E-guide

for Local Governments

Recommendations on transfer and replicability of energy efficient retrofit of historic buildings at urban level

(D6.3 – Summary results e-guide for local governments outlining replication potential)

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0 Executive Summary

Energy efficiently retrofitting cultural heritage provides the opportunity for a wide spectrum of actions with social, cultural but also economic impact at the local community level. This makes it an **interesting area of engagement for local governments as the leaders and administrators of their local community**. They have the mandate and interest to stimulate local sustainable development, making their communities liveable and supporting good quality of life for citizens and businesses alike,(jobs, services, etc)..

The built environment and energy are at the heart of these discussions today, exploring ways to optimise energy efficiency and moving away from fossil fuels **– towards a low carbon economy**. Many European cities and towns are exploring how to achieve this, implementing technologies and stimulating behaviour, as outlined in their Sustainable Energy Action Plans (SEAPs) or Climate Plans. These **plans need to be closely linked to, or integrated in the Urban Master Plan, the Sustainable Development Plan and any other key policies** outlined for the local community. This will help to optimise planning, implementation and monitoring.

In the EU 14% of the building stock was constructed before 1919, 26% before 1945. A certain amount of these buildings are listed, most of them have historical significance and should be treated with care. They are a trademark of many European cities, towns and villages and represent a symbol of Europe's rich cultural heritage. At the same time these buildings are not energy efficient and are substantially contributing to greenhouse gas (GHG) emissions and rising energy bills.

Local governments need to be involved in exploring how to include cultural heritage **into a broader urban sustainability concept**.

Local leaders can trigger and intensify discussions, outline a clear direction and strategy for the community, and monitor implementation by the local government when dealing with these topics. This guide aims to highlight lessons learnt within the framework of the 3ENCULT project that can be replicated across Europe through supporting **local government representatives in making informed decisions.**

Through brief outlines of **eight case studies**, situated in different countries, climatic zones, and historic eras, these recommendations wish to share highlights and results obtained, while **linking them to the policy framework** and to the decision-making process that influenced their development.

1. Introduction

Energy prices are rising. Climate change is a reality. Sustainable development and green growth have been identified as global priorities. It is understood that sustainable energy – energy conservation, energy efficiency and the transition to renewable energy – is at the heart of these issues. Further, considering that one can energy efficiently retrofit old buildings, that these are a core tourist attraction in many European cities, and that funding is increasingly available for local sustainable energy roll-out, this is an area where local governments can and should engage.

There are different options that can be used in finding suitable ways to balance historic buildings conservation requirements with the need for an optimized energy efficiency – from design to technology and materials. Typically each building is unique and needs its own tailor-made solution, selecting from a range of existing possibilities. **Yet, what could be done to achieve change on a wider scale?**

This document outlines how **eight case studies** have contributed to the integration of cultural heritage and energy efficiency into their local sustainability progress.

The overall approach taken by the municipality at a strategy, policy, and regulatory level can help to address many historic buildings, going beyond an ad hoc approach to a comprehensive vision for the local community, supporting the maintenance (or even reclaiming) its cultural heritage and changing energy use to more efficient and sustainable approaches.

As **each building is unique and needs its own tailor-made solution**, it is impossible to provide a list of solutions able to fit all cultural heritage buildings. Nonetheless, while observing **the policy framework, the methodology and the planning** for the retrofit of the case study, it is possible to extrapolate and outline a series of **replicable principles** and **recommendations (also relatively technical)** on what to consider and how to make cultural heritage part of sustainability strategies at urban level.

The input comes from the **3ENCULT project** (**Efficient Energy for EU Cultural Heritage)** , a project implemented in the 7th Framework Programme (FP7) of the European Commission (EC). It bridges the gap between the conservation of historic buildings and dealing with climate protection. While this may seem like a contradiction in terms, it is clear that historic buildings have a higher chance of “survival” where energy efficiently retrofitted.

1.1 Target group

Local leaders can trigger and intensify discussions, outline a clear direction and strategy for the community, and monitor implementation by the local government when dealing with these topics.

