a comprehensive understanding of a building's carbon footprint and helps to identify strategies to reduce environmental impacts while maintaining historical integrity. Sharma et al. [24] emphasise that LCA is essential for identifying sustainable material choices in heritage renovations. For example, choosing materials with lower embodied carbon or reusing existing structures can significantly reduce the overall environmental impact of renovations.

The importance of LCA in sustainable renovation lies in its ability to highlight the trade-offs between different interventions. For historic buildings, this means assessing not only energy performance improvements but also the impact of material choices and construction processes on the long-term sustainability of the building. Studies such as that by Sharma emphasise that LCA helps to ensure that interventions to improve energy efficiency do not inadvertently cause greater environmental damage through inappropriate material use or disposal practices.

Innovative strategies, such as integrating renewable energy technologies and incorporating phase change materials, represent a promising avenue for enhancing the environmental performance of historic building renovations. As highlighted by Bernardi et al. [25], the careful application of solar panels, heat pumps, and other renewable technologies can significantly reduce energy demand while respecting the aesthetic and structural integrity of heritage buildings. Similarly, Cabeza et al. [26] emphasise the potential of phase change materials, which can store and release thermal energy, thereby improving indoor thermal comfort and energy efficiency. These materials, when incorporated into building envelopes or interior systems, allow for a more sustainable energy profile without compromising the historic character of the structures. These approaches underscore the importance of combining advanced technologies with sensitive restoration practices to achieve both conservation and sustainability goals. In addition, the impact of climate change on retrofitted historic buildings, as discussed in Hao [27], underlines the importance of considering climatic factors in the renovation process. This perspective is crucial to ensure that retrofitted buildings remain resilient and sustainable in a changing climate.

The environmental dimension of retrofitting historic buildings has become increasingly important in the context of sustainable development. Life cycle assessment (LCA), as highlighted by Sharma et al., plays a key role in comprehensively assessing and minimising the carbon footprint of a building throughout its life cycle. Their research emphasises that an LCA approach allows stakeholders to identify opportunities to reduce embodied and operational carbon, ensuring that retrofit efforts are aligned with broader environmental objectives. By incorporating LCA into the planning and execution of retrofit projects, decision makers can balance the dual imperatives of heritage conservation and sustainability, promoting a more holistic approach to environmental stewardship. This methodology allows for a holistic assessment of the environmental footprint associated with the refurbishment of historic buildings, considering the choice of materials, energy efficiency, and long-term sustainability.

The renovation of historic buildings combines therefore cultural, social, economic, and environmental values. The preservation and adaptive reuse of these structures reflects respect for historic buildings and a commitment to sustainable management. The CALECHE project, based on this extensive literature, aims to preserve the rich heritage while adapting historic structures to contemporary sustainability goals. This approach ensures that these buildings remain vibrant and relevant parts of the community, contributing to a sustainable future.

Table 2 provides a summary of key values in historic building renovation, including cultural, social, economic, and environmental perspectives.

Table 2. Multi-Benefit Decision-Making Criteria for Historic Building Renovation.

3.1.1 Cultural and social values	Cultural identity and social cohesion	Heritage buildings are manifestations of historical narratives and cultural identities. Their rehabilitation supports community engagement, promotes continuity, and strengthens a sense of belonging. For example, restored community centres can host cultural events, preserving traditions while encouraging social interaction.
3.1.2 Economic benefits	Economic growth and urban regeneration	The renovation of historic buildings stimulates the local economy by attracting tourism, creating jobs in restoration and hospitality, and increasing property values. The revitalisation of La Chaux-de-Fonds in Switzerland illustrates how heritage conservation can be a catalyst for wider urban development and economic activity.
3.1.3 Environmental sustainability	Sustainable development and energy efficiency	The renovation focuses on improving energy efficiency and minimising environmental impact, while preserving the historic character. Methods such as life cycle assessment (LCA) help to assess material sustainability and climate resilience. For example, the integration of renewable energy technologies can significantly reduce the carbon footprint.
3.1.4 Multi-dimensional value assessment	Integrated value assessment	A holistic approach that balances cultural, social, economic, and environmental benefits. This ensures that renovation decisions respect historic integrity while addressing contemporary sustainability needs and community priorities.

4. Discussion of the Literature on Value Assessment and Prioritization

Multi-dimensional value assessment

Historic buildings embody different values, including cultural, social, economic, and environmental aspects. The challenge is to assess these multiple benefits, which often requires different methodologies and criteria. For example, cultural value might be assessed in terms of architectural authenticity and historical significance, while economic value might be measured in terms of tourism income, job creation, and increased property values. On the other hand, environmental benefits are assessed through energy efficiency improvements, reduced carbon emissions, and life cycle assessments. The literature suggests a multi-criteria approach to value assessment that recognises the interplay between these factors. For example, Historic Environment Scotland's guidelines provide practical frameworks for integrating cultural and environmental values, demonstrating how multi-benefit approaches can harmonize heritage conservation with modern sustainability goals [28]. This approach is also supported by studies such as Johansson et al. [29], which emphasise the importance of balancing different criteria in heritage conservation.

Cultural and social priorities

The prioritisation of cultural and social benefits is critical in the conservation of heritage buildings due to their profound impacts on community identity and cohesion. For example, how heritage sites foster a sense of belonging within communities is discussed by Araoz [13]. Johansson et al. highlight the importance of selecting energy renovation measures that respect the historical and cultural significance of buildings. Their approach is in line with the need to maintain a community's link with its past by ensuring that the historical integrity and aesthetic values of these buildings are preserved. This is not just about nostalgia but about maintaining identity and continuity, which are vital to the social fabric of communities.

Cultural conservation

This aspect emphasises the importance of maintaining the architectural authenticity and aesthetic value of heritage buildings, safeguarding the stories and artistic expressions embedded within these structures. Bandarin and van Oers [30] highlight that heritage buildings play a crucial role in preserving cultural identity and historical narratives, embodying the traditions and values of past societies. This approach aligns with the principles of the Venice Charter, which underscores the responsibility to preserve and transmit the authenticity and integrity of cultural heritage to future generations, recognizing their universal value as shared assets of humanity (Venice Charter, 1964). Furthermore, respecting their historical construction techniques and materials is integral to retaining their authenticity, as highlighted by Frabbri and Zuppiroli [31] in their studies on heritage buildings in Italy.

Social connection and engagement

Beyond their physical preservation, heritage buildings serve as vital hubs for fostering community engagement. These spaces often transform into centres for cultural events, exhibitions, and communal gatherings, acting as catalysts for social interaction and collaboration. By bringing people together, they create opportunities for shared experiences and dialogue, which are crucial for strengthening community ties and fostering a sense of belonging among residents. Studies have shown that such communal activities help reinforce social cohesion and contribute to the well-being of the local population [18]. Additionally, adaptive reuse of heritage sites can create inclusive spaces that engage diverse groups, enabling broader access to cultural heritage and reinforcing its relevance in contemporary society [32]. These social benefits highlight the critical role heritage buildings play in enriching the social fabric of communities while preserving their historical significance.

Educational opportunities

Heritage buildings serve as invaluable educational resources, offering immersive, hands-on learning experiences that delve into history, architecture, and cultural traditions. These structures function as tangible links to the past, allowing learners to engage directly with historical narratives and architectural innovations. Facilitating access to heritage buildings provides communities with the opportunity to educate younger generations about their cultural legacy, fostering an appreciation for the richness of their heritage. This not only instils a sense of pride but also cultivates a responsibility for its preservation. Research highlights that experiential learning in heritage settings enhances historical understanding and critical thinking skills, bridging the gap between theoretical knowledge and real-world contexts [33]. Furthermore, integrating heritage education into formal and informal learning environments has been shown to strengthen cultural awareness and promote intergenerational dialogue [34].

Social inclusion

The adaptive reuse of heritage buildings is a powerful mechanism for promoting social inclusion. By transforming these spaces into community centres, libraries, cultural hubs, or other contemporary uses, they become accessible and relevant to a wider demographic. This approach democratises heritage, ensuring that it is not confined to an elite minority but is shared and enjoyed by all members of the community. Research shows that adaptive reuse not only revitalises under-utilised heritage spaces but also strengthens social cohesion by creating inclusive environments that bring diverse groups together [35]. Furthermore, heritage buildings repurposed for public use provide platforms for cultural expression, education, and dialogue that help to reduce social inequalities and foster a sense of collective belonging [36].

