

EEHB 2024

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The 5th International Conference
on Energy Efficiency in Historic Buildings

Based on the reflexive process of the standard EN 16883, how can the energy retrofiting of historic and traditional residential buildings be supported?
Decision-making tools provided by the “P-Renewal” research project.

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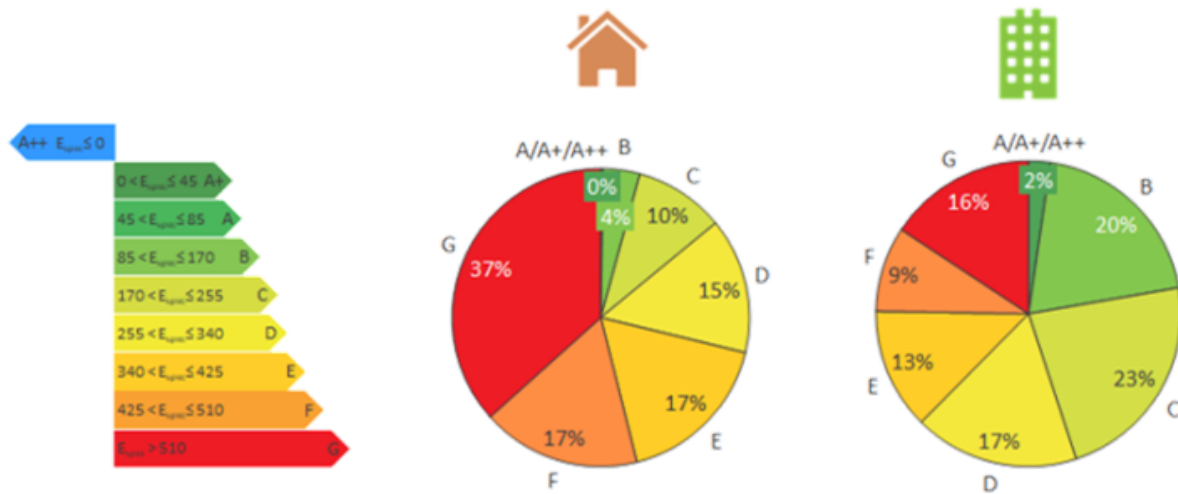
P-Renewal project



- **Funded by the Energy Department of the Walloon Public Service (Wallonia, Belgium)**
- **Conducted in collaboration with the Unit Building Performances & Renovation of the Belgian Building Research Institute (Buildwise).**
- **Four-years research projects, from 2017 to 2021**
- **Focused on pre-war residential buildings, listed or not, and presenting heritage value.**
- **With a bottom-up, integrated and multidisciplinary approach**

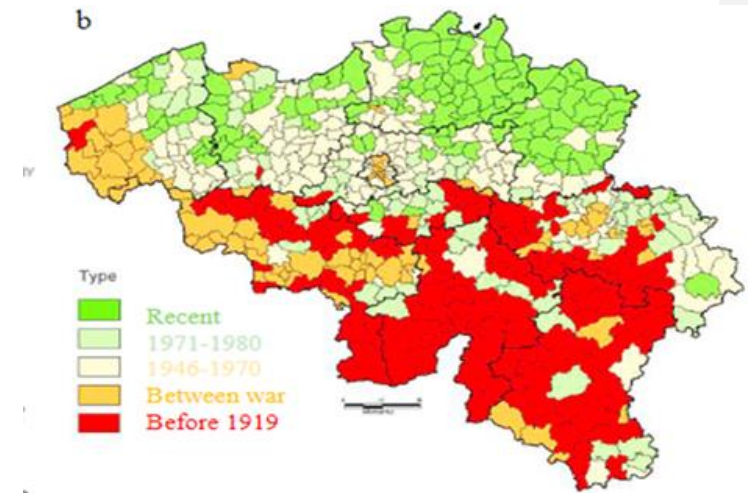
Why pre-war residential buildings?

- This building stock represents around 25% of the Walloon dwellings stock
- It also represents an historical, cultural and economical value for Wallonia
- This building stock is considered as old and energy intensive

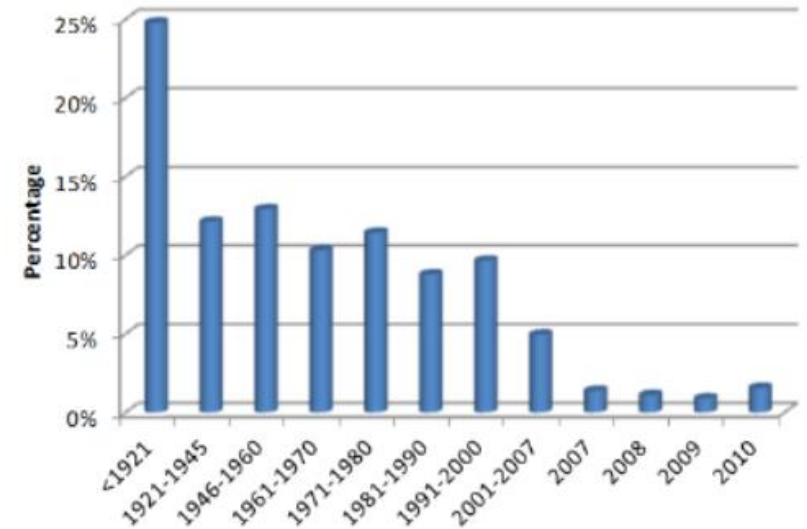


EPB scale and distribution of the Walloon residential building according to its energy performance (houses and apartments) – Source: EPB and EPB certificates Databases

General source: <https://energie.wallonie.be/servlet/Repository/qw-201112-strategie-renovation-2020-rapport-complet-final.pdf?ID=60498>



Geographical distribution of the building according to age - Source: Géographie KULeuven & UCL. Analyse & cartographie : INS - ESE. Belgium



Year of construction of Walloon dwellings - Source: Energy Consumption Survey, 2012

Bottom-up, integrated and multidisciplinary approach

Bottom-up approach



P-Renewal project was developed,
based on five representative study
cases in Wallonia



Integrated approach



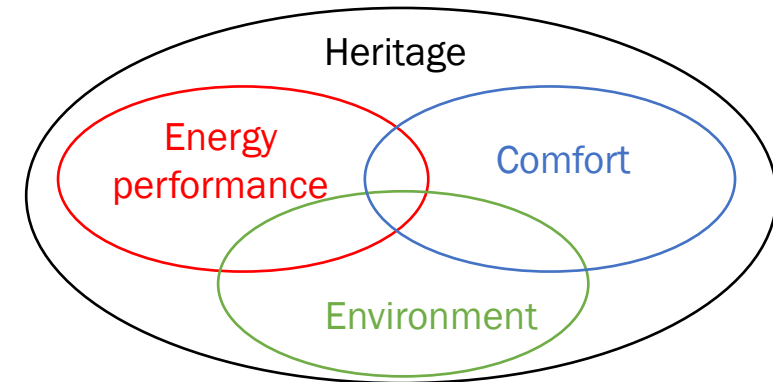
P-Renewal project was developed,
with the support of a group of
practitioners and experts in both
heritage and energy renovation.
Foster a shared understanding
among all stakeholders.