To act as a driver for such strategies **local government representatives need to make informed decisions** – based on an understanding of what is possible and not possible. This is also the case for historic buildings and monuments, as more complex building types to be addressed. Although they make up a small percentage of the total building stock in a city or town, their value goes far beyond their current use as monuments, office space or residences. These buildings are the heart and soul of our European cities. Visitors from around the globe flock to see and admire them. They add greatly to the local economy, purely by existing. Decisions about energy efficient retrofit can (and should) ideally be linked to the broader municipal strategy, e.g. the Urban Master Plan and the Sustainable Energy Action Plan (SEAP) or Climate Plan.

Why local authorities? Local leaders:

- **shape local strategy and policy** (e.g. sustainable development, climate protection, job creation, ...);
- **deal with urban planning and updating the urban master plan**;
- **outline and enforce building regulations** (also protection and maintenance of monuments);
- **plan the sustainable energy transition in the community** (e.g. Sustainable Energy Action Plan);
- **can reduce energy demand in municipal buildings and switch to renewable energy**, e.g. green electricity; and
- **encourage the local community to engage in the sustainable energy transition** (stakeholder action).

Energy efficiency retrofit of heritage could become a quite beneficial selected action to implement into a **Sustainable Energy Action Plan**, as it would help facilitate reaching the 20-20-20 target (reduction of emissions, increase of renewables by 2020) while triggering a wide **social impact**. It is a great start for living up to this challenge.

1.2 Guide focus

This guide offers a **set of recommendations for local decision-makers** on the integration and advancement of sustainability criteria at urban level, and the role that energy efficiency retrofit of cultural heritage can play in advancing the local sustainability agenda.

Using the 3ENCULT Case studies´ results, the guide aims at providing **inspiration and ideas,** on how the nexus between a sustainable city and the protection of its historic buildings can be addressed in an optimized and reciprocally beneficial approach.

The guide will analyze technical solutions and **innovations** applied, as well as underline the **relationship with the owner** of the building, with all **stakeholders** engaging in the process, providing a set of replicable **recommendations in connection to cultural heritage conservation, urban, climate and energy planning**.

Note: Please note that the description of the cases included is not exhaustive. Only selected technologies and solutions applied are described in the text. If you want to learn more about the cases in detail, please visit www.3encult.eu

Specifically aimed at local decision-makers who are not necessarily experts on sustainable energy, urban planning and buildings, this set of recommendations will help to inform local leaders who are involved in municipal decision-making processes relevant to the built environment, urban planning, the energy sector as well as tourism and sustainable economic development.

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2 Integration at urban level

Many cities across Europe are working on the integration of their climate and energy plans with actions that the community can benefit also from a social point of view. Often a rather challenging task, the integration of historic buildings into these larger frameworks is usually quite successful from an economic and social point of view, as historic buildings are not just dwellings but a potential identity drive for the community.

To ensure a successful integration of these actions and the best possible benefit for the community, the first step is to recognize where our process stands.

The CCP five milestones process developed for planning and development of sustainable climate actions can be adapted for this process[1].

This circle is developed to encourage local authorities and their stakeholder to accelerate and develop action in a measurable, reportable and verifiable manner. The approach aims to increase transparency and accountability and with it, to increment participation of all relevant stakeholders to the process.

1: ICLEI´s Cities for Climate Protection (CCP) milestones

It is important to consider the close link between accountability and enhancing investments, as well the capability to foresee future actions to be taken for improving the quality of life of the community, and to increment long-term strategies for development both social and economic (creation of new jobs in the future). Public investments in the cultural heritage as catalyst for the revitalization of the wider area, attracting local as well as external private investment and stimulating the creation of new developments.

Developing a master plan or a climate and energy strategy affecting a community is crucial to ensure a thorough knowledge of all the elements that may affect the planning:

[1] Initiated in 1993 by ICLEI, the Cities for Climate Protection (CCP) Campaign is the first international initiative that aims to facilitate emissions reduction of local governments through a five milestone process of measurement, commitment, planning, implementing and monitoring.

The CCP Campaign assists cities to adopt policies and implement quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability. The five milestones of the CCP and the methodology behind provide a simple, standardized means of calculating greenhouse gas emissions, of establishing targets to lower emissions, of reducing greenhouse gas emissions and of monitoring, measuring and reporting performance.

The five milestones provide a flexible framework that can accommodate varying levels of analysis, effort, and availability of data. This element makes the CCP both unique and innovative, by increasing its transferability amongst local governments. It is the breadth of this program that enables it to cross north/south, developed/developing, metropolis/town boundaries and that has made it successful worldwide.