Enriching community life

The cultural and social revitalisation of heritage buildings goes beyond simply preserving the past; it actively contributes to enriching community life in the present. When heritage buildings are thoughtfully integrated into the social fabric, they become vibrant spaces that promote cultural enrichment, encourage social interaction, and support shared learning. These buildings often host community activities such as workshops, exhibitions, and public events that promote cultural expression and strengthen community ties [37]. Research has shown that revitalised heritage spaces can significantly improve residents' quality of life by providing inclusive venues for dialogue and collaboration, thereby strengthening a sense of community identity and belonging [38]. In addition, these spaces can serve as hubs for creative and educational initiatives that not only preserve historical narratives but also inspire innovation and collaboration within communities.

Lasting relevance and usefulness

The goal of heritage conservation goes beyond the mere preservation of historic spaces as static monuments. It emphasises their sustainable adaptation to meet the evolving needs of contemporary communities, while preserving their cultural and historical significance. By embracing adaptive reuse and integrating modern functionalities, heritage buildings can remain dynamic and relevant, providing ongoing value as living parts of the urban and social landscapes. This approach ensures that these structures not only preserve the past but also contribute to the present and future by supporting activities that meet the needs of the community, such as housing, education, and cultural engagement. The continued relevance of these spaces enhances their utility, promotes a stronger connection between heritage and contemporary society, and ensures their enduring significance for future generations [39].

Economic benefits and sustainability

Economic considerations are fundamental to justifying the funding of heritage regeneration projects. The existing literature highlights the significant economic potential of heritage structures, particularly their ability to promote tourism and contribute to urban regeneration [40]. These structures often become focal points for cultural tourism, creating jobs and stimulating local economies while preserving cultural identity [41].

An emerging discourse on sustainable economics is reshaping this perspective, emphasising long-term sustainability over immediate financial gains. This approach integrates economic viability with environmental sustainability, focusing on energy efficiency and reduced carbon footprints in retrofits [26]. For example, energy-efficient retrofits not only reduce operating costs but also increase the long-term value of heritage buildings [42]. This dual focus ensures that heritage conservation is aligned with the broader goals of sustainable development, creating a model that is both economically viable and environmentally responsible [43].

Environmental impact and energy efficiency

Environmental sustainability has become increasingly important in the renovation of historic buildings. The literature highlights energy efficiency and reduction in environmental impact as critical considerations in this area [44]. This focus is part of a wider trend towards sustainable development, which recognises the need to balance heritage conservation with environmental objectives. Historic buildings are often sustainable due to their longevity and the carbon footprint amortisation of their construction materials over time. Recent studies [45] reviewing the integration of renewable technologies in historical and cultural heritage buildings have highlighted innovative approaches. These include the adoption of renewable energy sources and the use of energy-efficient materials, which improve the environmental sustainability of heritage buildings while maintaining their historical integrity [46].

Balancing and integrating different benefits

One of the key themes in the literature is the need to balance and integrate these multiple benefits. This involves finding synergies between cultural, social, economic, and environmental objectives. The literature suggests that successful regeneration projects manage to balance these different benefits, creating spaces that not only are preserved for their historic value but are also economically viable, socially inclusive, and environmentally sustainable [47]. In other words, the assessment and prioritisation of benefits in the refurbishment of historic buildings is complex and multifaceted. The literature reviewed in this chapter provides a comprehensive framework for understanding and assessing the different benefits of these projects. This balanced approach ensures that renovations not only respect heritage values but also contribute positively to contemporary social and environmental goals [48].

Analysis of the impact on users and local communities

This chapter seeks to explore the profound and multifaceted impacts of the renovation of historic buildings on the people and communities that interact with these spaces, drawing on a wide range of literature to provide a comprehensive understanding of how these projects touch the lives of individuals and shape community dynamics. The environmental sustainability and energy efficiency of these renovations play a crucial role, in line with broader sustainable development goals to ensure heritage conservation alongside greener practices. Historic buildings are inherently sustainable, thanks to the long-term amortisation of the carbon footprint of their construction materials. The integration of renewable energy sources and energy-efficient materials, as detailed in the work already cited of Cabeza, de Gracia, and Pisello, is a significant step forward in improving the environmental sustainability of heritage buildings without compromising their historical integrity. This holistic approach ensures that these structures retain their significance and contribute to the ecological and social fabric of modern urban environments.

Introduction to user and community impact

Renovating historic buildings is not just about preserving bricks and mortar; it is about revitalising spaces that have significant meaning for local communities and users. These buildings often serve as cultural landmarks, social hubs, and symbols of collective memory [17]. As such, the impact of these renovations extends far beyond the physical structure itself, affecting the daily experiences of the people who live, work, or visit these buildings, as well as the surrounding areas. The social and cultural value of these structures, combined with their economic and environmental contributions, creates a dynamic interplay that shapes the identity of communities. As Myers et al. (2016) emphasize, heritage inventory and management systems, such as Arches, play a crucial role in the preservation and sustainable management of cultural heritage, promoting community engagement and conservation [49]. Understanding how these renovations influence community engagement, cultural preservation, and local economies is crucial for assessing the full extent of their impact [50].

Cultural and social engagement

Heritage buildings are not only physical structures; they are living representations of a community's history, values, and cultural identity. The renovation of these buildings can significantly contribute to strengthening community bonds, fostering social cohesion, and revitalising local identity. Their restoration often acts as a catalyst for positive social change, providing spaces where people can gather, share experiences, and celebrate their heritage [51]. As Smith [32] emphasizes, heritage sites are central to forming a sense of belonging and pride within communities. This process can also contribute to the revitalisation of surrounding areas, creating spaces for social activities and cultural events that promote a sense of belonging and community pride.

In particular, the adaptive reuse of historic buildings offers numerous opportunities for social inclusion as these spaces can be transformed into community centres, museums, and cultural venues that serve a broad spectrum of the population [52]. By making heritage accessible, these projects ensure that all members of society, including marginalized groups, can engage with their cultural legacy. This inclusivity fosters social interaction and strengthens the collective memory of the community [53].

The integration of energy-efficient technologies in heritage buildings also plays a key role in maintaining their relevance in modern society. The application of sustainable energy systems, such as ground-source heat pumps or solar panels, can be seen in several case studies across Europe, including Italy [44,45,48] and Spain [46], which have successfully balanced heritage conservation with environmental goals. These upgrades not only improve the buildings' environmental performance but also increase their utility for contemporary social functions, ensuring their long-term sustainability in both environmental and social terms [54].

Economic regeneration and tourism

The economic impact of heritage rehabilitation on local communities is significant. Studies have shown that well-preserved heritage sites attract tourists, leading to increased revenue for local businesses and new employment opportunities [55]. This economic uplift can lead to wider urban regeneration, with renovated buildings acting as catalysts for further investment and development in the area. The economic benefits of heritage rehabilitation are not limited to business owners; they also extend to improving the quality of life for residents as revitalized areas can enhance public amenities, increase property values, and create vibrant social spaces. Furthermore, heritage projects often spur local job creation in specialized sectors such as craftsmanship, construction, and tourism, providing long-term employment opportunities that sustain the local economy [56].

Renovated historic buildings can significantly improve the quality of life for users and local communities. Literature suggests that living or working in an aesthetically pleasing and historically rich environment contributes positively to individual well-being by fostering a sense of pride, connection and identity with the space. As highlighted by Tacon [57], well-preserved heritage sites can act as a key element in improving community well-being by fostering cultural engagement and pride. The aesthetic appeal of historic buildings, combined with their historical significance, can enhance psychological well-being by providing a sense of continuity and connection to the past. Gustafsson [58] further supports this notion, noting that heritage sites not only preserve cultural identity, but also improve social cohesion, which has a positive impact on mental health and well-being. In addition, incorporating modern amenities and sustainable features into renovations—such as energy efficient systems and passive design strategies—can improve the functionality and comfort of these buildings, making them more accommodating and enjoyable for contemporary use. According to Allu-Kangkum [59], sustainable architectural practices, including energy efficiency, contribute to both environmental benefits and improved occupant comfort, which plays a role in overall health and satisfaction. These renovations not only meet contemporary needs, but also contribute to overall health by providing healthier indoor environments, reducing energy consumption and increasing comfort. In addition, the revitalisation of these spaces often leads to improved public spaces, increased green spaces, and the promotion of social cohesion, further improving the quality of life for the surrounding community. As Balali et al. [60] point out, these transformations can also reduce environmental impacts while promoting sustainable living practices.