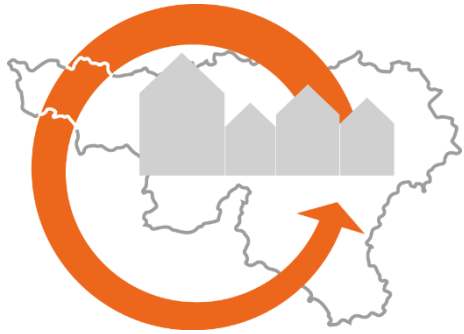
Multidisciplinary approach



P-Renewal project was developed,
by combining energy performance
and indoor comfort with heritage
conservation and environmental
performance



P-Renewal project - objectives



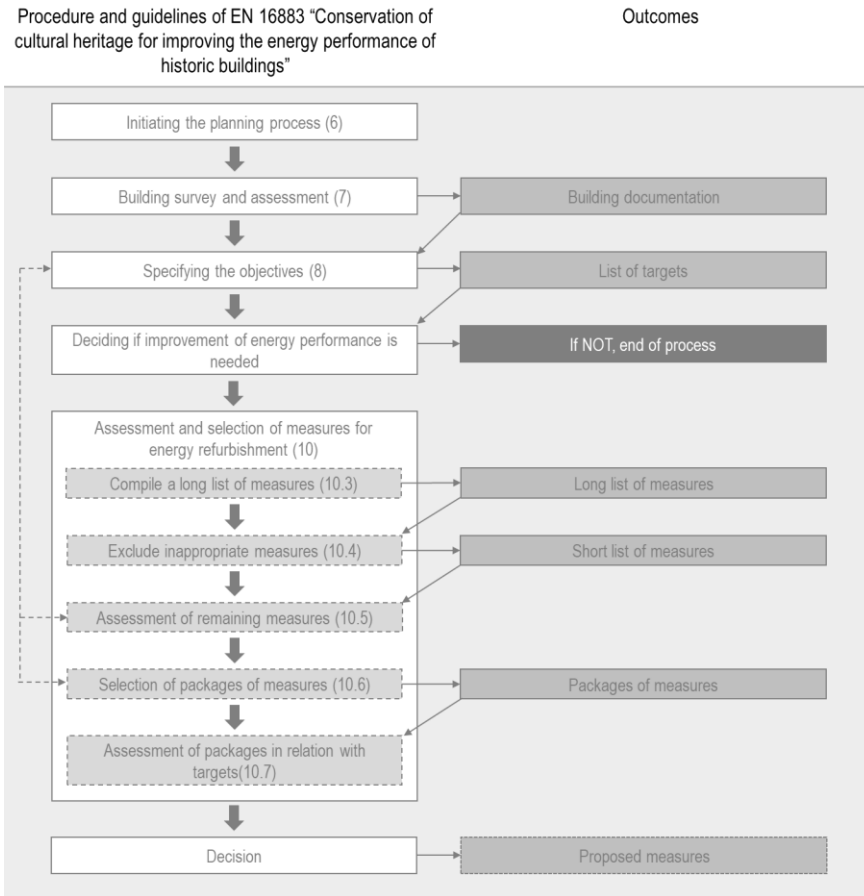
The project shares the same objectives as the standard EN16883,

- (1) **facilitate and support the planning process** during energy renovation of residential buildings (listed or not),
- (2) **provide decision-making tools** to help owners and design professionals to adequately select renovation measures while preserving heritage value

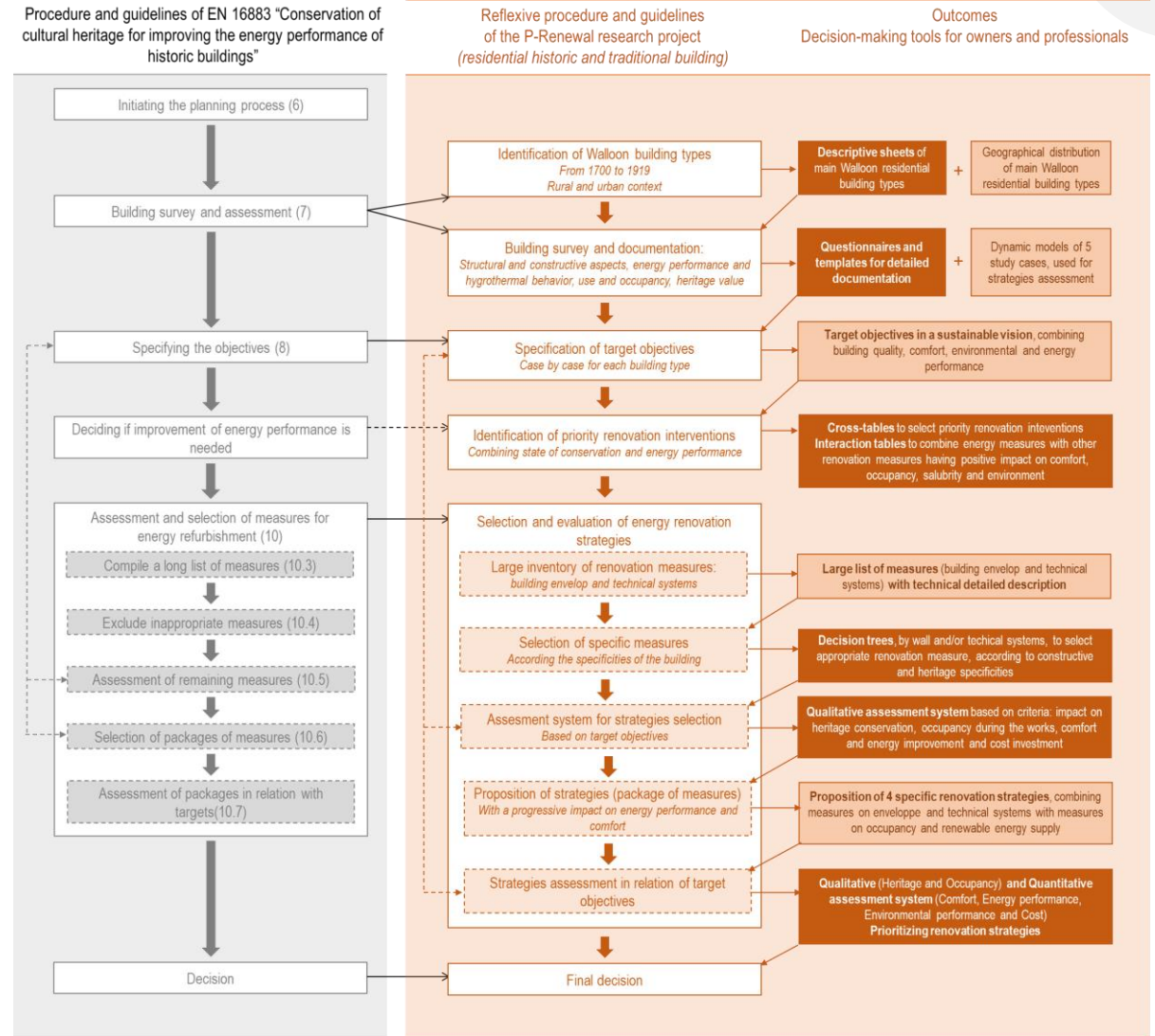
WITH specific innovations to enhance the usability of the planning process