1. **Assessment – Understanding the building/site before carrying out works**
    - Make sure that experts from the **monument protection agency** are involved since the beginning of the process and implement appropriate **environmental indoor analysis** – including analysis on energy demand and actual level of energy consumption.
    - **Assess the opportunities**: retrofitting and enhancing the historic fabric of your city can generate private investment. Can you include retrofitting of historic buildings into your **Sustainable Energy Action Plan**? What is the state-of-the art concerning adaptation and mitigation strategies? What are the risks for your local heritage? Do you have any **resilience strategy** to ensure its preservation?
2. **Target setting – Identify challenges and priorities**
    - Consider the potential for **job creation and income generation**, for the increase in property values and the **impact on revitalization** of the area.
    - Involve all relevant **stakeholders** at each stage of the process.
3. **Planning – Explore solutions**
    - **Every historic building is unique:** Is this a listed monument? Or is it subject to any specific relevant regulations? What limitations to interventions (what and why)
    - **Innovation and technical solutions:** what are the optimal renovation/protection options?
4. **Implementation – what steps to take**
    - **Money, money:** There are several options for supporting energy efficiency retrofit of historic buildings, from European to national funds and the options of Private Public partnerships.
5. **Monitoring – evaluate, optimise and start to improve again!**
    - Monitoring allows not only assessing the **effectiveness of the intervention** implemented but also ensures **transparency and accountability** to the actions undertaken, and to improve your next actions.

For a step by step overview of what to consider while exploring the integration of historic building retrofit into urban / climate / energy planning read: “**Recommendations for Local Governments integrating energy efficient retrofit of historic buildings into policy and planning**”.

For more information, visit: www.3encult.eu

3 The Case Studies

This e-guide aims at identifying replicable factors for the integration of energy efficient retrofit of cultural heritage in urban sustainability.

Recommendation and guidance on this specific topic, both with focus on sustainability, and on urban planning and policy have been provided through two guidelines, developed by ICLEI Europe within the 3ENCULT project:

- **"Recommendations for Local Governments on integrating energy efficient retrofit of historic buildings into policy and planning"**
- **"Recommendations for Local Governments on integrating energy efficient retrofit of historic buildings into urban sustainability"**

This guideline **takes as starting point the recommendations above**, and aims to focus on the **replication potential** and on the lesson learnt from each of the eight **3ENCULT case study**.

The eight case studies were chosen in order to represent

- different climatic conditions
- different utilisations
- different epochs and degree of conservation restrictions
- different needed/planned interventions
- different time schedule of implementation
- different owners

Policy and planning frameworks related or in the context of the local case study, **will be used both to contextualize the building and to reflect on the impact that the retrofit had, or could have at urban scale**. The methodology used the dialogue with the stakeholders and the innovation developed within the case study will also be highlighted to inform recommendations for replication.

Note: Please note that the description of the cases is not exhaustive. Only selected technologies and solutions applied in the case studies are described in the text.

To learn more about technical solutions for energy efficient retrofit of cultural heritage, read the **"Summary Guide for Local Decision makers -Technical guidance on energy efficient renovation of historic buildings**", developed by ICLEI within the framework of the 3ENCULT project.

For more information: www.3encult.eu

3.1 About replicability

Each building is unique. There is no solution one fits-all. This is even more true when it comes to cultural heritage where the **priority remains protecting** the building and its value.

Nonetheless it is possible to outline generic recommendations and factors that can contribute to the success of an energy efficient retrofit regardless of the specific features of the building.

The analysis of the eight 3ENCULT´s case studies has provided highlights and input on both methodologies, approaches and strategies to adopt while dealing with energy efficiency and renewable in cultural heritage.

The guidance and outcomes of each case study will be contextualised below with a description of the building and with a focus on **innovation, governance and replicability** and how they can be integrated **into sustainability concepts and strategies.**

3.2 About sustainability

A **sustainable community** strives to **reduce its per capita use of natural resources** to a level that endangers neither local nor global ecosystems, and at the same time, it **ensures that political, economic and social** systems guarantee a high **quality of life for everyone**.

Not only environmental factors, but also governance, society, and economy are directly included in the concept of a sustainable development[2] that aims at meeting the needs of today without compromising future generations' ability to meet their own needs in the future.