Challenges and concerns

While there are many benefits to the rehabilitation of historic buildings, such as economic revitalization and social cohesion, there are also significant challenges and concerns that must be addressed. One of the primary issues is gentrification and displacement, where rising property values following refurbishment may force out long-term residents who can no longer afford to live in the area. This phenomenon is particularly prevalent in neighborhoods that are undergoing rapid revitalization. Gentrification can result in the loss of affordable housing, cultural displacement, and a reduction in community diversity. The literature suggests various strategies to mitigate these risks, such as inclusive planning and community engagement in the decision-making processes, ensuring that the voices of existing residents are heard and that they benefit from the changes made to their neighborhoods [61]. Involving the community in the planning stages and prioritizing affordable housing initiatives can help prevent displacement and ensure that revitalization efforts benefit all residents, not just newcomers. Additionally, the implementation of policies that focus on equitable development and the preservation of local cultural heritage can create a balance between modernization and maintaining the social fabric of the community. As Barton et al. [62] emphasize, inclusive planning and community engagement are essential to ensuring that the benefits of urban regeneration are shared by all, preventing the displacement of long-term residents.

Environmental impact on local communities

The environmental aspect of building refurbishment is particularly important in urban areas. Energy-efficient and environmentally sustainable renovations contribute to the creation of greener and healthier urban environments [63]. This includes reducing the carbon footprint of buildings, improving local air quality, and often introducing green spaces or sustainable practices that benefit the whole community.

Community involvement and participation

A key theme in the literature is the importance of community involvement in the regeneration process. This includes participatory planning approaches that consider the needs and preferences of local residents and users. The aim is to identify models of effective community involvement and show how these practices lead to more successful and sustainable regeneration projects. Innes and Booher [64] emphasise that fostering a culture of collaboration within community engagement improves project outcomes and strengthens social networks, laying the foundations for sustainable community resilience and empowerment. Their research highlights the transformative potential of integrating diverse community perspectives into planning processes, ensuring that regeneration efforts are deeply rooted in local values and aspirations.

Long-term sustainability and legacy

Finally, we discuss the long-term sustainability of the regeneration of historic buildings. What impact will these projects continue to have on users and communities over time? The literature suggests that renovations that are sensitive to the historical, cultural, and social context of buildings tend to leave a lasting positive legacy for communities, promoting both physical and intangible benefits for future generations [60]. Well-conducted renovations help to preserve not only the physical structure but also the cultural identity embedded in the space, ensuring that future generations can continue to benefit from the cultural and historical value of these buildings. The long-term success of these projects also depends on how effectively the buildings are integrated into the evolving urban fabric, ensuring that they remain relevant and useful to users in the face of changing societal needs.

The regeneration of historic buildings has a significant impact on users and local communities. These projects can transform not only the physical structures but also the social, cultural, economic, and environmental fabric of communities. By understanding and responding to the diverse needs and concerns of the people affected by these refurbishments, restoration projects such as the CALECHE project can ensure that the regeneration of historic buildings is inclusive and sustainable, leaving a positive and lasting impact on communities and individuals. This lasting legacy, when aligned with the principles of sustainability and community participation, will help ensure that the value of heritage continues to flourish for generations to come.

4.1. Research Gaps and Needs in Energy Retrofitting of Historic Buildings

This section examines the current research gaps in the field of energy retrofitting of historic buildings. It identifies the limited studies available, highlights the challenges of balancing heritage conservation and energy efficiency, and underlines the need for more focused and comprehensive research.

In the field of energy retrofitting of existing buildings, multi-criteria decision making is a topic of considerable debate in research circles. Its main objective is to identify the most effective combination of retrofit measures, considering hard science criteria such as energy efficiency, LCA, and cost. It is often used for walls to select the best technique (internal insulation, external insulation, etc.), insulation material (mineral wool, lime hemp concrete, etc.), and thickness.

However, its application to the retrofitting of a historic building is not so common. In their study, Hamid et al. [65] identified 74 publications on this topic using a simple but effective search method. Of these, they found that only nine publications included a methodology that specifically addressed the energy retrofitting of historic buildings. More publications only address the walls as this is the most sensitive component of the building in terms of heritage significance and moisture transfer [66].

This lack of research is notable, especially considering the unique challenges that historic buildings present in balancing the preservation of their cultural and historical values with the demands of modern energy efficiency. The complexity of multi-criteria decision making in this context extends to a wider range of criteria, including but not limited to technical and economic aspects. It encompasses the complex interplay between historic preservation, environmental impact, and socio-economic factors. The limited research highlighted by Hamid et al. emphasises a significant gap and the need for more focused studies. These few but critical studies pave the way for future research aimed at developing comprehensive multi-criteria decision-making frameworks that are tailored to the unique characteristics of historic buildings and effectively balance conservation needs with contemporary sustainability requirements.

4.1.1. Decision Support System for Energy Retrofitting in Historic Buildings

Decision support systems (DSSs) are essential tools that facilitate informed decision making by integrating multiple criteria such as energy performance, heritage conservation, cost, and environmental impact. However, the application of DSSs specifically to the energy retrofitting of historic buildings remains underexplored. This gap highlights the need for targeted solutions that can balance the unique constraints of heritage conservation with the demands of modern energy efficiency.

Several studies have made progress in this area. Ruggeri et al. [67] proposed a score-based decision support system for historic building stock. While promising, their approach was more akin to multi-criteria decision making (MCDM) than a dedicated DSS tool. The results were not implemented as an interactive or adaptive system that could provide real-time decision support.

4.1.2. Energy Retrofitting: Safeguarding Europe's Historic Treasures

In the field of historic building conservation, any intervention, in particular energy retrofitting, must be approached with great care to avoid altering the intrinsic heritage value and physical integrity of the building. Across Europe, there are numerous examples of how energy retrofitting can inadvertently threaten the very essence of historic buildings.

Heritage value, often intangible and imperceptible to the untrained eye, is particularly vulnerable in buildings that have not been legally designated as heritage. In such cases, the urgency of tackling climate change can sometimes overshadow the preservation of heritage aspects. Energy efficiency measures are often implemented without fully assessing their impacts on the building's defining characteristics, resulting in unintended but significant changes to its historic character.

Moreover, the use of inappropriate materials in these often moisture-sensitive structures can lead to significant moisture damage, further compromising their integrity. For example, the STBA's "Responsible Retrofit" framework highlights the critical importance of selecting vapour-permeable and capillary-active materials to ensure compatibility with traditional construction techniques. Failure to do so often results in unintended consequences such as mould growth and loss of structural integrity, as observed in various case studies across Europe [68]. Indeed, common insulating materials from the petrochemical industry, like polystyrene or polyurethane, or renders containing cement are vapour-tight (they cannot be crossed by vapour) and not capillary-active (they cannot convey liquid water within their structure). Traditional materials, like earthen bricks, cob, lime, and plaster, are, on the contrary, permeable to vapour and can contain a certain amount of liquid water without damage. Covering a traditional wall with a vapour-tight and not capillary-active material will block moisture at the interface between them or worse, within the wall. The accumulation of moisture can then lead to mould growth and decay of wooden parts of the wall, especially wooden beams supporting the floor (as is very often the case in historic buildings) or timber-framed walls. It can also nullify the gain of insulation as wet insulation is ineffective but can also lead to aesthetic damages (cement-based render comes apart when the moisture trapped between the wall and the render freezes). Lastly, if mould growth occurs near the interior surface, it can jeopardize the occupants' health as some strains can induce asthma. These damages are even more serious as they develop out of sight, in the wall or behind finishes, without anyone noticing it until it is too late. These are critical issues as many historic buildings are particularly vulnerable to such damage due to their unique construction materials and techniques.