- **Scientific and technical information** on pre-war traditional residential buildings
- **Comprehensive details and illustrations** of energy improvement solutions / measures
- **Tools** to facilitate the user's decision-making process

P-Renewal project >< Standard EN 16883

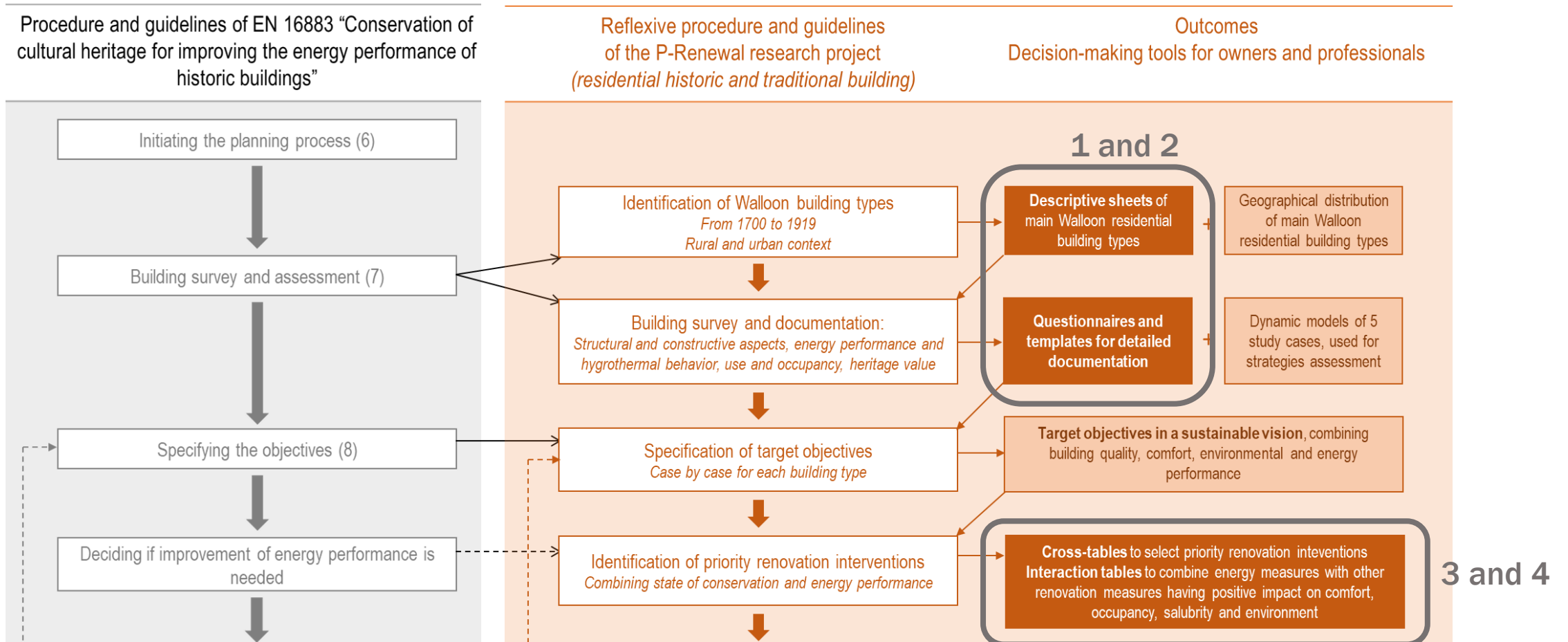


Reflexive planning process provided by the standard (in grey) and by the P-Renewal project



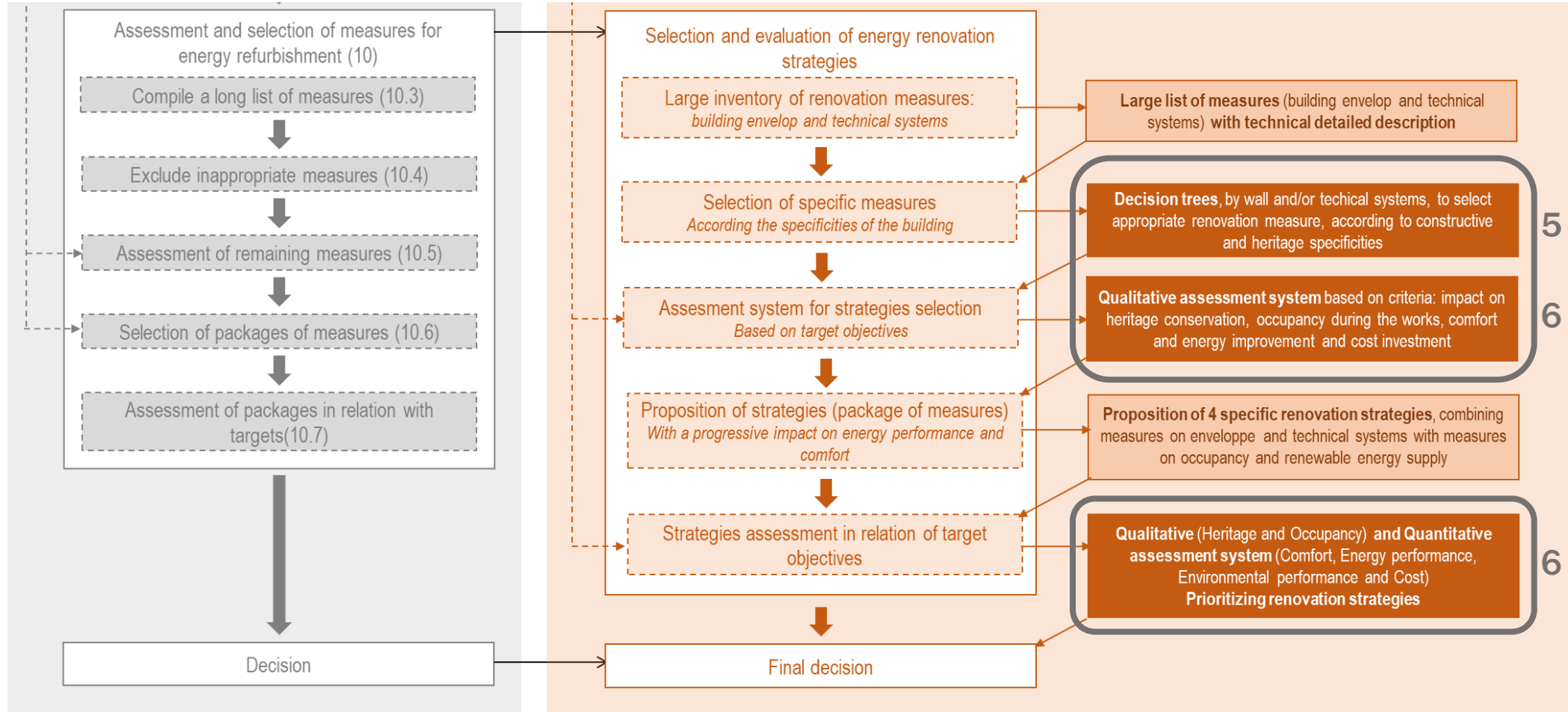
P-Renewal project - decision-making tools