A sustainable city works to reduce environmental risk, implements policies and strategies both to mitigate and adapt to the effects of climate change and become resilient[3] to it. A sustainable city contributes positively, through its policies, not only to the decrease of environmental degradation, but also in alleviating poverty and inequality, adopting a long term approach that goes beyond simply tackling environmental issues.

Re-use of existing built assets, reducing waste, water and energy consumption, respecting the local environment, community history, and biodiversity are vital to achieving the smart, sustainable city of the future. Through retrofit of cultural heritage, local authorities can act in their role as regulator and as real estate owner and use it as an opportunity for regeneration of disadvantaged areas, poverty alleviation, job creation and for climate protection.

3.3 CS1: Weight house – Bolzano, Italy

About the building
- **How was the building chosen /why?**
The building of Romanesque origins is placed in the historic city centre of Bolzano. It is part of the "Portici di Bolzano", which were built at the end of the 12th century. The "Portici" represent a typical composition of "street market" with a central grain trade.

[2] "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs", World Commission on Environment and Development's (the Brundtland Commission) report: Our Common Future (Oxford: Oxford University Press, 1987)

[3] For the European Environment Agency (EEA) a resilient city as an "urban ecosystem" that is dynamic: consuming, transforming and releasing materials and energy in an adaptive way and interacting with other ecosystems, tackling mitigation and adaptation efforts and addressing quality of life through better and greener urban planning

2: Public Weigh House, Bozen/Bolzano (Italy)

The “Via dei Portici” once formed the nucleus of the town. The oldest settlement consists of a road axis along which the constructions of the “Portici” are built on both sides, on narrow and long properties, arranged rectangular to the street. The widespread medieval building type is a house with narrow facades to the street, lined up continuously along the road axis. A characterizing aspect of the “Portici” of Bolzano is the continuous arcade/walkway along the street front. It is noteworthy, moreover, the intensive use of land, which led to a complete use of the property for the construction, not only in width but also in depth - the typical arcade house is four steps wide (not quite 4 meters), 50 meters deep and structured by the atriums into a front, middle and rear house. Through this situation and the serial repetition of this type of building a constant structure has been formed, that is interrupted by a system of atriums for the supply of air and light to the interior spaces. This original, urban system is still perfectly recognizable today. Every building consists of ground floor and usually three upper full storeys, up to three basement floor and an originally non-inhabited top floor. The ground floor was and is used as shopping area. The cellar served to store the goods, while on the upper floors there the living space was situated.

The Public Weigh House is part of the “Portici Street”, but it is separated from the continuous structure of arcade houses on both long sides through a narrow alley. The central part of the building towards the „Portici“ and the rear building, as well as the two basement floors are of Romanesque origins of the 12th century. Only afterwards, during the 2nd half of 15th century, the continuous walkway, the arcades, typical for the “Portici” street, were added on the north side. To connect the building to the neighbour building on the west side, during the 1st half of 16th century a bridge over the narrow alley was built. Towards the end of the 16th century, the building has undergone a major intervention, which included among other interventions, the unification of window openings and extensions on the east and west side (over the bridge) of the building as well as the subdivision of the south building part on 2nd floor with interior walls. Several inside partition walls were added during the last century.

Until 1780 the building was seat of the so-called “Fronwaage”, a public officially calibrated town scales. The following history of the use of the building has not been sufficiently analysed so far, but probably, even after completion of the work of the “town scales”, the rooms were used for commercial purposes. In the first half of the 20th century, the building was converted into a dwelling house and only the ground floor was further used for business. Especially after the Second World War the interior rooms have been given new dimensions, there have been installed some partitions to create more dwelling units. Since the 90s of the last century, the house was uninhabited and vacant. In 2009 it was sold by the city of Bolzano to the Foundation Cassa di Risparmio. The purchase agreement states that the property from the first to the third floor and in the second basement floor must be used for cultural purposes for 20 years.