A poignant example of this is seen in a school building, not statutorily designated as cultural heritage, yet possessing modest but significant elements typical of its construction period and typology. These elements, emblematic of the building's heritage and architectural narrative, were unfortunately lost in the retrofitting process. This incident highlights a clear disregard for the building's heritage value, illustrating the broader issue of how energy retrofitting, when not conducted with a heritage-sensitive approach, can irreversibly impact historic structures. Ruggeri et al. provide a similar cautionary perspective, emphasising the need for retrofitting strategies that integrate heritage values into the decision-making process. The removal of traditional elements such as wooden shutters (as shown in Figures 1 and 2) not only affects the visual and historic integrity of the building but also reduces its ability to regulate indoor temperatures naturally. This highlights the importance of considering heritage-sensitive approaches in energy retrofit projects to avoid unintended consequences such as increased overheating and moisture-related damage.

In addition, insulating this type of building with polystyrene can lead to moisture damage, as polystyrene is not sympathetic with walls made of stones and mortar.

This scenario underscores the need for a balanced approach in retrofitting historic buildings, one that duly considers both the urgency of climate change mitigation and the preservation of cultural heritage. It calls for a more nuanced understanding of heritage value, beyond statutory designations, and advocates for retrofitting methods that are sensitive to the unique characteristics of historic buildings.

Figure 1. This image shows a school building in eastern France prior to energy retrofitting. Notable heritage elements such as traditional wooden shutters, original stone facades, and decorative features typical of the building's period of construction are clearly visible. These elements play a key role in preserving the historic character of the building and providing passive climate control by reducing solar heat gain.

Figure 2. This picture shows the same school building after energy retrofitting. The traditional wooden shutters and decorative features of the façade have been removed, and the original stone

façade has been covered with an external insulation system using synthetic materials, probably polystyrene. This change has significantly altered the historic appearance of the building and may have compromised its ability to manage moisture effectively. The loss of traditional shading devices has also reduced the building's passive climate control, potentially increasing the risk of overheating in warmer seasons.

In conclusion, energy retrofitting in the context of historic buildings is a complex challenge that requires a careful and informed approach. It is vital to navigate this path with an awareness of both the environmental imperatives and the cultural significance of these buildings, ensuring that efforts to make them more energy efficient do not inadvertently compromise their historical and cultural integrity.

4.1.3. Answers from Civil Society Organisations

Civil society organisations across Europe have responded to the challenges of energy retrofitting in historic buildings by publishing various guidelines and handbooks. In the UK, for example, the Sustainable Traditional Buildings Alliance (STBA) provides detailed advice on the sustainable retrofitting of historic buildings. Similarly, in France, the CREBA resource centre, led by Cerema, compiles guidelines such as the "Guide pour la réhabilitation du bâti ancien en centre-bourg", which emphasises traditional materials and techniques to improve energy efficiency in heritage buildings [69]. In Italy, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) contributes to projects that balance conservation with modern energy needs, as highlighted by the Politecnico di Milano [70] in its handbook on the conservation and energy efficiency of historic buildings.

Sweden's National Heritage Board provides guidelines for retrofitting historic wooden buildings, focusing on energy efficiency while preserving architectural features, as documented by Broström [10] from Uppsala University. In the Czech Republic, initiatives such as "Heritage First!" by the Czech National Trust emphasise the importance of preserving historic features during energy retrofitting. Similarly, in Poland and Croatia, the Sendzimir Foundation and the Croatian Green Building Council have published a handbook on the modernisation of historic buildings in the context of climate change. In Austria, the Austrian Society for the Preservation of Historic Monuments and Townscapes provides resources on retrofitting historic buildings tailored to the Austrian cultural heritage. Belgium's Royal Institute for Cultural Heritage (KIK-IRPA) provides guidance on energy-efficient renovation, particularly for the country's iconic brick and stone heritage buildings, while Spain's Instituto del Patrimonio Cultural de España (IPCE) focuses on integrating energy-efficient solutions into different architectural styles without compromising their historical integrity. Germany's Deutsche Stiftung Denkmalschutz provides comprehensive guidelines for retrofitting a wide range of historic buildings, ensuring that energy efficiency is compatible with conservation principles. In Switzerland, organisations such as Schweizer Heimatschutz and SIA have developed guidelines that emphasise the use of local, traditional materials and techniques in retrofitting, ensuring that Swiss architectural styles are preserved while improving energy efficiency.

4.1.4. Early European Research Projects Involving Multi-Criteria Decision Making and DSS

Over the last 15 years, several European projects have focused on the energy retrofitting of heritage buildings, with significant contributions from nationally funded projects such as Spara och bevara in Sweden, P-Renewal [71] in Belgium, or BATAN [72] in France. These projects often referred to multi-criteria decision making (multi-criteria decision making) and decision support systems (DSSs) as solutions for better informed decisions, although none of them included intelligent decision support systems (IDSSs) due to the nascent state of AI technology at the time.

The CALECHE project shares foundational elements with the pioneering 3ENCULT project [73], which was funded under the EU Seventh Framework Programme and coordinated by EURAC Research. The 3ENCULT project focused on integrating energy conservation into historic buildings, setting a precedent for balancing energy efficiency with cultural heritage preservation. The methodologies, findings, and case studies from 3ENCULT provide a valuable framework upon which CALECHE can build and innovate. By leveraging the advancements made in 3ENCULT, particularly in passive and active retrofit solutions, diagnostic tools, and long-term sustainability practices, CALECHE can further its mission of retrofitting historic buildings to enhance both longevity and energy efficiency. Troi's publication [74] continues to serve as a milestone for professionals in the field.

Similarly, the EFFESUS project [75], which focused on improving energy efficiency in historic urban areas while preserving cultural heritage, provides important lessons for CALECHE. Supported by the European Commission, EFFESUS developed multi-criteria decision-making-based decision support systems to help stakeholders evaluate and prioritise retrofitting measures. These tools are particularly relevant as they demonstrate how energy efficiency can be harmoniously integrated with heritage conservation, providing a comprehensive approach to decision making that CALECHE can adapt and extend. Although the EFFESUS DSS has been applied at an urban scale, it serves as a robust starting point for CALECHE, as discussed by Egusquiza [76].

Another influential project is RIBuild [77], funded by Horizon 2020 and coordinated by Aalborg University, which focused on internal insulation in historic buildings. RIBuild developed tools for multi-criteria decision making specific to internal insulation, addressing both heritage acceptance and potential moisture damage. The project's emphasis on user-friendly tools and effective dissemination can inspire CALECHE's approach to public and research engagement.

Task 59 and HiBERatlas [78], projects carried out by EURAC Research, aimed to identify and promote best practices for the energy retrofitting of historic buildings. Task 59, funded by the International Energy Agency's Energy in Buildings and Communities programme, focused on integrating solar technologies into the built environment in a way that respects heritage. HiBERatlas, funded by the European Interreg Alpine Space project "ATLAS", created a user-friendly database of best practices and developed an online decision support tool called HiBERtool. These initiatives provide the basis for CALECHE to respond effectively to both public and research needs.

The research community, fostered by these projects, has seen the energy retrofitting of historic buildings emerge as a topic of high interest. Conferences such as Energy Efficiency in Historic Buildings, held in various European cities, reflect the growing importance of this field. The CALECHE project, together with other projects funded by recent EU calls, aims to make significant contributions to ongoing research in the field of retrofitting of historic buildings.

4.2. Challenges and Decision-Making Barriers in Retrofitting Projects

The following discussion addresses the challenges and barriers faced by stakeholders in the decision-making process for retrofitting historic buildings, including conflicting priorities, mistrust of decision support tools, and the complexity of integrating multiple criteria in a heritage-sensitive manner.

The decision-making process for energy retrofitting in historic buildings is fraught with challenges, especially when the full range of criteria required for a holistic approach are not considered. Stakeholders' current practices and perceptions play a crucial role in this process, and neglecting them can lead to failure, as emphasised by Schweber [79].

A key challenge is to ensure that stakeholders understand that energy retrofitting can improve sustainability while preserving the heritage value of buildings. This belief is not universal, as some stakeholders consider conservation principles to be incompatible with energy retrofitting, leading them to either avoid retrofitting altogether or opt for invasive measures that disregard heritage value. Haas [80] and Lidelöw [81] highlight the importance of bridging the gap between research and practice through compelling examples, such as those presented on the HiBERatlas website. However, technical and non-technical barriers need to be addressed to promote the widespread adoption of energy retrofits in heritage buildings.