Reflexive planning process : preliminary steps



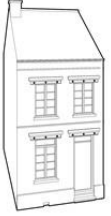

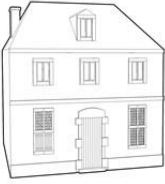




P-Renewal project - decision-making tools

Reflexive planning process : selection of energy renovation measures / strategies



P-Renewal project - decision-making tools

1. Descriptive sheets of housing types

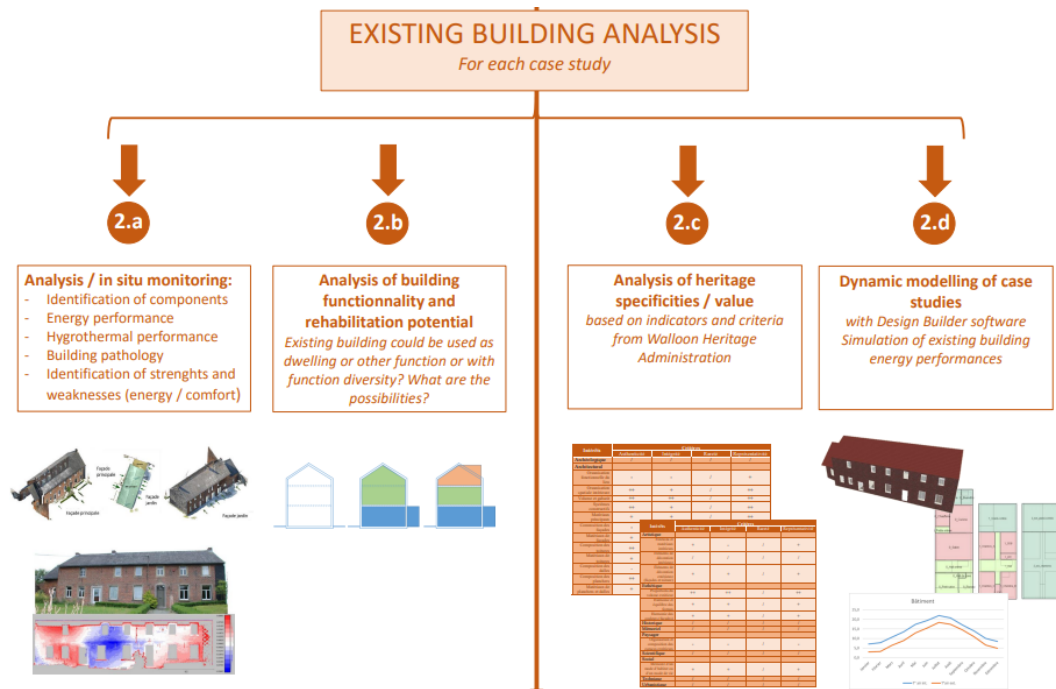
TYPES	WORKER'S DWELLING	MIDDLE-CLASS DWELLING			MULTICELLULAR FARM		FARM WITH COURTYARD
Subtypes	Modest house 	'Maison bourgeoise' 	'Villa' 	'Hôtel de maître' 	Lengthwise farm 	Farm in block 	Farm with parallel buildings, L or U-shaped farm, Square farm 
Context	Urban and rural	Urban			Rural		
Population	In the popular and industrial districts	Urban middle-class		Upper bourgeoisie and the aristocracy	Population in function of the size of the building		Powerful groups established by the stately and abbey farms
Spatial organization	Very basic Initially, only one room and a attic	Three different spaces: reception spaces, family spaces and services or domestic spaces			Same spatial organization but different in size and volume One or two levels divided in two or three (sometimes four) parts to host the family life, beasts and crops		Quadrilateral fully or partially closed which looks out onto a courtyard
Materials	Local stone	Different level of architectural composition and decoration in function of the social level of the occupant		Important decoration	Local stone masonry for the whole house or only a part		Local materials with high quality (limestone, marble and oak) Important decoration

- Historical development
- Context and situation
- Dimensions and forms
- Spatial organization
- Relation to public space
- Construction system and materials
- Common heritage specificities
- Reference-built examples

P-Renewal project - decision-making tools

2. Template for detailed building documentation

Steps of building's survey and documentation, on the five study cases



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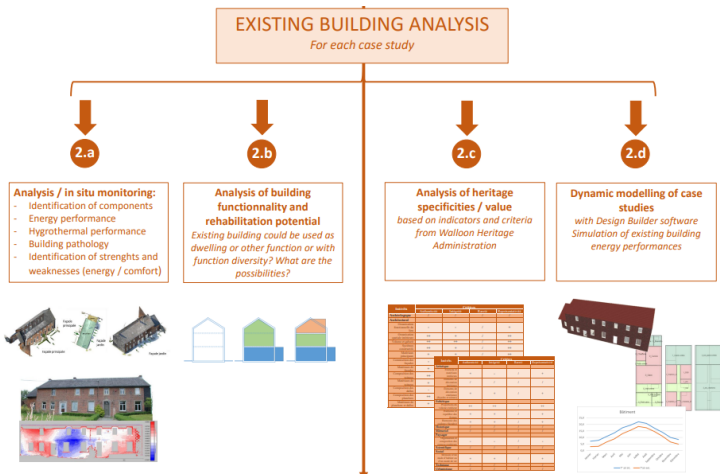
Data and information collected

Preliminary Surveys	
Building site and local environment	Description of the local context and external spaces. General description of the building.
Building technologies and materials	Description of constructive system, material components (nature and thickness), and the state of conservation of roof and roof structure, attic, façade walls, windows (frame and glazing), doors, slab and floors, and internal walls.
Spatial organization	Description of spatial organization and natural lighting of the ground floor, first floor, second floor, attic, and ceiling (if exists).
Building services and technical systems	Description and state of the conservation of the sewerage network and stormwater collection, heating system, ventilation system, electricity network, and lighting.
Statements of energy consumption	Analysis of energy bills, in agreement with the occupant.
Discussion with occupants	Discussion about the perceived advantages and weaknesses in terms of comfort and the use of the building.
Geometric documentation	Photogrammetry and 3D surveying techniques.
In-depth analysis (energy efficiency and comfort)	
Diagnostics	Thermography (with camera). Flatness (for façades and floors). Salts and moisture. Air tightness (with blower door test).
Energy efficiency and thermal comfort	U-value estimation. Monitoring (temperature and relative humidity).
Complementary analysis	
Heritage specificities	Description of building heritage specificities <ul style="list-style-type: none"> - In general; - External: façades walls, windows, doors, and roofs; - Internal: finishes and decorations.
Occupancy potential	Development and proposal of various occupancy scenarios allowing the densification and/or expansion of certain spaces (by extension, annex, etc.)