The use of decision support tools is also not widespread outside the research community. The EN 16883 standard [82] aimed to provide a structured approach for building owners, authorities, and professionals. However, its usability has been questioned, with Leijonhufvud [83] noting that potential users are often uncertain about the benefits and lack external pressure to adopt the standard. Improvements are needed to realise the full potential of this standard, as suggested by Buda [84].

In addition, there is often mistrust of computer-generated decisions, particularly where AI is involved. Stakeholders tend to favour the judgement of experienced professionals over automated systems. This point of view is supported by English Heritage [85], which emphasises the importance of professional expertise in the retrofitting of historic buildings. Stakeholders often distrust automated systems, favouring the judgment of experienced professionals. This hesitance underscores the need for decision support tools to be transparent and inclusive, bridging the gap between technical data and practical expertise. Furthermore, it is important not to overlook the views of residents, whose perceptions of heritage value may differ significantly from those of experts, as shown by Fouseki [86] and Okutan [87].

Decision-making processes in energy retrofits can be broadly divided into two types: stakeholder compromise and the use of structured evaluation methods. The former is common in the retrofitting of historic buildings, with methods such as EN 16883 mentioned above and KuReRA, a method developed by Arfvidsson et al. [88], facilitating stakeholder compromise. However, these approaches often suffer from low replicability and robustness as results can vary depending on the stakeholders involved. Okutan's findings suggest that public opinion should be considered alongside expert analysis to achieve a more balanced approach.

Structured evaluation frameworks offer an alternative by providing a systematic approach to decision making. Stephan [89] used an ELECTRE III methodology to determine the best retrofit strategy for limestone buildings, considering both qualitative and quantitative criteria. Stanojevic [90] applied the fuzzy analytic hierarchy process (AHP) within the DSS of the EFFESUS project, demonstrating the robustness and replicability of this methodology. However, the challenge is to select the most appropriate framework for the specific context of retrofitting historic buildings.

The choice of criteria is crucial in these structured approaches. Marincioni [91] emphasised the importance of context in selecting retrofit measures, while Vitruvius' principles of *utilitas*, *firmitas*, and *venustas* [92] provide a framework for integrating both objective and subjective criteria. Heritage value and moisture damage are particularly important considerations that need to be incorporated into the assessment process to address the unique challenges of historic buildings [93].

The evaluation of these criteria requires a detailed assessment of both quantitative and qualitative aspects. Quantitative criteria such as energy consumption, cost effectiveness, and environmental impact need to be carefully measured to ensure accuracy and relevance. According to Kyritsi et al. [94], an integrated methodology for energy retrofitting in heritage buildings requires comprehensive data collection and analysis of energy use and performance to ensure that energy efficiency measures are both effective and economically viable. In contrast, qualitative criteria such as heritage value, aesthetics, and user comfort are inherently more subjective and often require expert input. Marincioni et al. emphasise that decision making in the refurbishment of historic buildings should be supported by the scientific literature to better understand how these qualitative aspects influence the performance and conservation of heritage structures. The depth of assessment needs to strike a balance between precision and practicality as general approaches may be more accessible to non-experts, while detailed assessments may be too complex for those without scientific expertise.

4.2.1. Integrating Quantitative and Qualitative Assessments for Balanced Decision Making in Heritage Retrofitting

This subsection highlights the importance of integrated assessment, combining quantitative and qualitative data to balance heritage conservation with sustainability objectives. It emphasises the need for a user-friendly DSS that remains accessible to different stakeholders.

An integrated assessment, combining quantitative and qualitative data, is essential to ensure a balanced assessment that respects both heritage conservation and sustainability objectives. By including measurable criteria—such as energy consumption, cost efficiency, and environmental impact—alongside qualitative aspects such as heritage value, aesthetics, and user comfort, the decision-making process becomes more comprehensive and nuanced.

The CALECHE project's decision support system (DSS) must be designed with this integrated approach in mind. It should take into account the perspectives of different stakeholders and provide a user-friendly interface to ensure accessibility for non-experts. Despite the complexity of the involved concepts, the DSS should provide clear, actionable insights to help users navigate the trade-offs between conservation priorities and modern sustainability requirements.

This balanced assessment approach ensures that historic buildings can be retrofitted in a way that preserves their cultural significance while improving energy efficiency and reducing environmental impact. Integrating multiple data sources and stakeholder input strengthens the robustness of the decision-making process and supports the long-term viability of refurbishment projects.

4.2.2. Gaps and Opportunities

The CALECHE framework identifies several gaps in the current literature and provides opportunities for future research in the field of retrofitting historic buildings. Long-term studies of the durability of energy-efficient renovations are particularly lacking. According to the STBA's 2020 Gap Analysis, monitoring the performance of energy retrofitting over extended periods is essential to validate their effectiveness. This research is particularly critical to address unforeseen issues, such as material incompatibility and reduced insulation performance over time. CALECHE could lead research efforts to track these renovations over time, providing valuable insights into sustainable practices for heritage conservation. The integration of emerging technologies, such as AI and IoT, into historic renovations is another promising but under-researched area. These technologies could improve management and conservation practices and help to capture and interpret the historical and memorial significance of heritage structures.

The socio-economic impact of renovation projects on local communities also needs to be further explored. CALECHE could explore the balance between economic development and community heritage conservation, addressing issues such as gentrification and its socio-cultural implications. A nuanced cost–benefit analysis, in line with CALECHE's multi-dimensional approach, is needed to comprehensively assess the economic, environmental, social, and historical returns of regeneration projects.

Comparative studies of policy and regulatory frameworks in different regions could further inform CALECHE's strategy to ensure that renovation practices are adapted to different regulatory environments, while respecting the historical and memorial significance of heritage buildings. Environmental sustainability, beyond energy efficiency, especially in terms of material sustainability and life cycle assessment (LCA), is another critical area for research. CALECHE could contribute to the circular economy by exploring the sustainable sourcing and recycling of materials in renovations, always mindful of the historical value and memories associated with these materials.

Community involvement in renovation processes is crucial but often under-researched. Future research could focus on participatory approaches to ensure that renovations reflect the needs and values of the community, while respecting the historical and memorial significance of heritage sites.

5. Conclusions

The CALECHE framework literature review provides an in-depth analysis of the renovation of historic buildings, emphasising their cultural, social, and economic significance. These structures are not merely physical entities—they serve as living embodiments of our heritage, playing a critical role in preserving cultural identity across generations. They offer a tangible connection to the past, acting as custodians of history, culture, and memory while fostering a sense of belonging and continuity within communities. Moreover, historic buildings often act as catalysts for local economic development. Through heritage tourism, the revitalization of surrounding areas, increased property values, and the creation of jobs in specialized trades, renovation projects provide substantial economic benefits to the local economy, particularly in cities and regions where heritage is integral to the community's identity.

The environmental aspect of historic building renovation is equally vital. As energy efficiency becomes a central focus of contemporary renovation strategies, integrating sustainable practices into the refurbishment process allows historic buildings to contribute significantly to reducing carbon footprints and meeting broader sustainability goals. This approach aligns with the increasing emphasis on low-carbon, energy-efficient buildings as part of the European Green Deal and other global sustainability initiatives. Given their long life span, historic buildings inherently promote sustainability, with their reuse and refurbishment providing a low-carbon alternative to new construction, which typically requires more energy and results in greater environmental impact.

Despite the growing body of research on these topics, critical gaps remain, particularly in the areas of long-term sustainability and life cycle assessment of refurbishment projects. Most studies focus primarily on short-term impacts, often neglecting the long-term performance of renovated buildings. There is an urgent need for comprehensive research that assesses the environmental costs and benefits of renovation compared with new construction over the entire life cycle. Such studies would provide a more accurate understanding of the sustainability of heritage renovation projects and offer valuable guidance for policymakers, architects, and developers in making informed decisions. Additionally, the socio-cultural benefits of these projects—such as job creation in skilled trades, strengthening community ties, and the broader societal value of heritage conservation—have yet to be fully explored. While the economic advantages of renovating historic buildings are well-documented, further research into these social aspects is essential.