Source: Trachte, S. and Stiennon, D., P-Renewal Project: A Reflexive Contribution to the Evolution of Energy Performance Standards for the Renovation of Historic Buildings. Heritage, 2024

P-Renewal project - decision-making tools

2. Template for detailed documentation



Données générales	
Adresse et nom du site	
Personne de contact	
Parcelle cadastrale	
Surface de la parcelle	
Type de bâtiment	sur base des types bâtis décrits dans les analyses typologiques
Date de construction	si possible, donnez la date ou la période estimée
Architecte	
Rénovations/transformation déjà réalisées	description des travaux de rénovation énergétique ou des transformations importantes depuis la construction
Statut de protection patrimoniale	bâtiment classé - bâtiment sur liste d'inventaire - bâtiment inscrit dans une zone protégée - néant
Type d'environnement bâti	
Nombre d'entités composant le bâtiment	nombre de logements ou de fonction diverses (volumes fermés et distincts)
Type d'occupation actuelle	
Type d'occupation envisagée	
Données architecturales	
Nombre de niveaux	
Volume total extérieur	
Surface totale de planchers	
Type de mitoyenneté	
Orientation, forme et dimensions au sol du bâtiment	
Orientation de la façade principale	
Nombres d'ouverture et surface de baies	
Type de toiture	Description de la structure ou charpente - description du type de couverture
Hauteur du fait ou de la corniche	
Type de plancher	plancher massif type béton - plancher à voussures - plancher à gîte bois
Hauteur entre niveaux	
Type de murs extérieur	mur plein en maçonnerie de moellons - mur plein en maçonnerie de briques - double mur en maçonnerie - autres
Type de châssis	description châssis (nature et ouverture) et vitrage
Type de murs et cloisons intérieurs	
Données relative à la performance énergétique	
Volume protégé (isolé ou à isoler)	
Surfaces de murs extérieurs hors-sol	
Surfaces de murs extérieurs sous-sol	
Surface de toiture	
Surface de dalle en contact avec le sol ou avec caves	
Présence de matériaux isolants dans les parois de l'enveloppe	
Présence d'un système de chauffage	description du système, localisation, année d'installation
Présence d'un système de production d'eau chaude sanitaire	description du système, localisation, année d'installation
Présence d'un système de ventilation	description du système, localisation, année d'installation
Présence d'un système de climatisation	description du système, localisation, année d'installation
Consommation en énergie primaire du bâtiment (estimation ou facture)	

Example of template

building generalities and front façade

Description générale	
Composition générale	
Longueur, largeur et hauteur sous corniche	
Modifications déjà réalisées	
Nombre d'ouvertures	Distinguer baies de fenêtres et portes
Surface pleine et surface vitrée	
Système constructif	
Matériaux principaux	
Matériaux secondaires	Soubassement, jambages de fenêtres, angles de façade
Éléments architectoniques	Appareillage des briques, jambages en pierre, potale, ancrs, tirants, éléments en ferronnerie
Châssis de fenêtre - matériaux	
Châssis de fenêtre - composition	
Harmonie des couleurs	

Composition du mur de façade 01				
Description des couches	nature du matériau	épaisseur estimée m	masse volumique estimée kg/m³	Conductivité thermique (λ) W/mK
extérieur				
Couche 1				
Couche 2				
Couche 3				
Couche 4				
intérieur				

Spécificités patrimoniales	
Composition de la façade	
Composition en travées ou en volumes	
Présence d'annexes? Sont-elles d'origine?	
La proportion plein / vides est-elle d'origine et conservée? Présence de modifications?	
Les baies de fenêtres sont-elles d'origine? Ont-elles subies des modifications?	
Raccord à la toiture - Corniche, cheneaux...	
Matériau principal	
Matériau de soubassement	
Matériau de jambage ou encadrement	
Autres matériaux présents	
Éléments architectoniques et décoratifs extérieurs	
Description des différents éléments	
Éléments architectoniques et décoratifs intérieurs	
Description des différents éléments	

P-Renewal project - decision-making tools

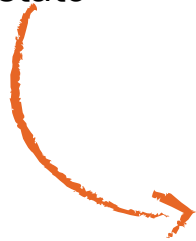
3. Cross-tables

State of conservation of the wall	1. Priority	2. Necessary	3. Possible	4. Non priority
Pitched roof wood frame	Wood frame and roof covering in poor condition	Wood frame in good condition but lack of watertightness	Wood frame and others roof layers with normal ageing state, without degradation	New or renovated for less than 5 years
Flat roof wood frame	Wood frame and watertightness in poor condition	Wood frame in good condition but water-tightness to be replaced	Wood frame and others roof layers with normal ageing state, without degradation	New or renovated for less than 5 years
Front façade	Façade with a lot of degradations	Façades frame with small and/or sporadic degradations	Façade with normal ageing state, without degradation	New or renovated for less than 5 years
Rear or other façades	Façade with a lot of degradations	Façades frame with small and/or sporadic degradations	Façade with normal ageing state, without degradation	New or renovated for less than 5 years
Window (frame and glazing)	Single glazing, window frame in poor condition, lack of airtightness	Single or old double glazing, window frame with sporadic degradations	Double glazing, window frame with normal ageing state, without degradation	New or renovated for less than 5 years
Slab	Slab in poor condition, including finishing	Slab in good condition, finishing with significant degradation	Slab with normal ageing state, without degradation	New or renovated for less than 5 years

Performance énergétique des parois du bâti	1. Very energy consuming	2. Energy consuming	3. Low energy consuming	4. Energy efficient
Pitched roof, wood frame and/or attic floor	No insulation layer $U > 1,5 \text{ W/m}^2\text{K}$	Thin insulation layer $1,5 \geq U < 1 \text{ W/m}^2\text{K}$	Medium insulation layer $1 < U < 0,4 \text{ W/m}^2\text{K}$	Thick insulation layer $U < 0,4 \text{ W/m}^2\text{K}$
Flat roof, wood frame	No insulation layer $U > 1,5 \text{ W/m}^2\text{K}$	Couche isolante faible $1,5 \geq U \geq 1 \text{ W/m}^2\text{K}$	Medium insulation layer $1 < U < 0,4 \text{ W/m}^2\text{K}$	Thick insulation layer $U < 0,4 \text{ W/m}^2\text{K}$
Front façade	No insulation layer $U \geq 3 \text{ W/m}^2\text{K}$	Thin insulation layer $3 < U < 1,8 \text{ W/m}^2\text{K}$	Medium insulation layer $1,8 < U < 0,5 \text{ W/m}^2\text{K}$	Thick insulation layer $U \leq 0,5 \text{ W/m}^2\text{K}$
Rear and other façades	No insulation layer $U \geq 3 \text{ W/m}^2\text{K}$	Thin insulation layer $3 < U < 1,8 \text{ W/m}^2\text{K}$	Medium insulation layer $1,8 < U < 0,5 \text{ W/m}^2\text{K}$	Thick insulation layer $U \leq 0,5 \text{ W/m}^2\text{K}$
Window (frame and glazing)	Old simple glazing frame $U_w > 6 \text{ W/m}^2\text{K}$	Old traditional single or double-glazing frame $6 < U_w < 3 \text{ W/m}^2\text{K}$	Newer traditional double-glazing frame $3 < U_w < 1,5 \text{ W/m}^2\text{K}$	Energy efficient double-glazing frame $U \leq 1,5 \text{ W/m}^2\text{K}$
Slab	No insulation layer, or $U > 3 \text{ W/m}^2\text{K}$	Thin insulation layer $3 < U < 1 \text{ W/m}^2\text{K}$	Medium insulation layer, $1 < U < 0,7 \text{ W/m}^2\text{K}$	Thick insulation layer $U \leq 0,7 \text{ W/m}^2\text{K}$



Level of conservation state



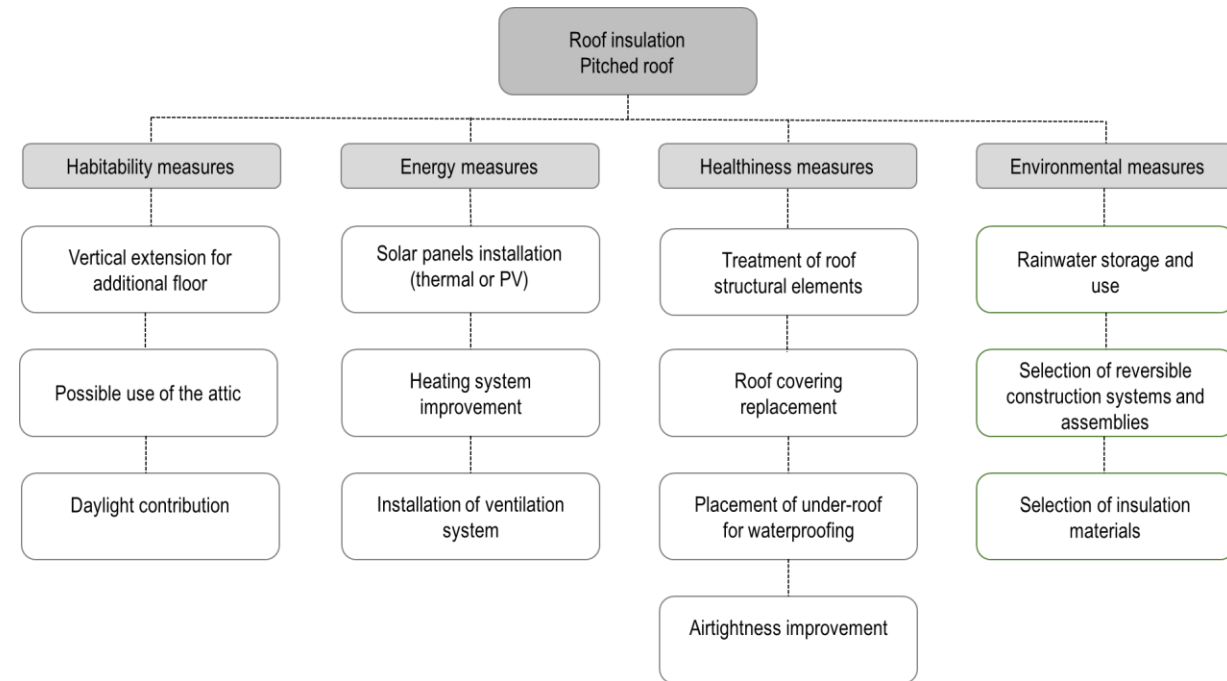
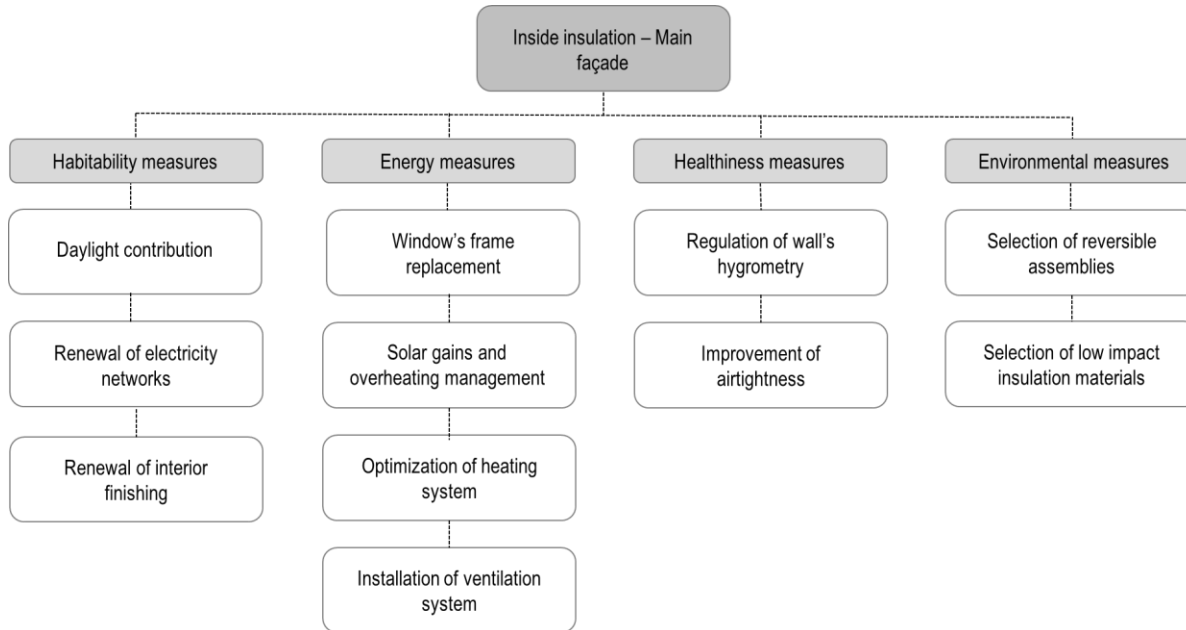
FRONT FAÇADE		State of conservation				
		1	2	3	4	
		Façade with a lot of degradations	Façades frame with small and/or sporadic degradations	Façade with normal ageing state, without degradation	New or renovated for less than 5 years	
Insulation performance	1	No insulation layer $U > 3 \text{ W/m}^2\text{K}$	priority	priority	necessary	necessary
	2	Thin insulation layer $3 < U < 1,8 \text{ W/m}^2\text{K}$	priority	priority	necessary	necessary
	3	Medium insulation layer $1,8 < U < 0,5 \text{ W/m}^2\text{K}$	priority	necessary	possible	possible
	4	Thick insulation layer $U < 0,5 \text{ W/m}^2\text{K}$			non priority	non priority