Technological innovation is another critical area for future research. The integration of modern building systems, advanced materials, and renewable energy technologies into historic buildings presents significant potential for enhancing energy performance without compromising the architectural and historical integrity of these structures. Emerging solutions, such as phase-change materials, advanced insulation techniques, and renewable energy systems, offer opportunities to create buildings that are both energy efficient and culturally sensitive. Research should focus on developing technologies that seamlessly integrate modern systems with traditional materials, ensuring that energy-efficient measures do not undermine the aesthetic, historical, or functional values of the buildings. Moreover, the adoption of digital tools like building information modeling (BIM) in heritage building refurbishment could improve the precision and efficiency of renovation processes, offering a more detailed understanding of a building's structure and energy performance.

Another key challenge identified in this study is the need for updated policy and regulatory frameworks that support both sustainable and culturally sensitive renovation practices. Current policies often lack clear guidance or incentives for energy-efficient renovation of historic buildings, and the lack of harmonization between regions further hinders the widespread implementation of these strategies. The CALECHE project has highlighted the need for policy frameworks that not only encourage sustainable practices but also respect the cultural and historical value of heritage buildings. Strengthening the integration of sustainability and heritage conservation into building regulations across Europe is crucial. Transnational cooperation and the exchange of knowledge are necessary to develop cohesive, effective policies that promote cultural heritage conservation while addressing contemporary environmental and social needs.

To broaden the applicability of the CALECHE framework, it is essential to develop recommendations that are adaptable to various geographical contexts, reflecting the unique characteristics of each region. These recommendations should account for regional differences in climate, construction materials, local heritage policies, and social and political contexts. For instance, in colder regions, where thermal performance is a significant concern, the focus may be on improving insulation and heating efficiency, while in warmer, Mediterranean climates, strategies for shading and cooling might take precedence. By adapting the CALECHE framework to suit these specific conditions, it can become a versatile, globally applicable tool for historic building renovation.

Integrating European case studies into the CALECHE framework further enhances its relevance and effectiveness. For example, retrofitting practices for timber buildings in Sweden, the adaptive reuse of industrial heritage sites in Germany, and conservation strategies for historic city centres in Italy can provide valuable insights into diverse approaches to heritage building renovation across Europe. Incorporating lessons from these case studies will not only validate the flexibility of the CALECHE framework but also ensure its applicability to a wide range of contexts, from rural heritage sites to urban centres. Furthermore, European initiatives like the 3ENCULT project and the Sustainable Traditional Buildings Alliance (STBA) guidelines in the UK exemplify successful interdisciplinary collaboration and can serve as inspiration for similar initiatives across Europe.

The CALECHE project offers a unique opportunity to make a significant contribution to the field of historic building renovation. Its findings and recommendations provide a valuable resource for policymakers, architects, conservationists, and researchers striving to reconcile heritage conservation with the demands of sustainable development. The project's European focus and interdisciplinary approach guarantee that its impact will be broad and lasting, offering a comprehensive framework for historic building renovation that is both scientifically rigorous and practically applicable. The research generated by this project will inform future renovation strategies and help create buildings that not only preserve our shared cultural heritage but also serve as models of sustainability, adaptability, and resilience.

We hope that the CALECHE project will continue to serve as a guide for future research and practice in heritage conservation. By emphasising interdisciplinary collaboration, the integration of innovative technologies, and the need for context-specific approaches, the project lays the foundation for ensuring a sustainable future for historic buildings. By embracing this vision, we can ensure that historic buildings remain vital and relevant for future generations, acting as bridges between the past and the future, and continuing to contribute to the social, cultural, and environmental fabric of our communities.

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References

1. Energy Performance of Buildings Directive (EPBD). *Directive EU/2023/1791*; Energy Performance of Buildings Directive: Coimbra, Portugal, 2023.
2. European Commission. *The New European Bauhaus Initiative*; European Commission: Brussels, Belgium, 2021.
3. European Commission. *Europe 2020: A Strategy for Smart, Sustainable, and Inclusive Growth*; European Commission: Brussels, Belgium, 2020.
4. De la Torre, M. *Assessing the Values of Cultural Heritage*; Getty Conservation Institute: Los Angeles, CA, USA, 2013.
5. Rypkema, D.; Cheong, C. *The Economic Impacts of Historic Preservation*; Advisory Council on Historic Preservation: Washington, DC, USA, 2016. Available online: https://www.achp.gov/sites/default/files/guidance/2018-06/Economic%20Impacts%20v5-FINAL.pdf (accessed on 16 January 2024).
6. European Commission. European Framework for Action on Cultural Heritage. 2019. Available online: https://op.europa.eu/en/publication-detail/-/publication/5a9c3144-80f1-11e9-9f05-01aa75ed71a1 (accessed on 16 January 2024).
7. European Cultural Heritage Summit. *Berlin Call to Action: Cultural Heritage for the Future of Europe*; European Cultural Heritage Summit: Berlin, Germany, 2018.
8. Historic England. Energy Efficiency and Historic Buildings: How to Improve Energy Efficiency. 2018. Available online: https://cms.historicengland.org.uk/media/5516/heag094-how-to-improve-energy-efficiency.pdf (accessed on 16 January 2024).
9. Avrami, E.; Mason, R.; De La Torre, M. *Values and Heritage Conservation*; Getty Conservation Institute: Los Angeles, CA, USA, 2000.
10. Broström, T.; Eriksson, P.; Norrström, H. *Bruka, Bevara och Energieffektivisera*; Offentliga Fastigheter: Stockholm, Sweden, 2015. Available online: https://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-269102 (accessed on 15 January 2024).
11. U.S. Environmental Protection Agency. Smart Growth and Preservation of Existing and Historic Buildings. Available online: https://www.epa.gov/smartgrowth/smart-growth-and-preservation-existing-and-historic-buildings (accessed on 16 January 2024).
12. Maxwell, I. *Integrating Digital Technologies in Support of Historic Building Information Modelling: BIM4Conservation (HBIM)*; COTAC: London, UK, 2014.
13. Araoz, G.F. Preserving Heritage Places under a New Paradigm. *J. Cult. Herit. Manag. Sustain. Dev.* **2011**, *1*, 55–60. [CrossRef]
14. Tyler, I. The Ethical Imperatives of Historic Preservation. *J. Herit. Ethics* **2007**, *5*, 102–115.
15. Akande, O.K.; Odeleye, D.; Coday, A.; Jimenez Bescos, C. Performance Evaluation of Operational Energy Use in Refurbishment, Reuse, and Conservation of Heritage Buildings for Optimum Sustainability. *Front. Archit. Res.* **2016**, *5*, 371–382. [CrossRef]
16. Cluver, J.H.; Randall, B. Saving Energy in Historic Buildings: Balancing Efficiency and Value. *Plan. High. Educ.* **2012**, *40*, 13–25.