Level of insulation performance



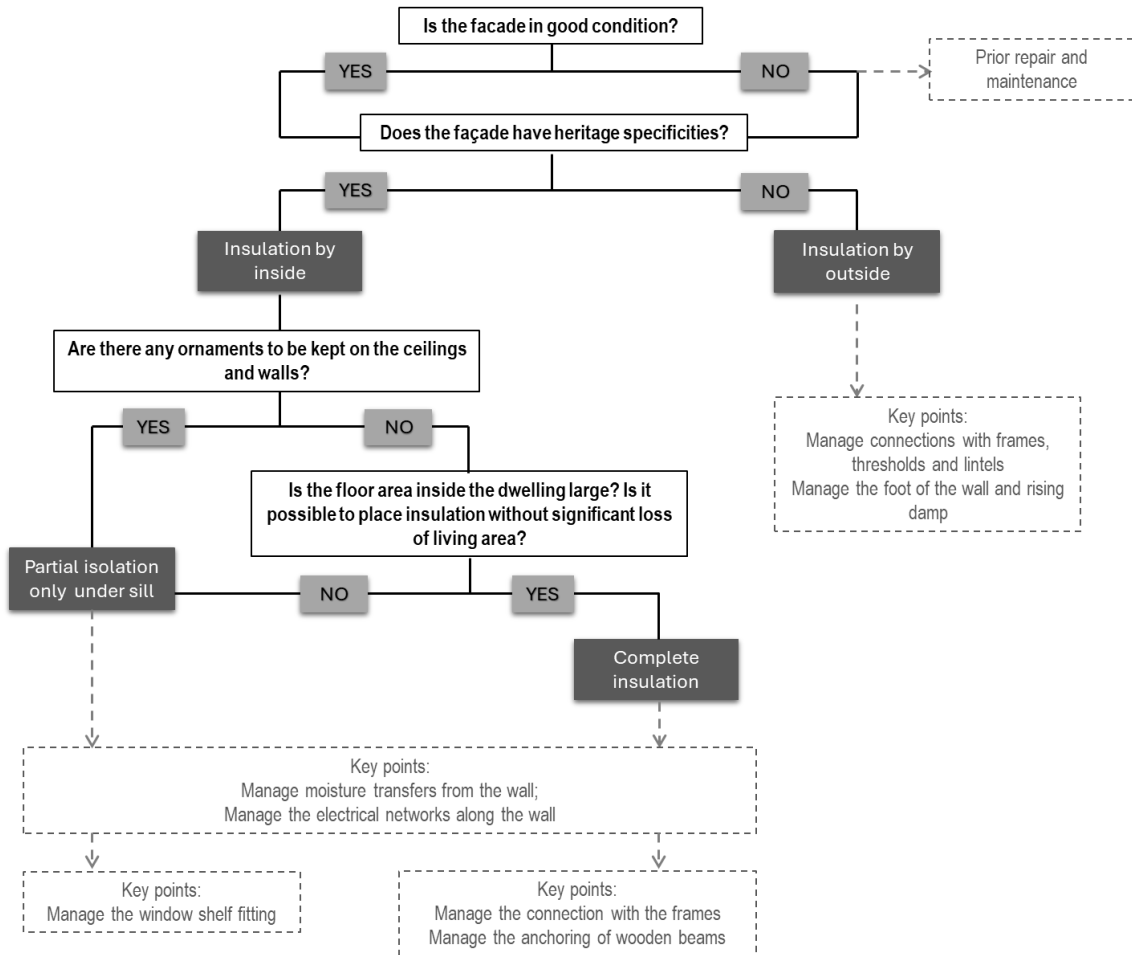
P-Renewal project - decision-making tools