17. Perret, N.-L.; Schmidt, H.-J. *Memories Lost in the Middle Ages: Collective Forgetting as an Alternative Procedure of Social Cohesion (Memoria and Remembrance Practices)*; Brepols Publishers: Turnhout, Belgium, 2023.
18. Mydland, L.; Grahn, W. Identifying heritage values in local communities. *Int. J. Herit. Stud.* **2012**, *18*, 564–587. [CrossRef]
19. Wise, F.; Jones, D.; Moncaster, A. Reducing carbon from heritage buildings: The importance of residents' views, values and behaviours. *J. Archit. Conserv.* **2021**, *27*, 117–146. [CrossRef]
20. Coles, T.; Dinan, C.; Warren, N. Carbon Villains? Climate Change Responses among Accommodation Providers in Historic Premises. *J. Herit. Tour.* **2016**, *11*, 25–42. [CrossRef]
21. Ashworth, G.J.; Tunbridge, J.E. *The Tourist-Historic City: Retrospect and Prospect of Managing the Heritage City*; Pergamon: Oxford, UK, 2000.
22. Mason, R. *Economics and Historic Preservation: A Guide and Review of the Literature*; Brookings Institution Metropolitan Policy Program: Washington, DC, USA, 2005.
23. Licciardi, G.; Amirtahmasebi, R. (Eds.) *The Economics of Uniqueness: Investing in Historic City Cores and Cultural Heritage Assets for Sustainable Development*; World Bank: Washington, DC, USA, 2012.
24. Sharma, A.; Saxena, A.; Sethi, M.; Shree, V. Life Cycle Assessment of Buildings: A Review. *Renew. Sustain. Energy Rev.* **2011**, *15*, 871–875. [CrossRef]
25. Bernardi, A.; Simon, S.; Riccio, M.; Troi, A. Evaluation of the Effect of Phase Change Materials Technology on the Thermal Stability of Cultural Heritage Objects. *J. Cult. Herit.* **2014**, *15*, 470–478. [CrossRef]
26. Cabeza, L.F.; De Gracia, A.; Pisello, A.L. Integration of Renewable Technologies in Historical and Heritage Buildings: A Review. *Energy Build.* **2018**, *177*, 96–111. [CrossRef]
27. Hao, L.; Herrera-Avellanosa, D.; Del Pero, C.; Troi, A. What Are the Implications of Climate Change for Retrofitted Historic Buildings? A Literature Review. *Sustainability* **2020**, *12*, 7557. [CrossRef]
28. Historic Environment Scotland. Guide to Energy Retrofit of Traditional Buildings. 2021. Available online: https://www.historicenvironment.scot/archives-and-research/publications/publication/?publicationid=47c9f2eb-1ade-4a76-a775-add0008972f3 (accessed on 22 December 2024).
29. Johansson, D.; Eriksson, P.; Luciani, A.; Rizzo, A.; Örn, T. Prioritize the Right Energy Measures in Historic Buildings—Approach and Measure Selection. *Earth Environ. Sci.* **2023**, *863*, 012042. [CrossRef]
30. Bandarin, F.; van Oers, R. The Historic Urban Landscape. In *Managing Heritage in an Urban Century*; Wiley Blackwell: Chichester, UK, 2012.
31. Frabbri, K.; Zuppiroli, M. Heritage buildings and energy performance. Mapping with GIS tools. *Energy Build.* **2012**, *48*, 137–145. [CrossRef]
32. Smith, L. *Uses of Heritage*; Routledge: London, UK, 2006.
33. Hooper-Greenhill, E. *Museums and Education: Purpose, Pedagogy, Performance*; Routledge: London, UK, 2007.
34. ICOMOS. *Guidelines for Education and Training in the Conservation of Monuments, Ensembles and Sites*; International Council on Monuments and Sites: Paris, France, 1993.
35. Bullen, P.A.; Love, P.E.D. Adaptive reuse of heritage buildings. *Struct. Surv.* **2011**, *29*, 411–421. [CrossRef]
36. Foster, S. Heritage for All: Promoting Inclusion through Adaptive Reuse. *J. Cult. Herit. Manag. Sustain. Dev.* **2020**, *10*, 12–25.
37. Tweed, C.; Sutherland, M. Built cultural heritage and sustainable urban development. *Landsc. Urban Plan.* **2007**, *83*, 62–69. [CrossRef]
38. Rodwell, D. *Conservation and Sustainability in Historic Cities*; Blackwell Publishing: Oxford, UK, 2007.
39. Pendlebury, J.; Townshend, T.; Gilroy, R. The conservation of English cultural built heritage: A force for social inclusion? *Int. J. Herit. Stud.* **2009**, *10*, 11–31. [CrossRef]
40. Loulanski, T.; Loulanski, V. The sustainable integration of cultural heritage and tourism: A meta-study. *J. Sustain. Tour.* **2011**, *19*, 837–862. [CrossRef]
41. Oruc, S.; Dikbas, H.A.; Gumus, B.; Yucel, I. The Impact of Climate Change on Construction Activity Performance. *Buildings* **2024**, *14*, 372. [CrossRef]
42. Hayles, C. *How Resilient Are Buildings in the UK and Wales to the Challenges Associated with a Changing Climate? Practical Recommendations for Risk-Based Adaptation*; Cardiff Metropolitan University: Cardiff, UK, 2022. [CrossRef]
43. Polo López, C.S.; Troia, F.; Nocera, F. Photovoltaic BIPV Systems and Architectural Heritage: New Balance between Conservation and Transformation. An Assessment Method for Heritage Values Compatibility and Energy Benefits of Interventions. *Sustainability* **2021**, *13*, 5107. [CrossRef]
44. Castaldo, V.L.; Pisello, A.L.; Boarin, P.; Petrozzi, A.; Cotana, F. The experience of international sustainability protocols for retrofitting historical buildings in Italy. *Buildings* **2017**, *7*, 52. [CrossRef]
45. Emmi, G.; Zarrella, A.; De Carli, M.; Moretto, S.; Galgaro, A.; Cultrera, M.; Di Tuccio, M.; Bernardi, A. Ground source heat pump systems in historical buildings: Two Italian case studies. *Energy Procedia* **2017**, *133*, 183–194. [CrossRef]

46. Martínez Garrido, M.I.; Fort, R.; Varas Muriel, M.J. Sensor-based monitoring of heating system effectiveness and efficiency in Spanish churches. *Indoor Built Environ.* **2017**, *26*, 1102–1122. [CrossRef]
47. Pisello, A.L.; Petrozzi, A.; Castaldo, V.L.; Cotana, F. On an innovative integrated technique for energy refurbishment of historical buildings: Thermal-energy, economic and environmental analysis of a case study. *Appl. Energy* **2016**, *162*, 1313–1322. [CrossRef]
48. Franco, G.; Magrini, A.; Cartesegna, M.; Guerrini, M. Towards a systematic approach for energy refurbishment of historical buildings: The case study of Albergo dei Poveri in Genoa, Italy. *Energy Build.* **2015**, *95*, 153–159. [CrossRef]
49. Myers, D.; Avrami, I.; Dalgity, A. The Arches Heritage Inventory and Management System: A Platform for the Heritage Field. *J. Cult. Herit. Manag. Sustain. Dev.* **2016**, *6*, 81–92.
50. Pendlebury, J. Conservation and the Historic Environment: The Contribution of Historic Buildings to Sustainable Development. *J. Urban Regen. Renew.* **2013**, *7*, 214–230.
51. Tilden, F. *Interpreting Our Heritage*, 4th ed.; University of North Carolina Press: Chapel Hill, NC, USA, 2007.
52. Polo Lopez, C.; Frontini, F. Energy efficiency and renewable solar energy integration in historical buildings heritage. *Energy Procedia* **2014**, *48*, 1493–1502. [CrossRef]
53. Lees, L.; Shin, H.B.; López-Morales, E. Gentrification and Displacement: Urban Inequality in Cities. *City* **2019**, *3*, 320–345. [CrossRef]
54. Bulkeley, H.; Betsill, M.M. Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change. *Environ. Politics* **2005**, *14*, 42–63. [CrossRef]
55. Gilderbloom, J.I.; Hanka, M.J.; Ambrosius, J.D. Historic Preservation's Impact on Job Creation, Property Values, and Environmental Sustainability. *J. Urban. Int. Res. Placemak. Urban Sustain.* **2009**, *2*, 83–101. [CrossRef]
56. Leask, A.; Fyall, A.; Garrod, B. *Managing World Heritage Sites*; Routledge: London, UK, 2006.
57. Tacon, P. New and Emerging Challenges to Heritage and Well-Being: A Critical Review. *Heritage* **2019**, *2*, 1300–1315. [CrossRef]
58. Gustafsson, A. The Social Benefits of Heritage. In *Applied Cultural Heritage: How Telling the Past at Historic Sites Benefits Society*; Museum International: Kalmar, Sweden, 2010.
59. Allu-Kangkum, E.L.A. The Role of Sustainable Architecture in Human Health and Well-Being: A Review. *Int. J. Res. Sci. Innov.* **2023**, *10*, 16–22.
60. Balali, A.; Yunusa-Kaltungo, A.; Edwards, R. A Systematic Review of Passive Energy Consumption Optimization Strategy Selection for Buildings through Multiple Criteria Decision-Making Techniques. *Renew. Sustain. Energy Rev.* **2023**, *171*, 113013. [CrossRef]
61. Bokolo, A.J. The Role of Community Engagement in Urban Innovation Towards the Co-Creation of Smart Sustainable Cities. *J. Knowl. Econ.* **2023**, *15*, 1592–1624. [CrossRef]
62. Barton, H.; Grant, M.; Guise, R. *Shaping Neighbourhoods: For Local Health and Global Sustainability*; SAGE Publications Ltd.: London, UK, 2010.
63. Allen, J.G.; MacNaughton, P.; Cedeno Laurent, J.G.; Flanigan, S.S.; Eitland, E.S.; Spengler, J.D. Green Buildings and Health. *Environ. Health Perspect.* **2015**, *123*, 672–680. [CrossRef]
64. Innes, J.E.; Booher, D.E. Refining and Broadening the Concept of Collaboration and Public Participation: Culture, Organizational Strategy, and Policy. *Public Adm. Rev.* **2004**, *64*, 593–607. [CrossRef]
65. Hamid, A.A.; Bagge, H.; Johansson, D.; Eriksson, P.; Fransson, V.; Kristoffersson, J. Strategies and Combinations of Measures for Renovations of Swedish Heritage Buildings—A Review. In *AIP Conference Proceedings*; AIP Publishing: New York, NY, USA, 2023. [CrossRef]
66. Zagorskas, J.; Zavadskas, E.K.; Turskis, Z.; Burinskienė, M.; Blumberga, A.; Blumberga, D. Thermal Insulation Alternatives of Historic Brick Buildings in Baltic Sea Region. *Energy Build.* **2014**, *78*, 35–42. [CrossRef]
67. Ruggeri, A.G.; Calzolari, M.; Scarpa, M.; Gabrielli, L.; Davoli, P. Planning Energy Retrofit on Historic Building Stocks: A Score-Driven Decision Support System. *Energy Build.* **2020**, *224*, 110066. [CrossRef]
68. STBA. Responsible Retrofit of Traditional Buildings. Available online: https://stbauk.org/stba-research/ (accessed on 15 January 2024).
69. CREBA. Espace Documentaire. Available online: https://www.rehabilitation-bati-ancien.fr/espace-documentaire (accessed on 15 January 2024).
70. Conservazione ed Efficienza Energetica dell'Edilizia Storica. Nardini Editore. Available online: https://www.nardinieditore.it/prodotto/conservazione-ed-efficienza-energetica-delledilizia-storica/ (accessed on 15 January 2024).
71. Stiernon, D.; Trachte, S.; Dubois, S.; Desarnaud, J. A Method for the Retrofitting of Pre-1914 Walloon Dwellings with Heritage Value. *J. Phys. Conf. Ser.* **2019**, *1343*, 012179. [CrossRef]
72. Cantin, R.; Burgholzer, J.; Guarracino, G.; Moujalled, B.; Tamelikecht, S.; Royet, B.G. Field Assessment of Thermal Behaviour of Historical Dwellings in France. *Build. Environ.* **2010**, *45*, 473–484. [CrossRef]
73. 3encult—Project—Welcome—Home. Available online: http://www.3encult.eu/en/project/welcome/default.html (accessed on 6 January 2024).

74. Troi, A.; Bastian, Z. Energy Efficiency Solutions for Historic Buildings: A Handbook. In *Energy Efficiency Solutions for Historic Buildings*; Birkhäuser: Basel, Switzerland, 2014. [CrossRef]
75. Rodriguez-Maribona, I.; Grün, G. Energy Efficiency in European Historic Urban Districts—A Practical Guidance. Available online: http://www.effesus.eu/wp-content/uploads/2016/06/EFFESUS_Booklet_Final-Version.pdf (accessed on 26 January 2024).
76. Egusquiza, A.; Brostrom, T.; Izkara, J.L. Incremental Decision Making for Historic Urban Areas' Energy Retrofitting: EFFESUS DSS. *J. Cult. Herit.* **2022**, *54*, 68–78. [CrossRef]
77. RIBuild. Available online: https://www.ribuild.eu (accessed on 16 January 2024).
78. Task 59, IEA SHC. Renovating Historic Buildings Towards Zero Energy. Available online: https://task59.iea-shc.org/ (accessed on 16 January 2024).
79. Schweber, L.; Leiringer, R. Beyond the technical: A snapshot of energy and buildings research. *Build. Res. Inf.* **2012**, *40*, 481–492. [CrossRef]
80. Haas, F.; Exner, D.; Herrera-Avellanosa, D.; Hüttler, W.; Troi, A. Making Deep Renovation of Historic Buildings Happen—Learnings from the Historic Buildings Energy Retrofit Atlas. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *863*, 012017. [CrossRef]
81. Lidelöw, S.; Örn, T.; Luciani, A.; Rizzo, A. Energy-Efficiency Measures for Heritage Buildings: A Literature Review. *Sustain. Cities Soc.* **2019**, *45*, 231–242. [CrossRef]
82. *CSN EN 16883*; Conservation of Cultural Heritage—Guidelines for Improving the Energy Performance of Historic Buildings. European Standard: Plzen, Czech Republic, 2017. Available online: https://www.en-standard.eu/csn-en-16883-conservation-of-cultural-heritage-guidelines-for-improving-the-energy-performance-of-historic-buildings/ (accessed on 5 January 2024).
83. Leijonhufvud, G.; Broström, T.; Buda, A. Suggestions for Enhancing the European Guidelines for Improving Energy Performance of Historic Buildings. IEA SHC Task 59. 2021. Available online: https://task59.iea-shc.org/Data/Sites/1/publications/D.B2--Proposal-for-standard-improvement.pdf (accessed on 16 January 2024).
84. Buda, A.; Pracchi, V. Potentialities and Criticalities of Different Retrofit Guidelines in Their Application on Different Case Studies. Semantic Scholar. 2019. Available online: https://www.semanticscholar.org/paper/Potentialities-and-criticalities-of-different-in-on-Buda-Pracchi/fca9d4132d5aca652d5a0abff9e5b171f30f3d4a (accessed on 16 January 2024).
85. English Heritage. Energy Efficiency and Historic Buildings—Application of Part L of the Building Regulations to Historic and Traditionally Constructed Buildings. Available online: https://responsible-retrofit.org/reference/ (accessed on 18 January 2024).
86. Fouseki, K.; Newton, D.; Murillo Camacho, K.S.; Nandi, S.; Koukou, T. Energy Efficiency, Thermal Comfort, and Heritage Conservation in Residential Historic Buildings as Dynamic and Systemic Socio-Cultural Practices. *Atmosphere* **2020**, *11*, 604. [CrossRef]
87. Okutan, R.S.; Kershaw, T.; Fernandez, M.H.; Coley, D. A Socio-Mathematical Approach to Exploring Conflicts Between Energy Retrofit and Perceived Heritage Character. *Build. Environ.* **2018**, *138*, 11–20. [CrossRef]
88. Arfvidsson, J.; Bjelke-Holtermann, B.; Mattsson, J. A Method for Status Determination and Risk Assessment of Energy Measures in Historic Buildings. *IOP Conf. Ser. Earth Environ. Sci.* **2021**, *863*, 012043. [CrossRef]
89. Stephan, E. Méthode d'Aide à la Décision Multicritère des Stratégies de Réhabilitation des Bâtiments Anciens en Pierre Calcaire: Application au Patrimoine en Tuffeau. Ph.D. Thesis, École Nationale des Travaux Publics de l'État ENTPE, Vaulx-en-Velin, France, 2014. Available online: https://theses.hal.science/tel-01631799 (accessed on 15 January 2024).
90. Stanojevic, B. Conservation Principles in Retrofitting of Historical Buildings. *Int. J. Conserv. Retrofit.* **2021**, *6*, 104–120.
91. Marincioni, V.; Gori, V.; de Place Hansen, E.J.; Herrera-Avellanosa, D.; Mauri, S.; Giancola, E.; Egusquiza, A.; Buda, A.; Leonardi, E.; Rieser, A. How Can Scientific Literature Support Decision-Making in the Renovation of Historic Buildings? An Evidence-Based Approach for Improving the Performance of Walls. *Sustainability* **2021**, *13*, 2266. [CrossRef]
92. Vitruvius: On Architecture. Available online: https://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/home.html (accessed on 7 January 2024).
93. Webb, A.L. Energy Retrofits in Historic and Traditional Buildings: A Review of Problems and Methods. *Renew. Sustain. Energy Rev.* **2017**, *77*, 748–759. [CrossRef]
94. Kyritsi, E.; Philokyprou, M.; Kyriakidis, A.; Michael, A.; Michopoulos, A. Energy Retrofitting of Heritage Buildings: An Integrated Methodology. *IOP Conf. Ser. Earth Environ. Sci.* **2023**, *1196*, 012108. [CrossRef]