4. Conceptual diagrams for improvement measures interaction

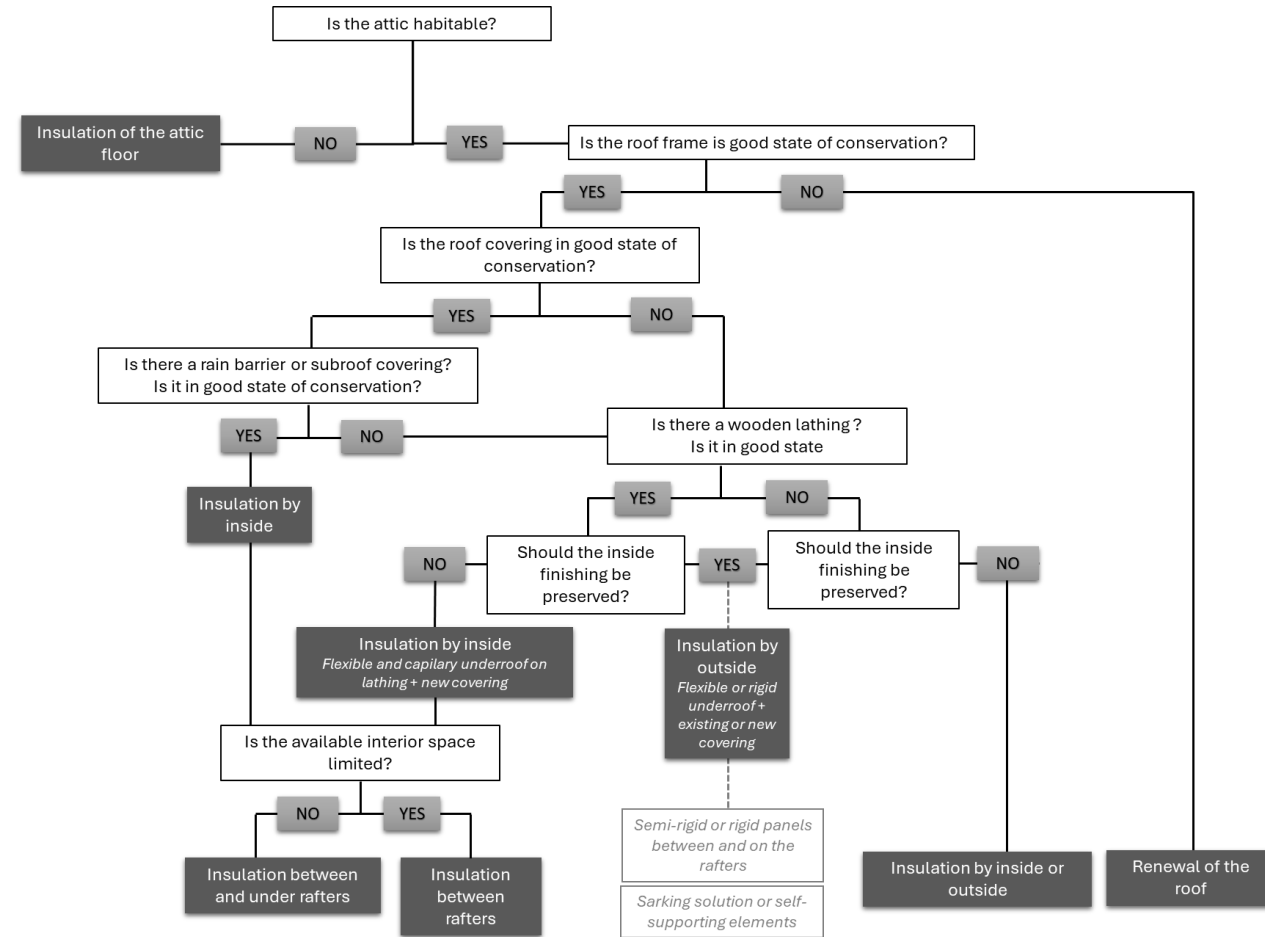


P-Renewal project - decision-making tools

5. Decision trees



Tree for front façade



Tree for pitched roof

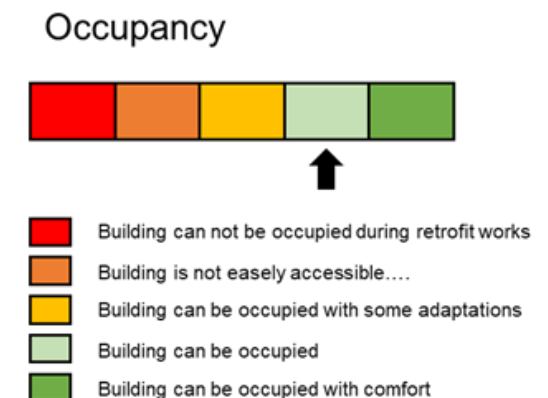
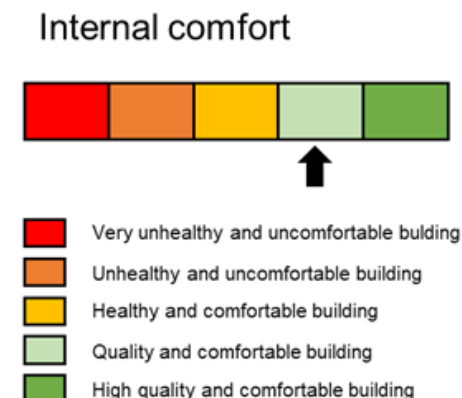
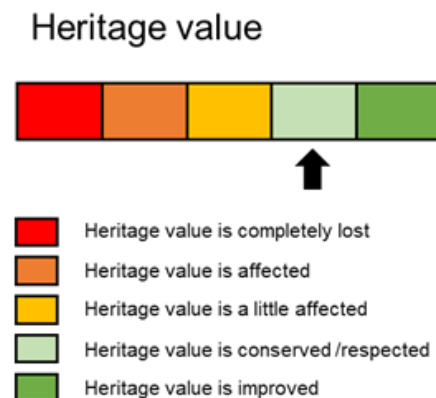
P-Renewal project - decision-making tools

6. Qualitative assessment

	Criteria for Renovation Strategy's Evaluation				
	Energy Performance and Indoor Comfort	Heritage Value	Financial Investment	Building's Occupancy and Use	Alternatives Measures
Strategy 1	Moderately improved	No impact	Limited	No impact	No
Strategy 1'	Moderately improved	No impact	Limited	No impact	Renewable energy production and/or building densification
Strategy 2	Improved	Low or moderate impact	Moderate	Low or moderate possible	Renewable energy production
Strategy 3	Significantly improved, EPB level A achieved	Significant impact	Significant	Significant impact	Renewable energy production

For each study case, four renovation strategies were proposed, combining improvement measures both e-on the envelope and technical systems.

In addition to a quantitative assessment (energy performance, environmental performance, cost), the project proposed a qualitative graphical assessment



P-Renewal project's main contributions

➤ Building type descriptive sheets

- Simplified accessible resource for identifying the type of the studied building (and its specificities)
- Better understanding of the construction and heritage characteristics of traditional building
- This tool could easily be incorporated into the standard, based on existing various studies conducted on historical building types (Tabula, Effesus,...)

➤ Documentation template

- Strong technical basis for analyzing existing historical buildings before considering renovation measures.
- This tool (or similar one) could be appended to the standard as an illustrative example of the procedure for building documentation and survey

➤ Cross-tables

- Practical support for the renovation planning process, enabling non-technical users to identify priority energy improvement measures

P-Renewal project's main contributions

➤ Conceptual diagrams

- Practical support for the renovation planning process, enabling non-technical users to incorporate energy solutions into a global renovation planning process alongside other actions. They enhance the efficiency of the planning process by reducing time and costs.
- With appropriate adjustments based on the energy performance requirements specific to each European country, those cross-tables and diagrams could also be appended to the standard

➤ Decision trees

- Valuable technical support, assisting in the selection of energy improvement measures adapted to the specificities of the building.
- With appropriate adjustments based on constructive and heritage aspects, those cross-tables and diagrams could also be appended to the standard

P-Renewal project's main contributions

➤ Qualitative assessment

- Qualitative evaluation system can be considered as a foundation for a more comprehensive and holistic evaluation of renovations on traditional and historic buildings

BUT there are some limits

- There is no consensus on assessing heritage value. Each country or region has its own assessment system.
- The occupation aspects such as buildings usability and densification can be very different from one region to another in Europe and influenced by regional and/or city's regulations
- The financial aspects of the renovation have been highly fluctuating in recent years. They also depend on the available workforce in each country or region. The demand for insulation materials is expected to increase significantly by 2050, as well as the demand for finishing materials.

Conclusions

- P-Renewal research project has demonstrated **it is possible to improve energy performance and occupants' comfort** while preserving heritage values of historical and traditional buildings, **using a more comprehensive planning process and a range of specific decision-making tools.**
- The reflexive planning process provided by the research project can serve as **an exemplary model and complement existing local and European regulations**
- Technical information and **decision-making tools** offered by the research project **can be easily adapted to various contexts and building types.**

Conclusions

P-Renewal project has developed **analytical tools** to analyze **construction and heritage characteristics of traditional buildings, including buildings not listed**. For such buildings, it is both urgent and essential to assess their heritage value and evaluate the impact of renovation measures on their heritage specificities.

Considering long-term renovation objectives and energy efficiency requirements, **there is a significant risk that our landscapes and urban areas will lose a substantial part of their historical and cultural quality**. This quality must be recognized as a tangible heritage, which should be preserved and passed down to future generations.

Conclusions

- **Trachte, S., & Stiernon, D. (2024).** P-Renewal project, a reflexive contribution to the evolution of energy performance standards for the renovation of historic buildings. *Heritage*. doi:10.3390/heritage7030074
- **Stiernon, D., & Trachte, S. (2020).** Quel avenir pour les logements d'avant-guerre à valeur patrimoniale en Wallonie ? *Lieuxdits*, (18), 15-20. doi:10.14428/ld.vi18.55853
- **Dubois, S., Desarnaud, J., Vanhellemont, Y., de Bouw, M., Trachte, S., & Stiernon Dorothée. (2019).** Combining multi-view photogrammetry and wireless sensor networks when modelling the hygrothermal behaviour of heritage buildings [Paper presentation]. WTA- PRECOM³ OS Symposium.
- **Stiernon, D., Trachte, S., Dubois, S., & Desarnaud, J. (2019).** A method for the retrofitting of pre-1914 Walloon dwellings with heritage value [Paper presentation]. CISBAT 2019 Climate Resilient Cities – Energy Efficiency & Renewables in the Digital Era, Lausanne, Switzerland. doi:10.1088/1742-6596/1343/1/012179
- **Dubois, S., de Bouw, M., Vanhellemont, Y., Stiernon Dorothée, & Trachte, S. (2018).** Combining multi-view photogrammetry and wireless sensor networks when modelling the hygrothermal behaviour of heritage buildings [Paper presentation]. *Energy Efficiency in Historic Buildings 2018*, Visby, Sweden.

Decision-making tools provided by the “P- Renewal” research project.

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THANK YOU!

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