The listed building consists of three full storeys, a top floor and two basement floors. All full storeys and the cellar are built in masonry of natural stones with lime mortar joints. Exterior walls have a thickness of about 60 to 80 cm. All walls (except on basement level) are plastered with lime plaster. Ceilings of the upper floors are built in wooden beams with wooden casing and filling material in between. The underside of the ceiling is plastered with lime plaster. Especially on ground and basement floor, the ceilings are vaulted. The building has a purlin roof with wooden rafters and wooden casing, roofing cardboard (bitumen) on the wooden casing and above it roof cladding with monk and nun roof tiles. In the Public Weigh House, the major part of the original windows, above all on first and second floor, were replaced by box-type windows from the 50s/60s of the last century with an outer an inner sash with single glazing. For shading and darkening, a wooden window shutter is used.

The building is an outstanding example of medieval construction right in centre of Bolzano and for its history and its very central location, the building is embedded into the daily life of the citizens, and it represents a major resource of identification for the citizens as well as an important touristic attraction.

- **Who is the owner of the building? How did he contribute?**

The owner of the building is the Stiftung Südtiroler Sparkasse (foundation), and it launched an ideas competition for a "house of photography" for the historic building.

The policy context

More than 20% of the buildings in Bolzano were built before 1919, a total of 37% before World War 2. Heating of these buildings costs more than 40 kt CO2 (0.4 t CO2 per person and year).

Bolzano joined the Covenant of Mayors on 10.02.2009, and it is engaged in reducing its CO2 emissions of 8.5 t/ person.

The **Master Plan** of the city was approved on 21.01.2010 and was followed by a **Plan for CO_2 neutrality** on 04.03.2010.

The Master Plan is tightly linked to the concepts of environmental, social, and economic sustainability, and it aims to build a relationship between urban and rural component of the city, paying particular attention to safeguarding the link between green spaces, the built environment and the territory. Energy efficiency, the possibility of recovering energy passively and the commitment to building zero emissions buildings for the future are at the core of the Plan. Adequate energy efficient retrofit of existing buildings is also foreseen.

Bolzano limits to maintain the size of the city and to favour retrofit within this area, to ensure a balance with green areas. The city provides support to contractors and owners, as well as runs 20 pilot projects within the city, and it is working on the development of n ESCO, able to facilitate access to funds for retrofit and provide white certificates.

For more information: http://www.comune.bolzano.it

Stakeholders

The relationship with **the local heritage office and the business sector** was one of the highlights of this case study through a very fruitful collaboration resulting into the development of an overall energy refurbishment concept and of pilot energy efficient windows, able to integrate well with the building's historic façade.

The **Local Government** took an interest in the developments and research by the 3ENCULT project and decided to include selected public cultural heritage in the Plans developed.

Furthermore, in 2014, the "Smart Cities´ & Communities´" SINFONIA project will build upon the work done so far by 3ENCULT, through a demonstration project, involving 25 partners, which will be carried out in the cities of Innsbruck (Austria) and Bolzano (Italy) within a five year project period.

Building renovation, introducing district heating and cooling networks and smart grids will all be addressed by the project. Residential houses and schools with a total floor area of 36,000 m² in Bolzano will be renovated to very low energetic need (EnerPHit standard) with additional renewable energy sources like photovoltaic and solar thermal energy drawn upon.

Sustainability criteria

The main sustainability criteria considered both with the same priority the **energy efficiency** (reduction of energy consumed) and **preserving the historical value** and appearance of the building.

The resulting sustainability conditions in detail were therefore:

- Conservation of building substance and of the documentary value
- Reduction of transmission and ventilation heat losses through the thermal envelope
- Comfort of the future users

Implementation highlights

- Technologies experimented / chosen

The main problems faced, were:

- high transmission heat losses through opaque parts of the thermal envelope and through windows
- high infiltrations respectively uncontrolled ventilation heat losses mainly caused by not tight/leaking windows
- slight overheating in summer
- lack of daylight, particularly towards tight neighbouring buildings
- condensation and mould grow risk in basement floors, in window reveals and weak points of the thermal envelope

Aim of the case study team was to contribute to the diagnosis of the case study, support its design and planning phase and give feedback with its monitoring.

After a comprehensive study on the actual state of the building regarding the construction elements and the determination of their heritage value as well as the assessment of the actual energy performance, a retrofit concept was proposed. All solutions were developed to improve energy performance and environmental comfort while simultaneously conserving the architectural and artistic value of the building elements. The local case study team concentrated on the development of passive solutions that are independent from the building use, as the specific use for the single rooms was still not committed.

The concept foresees:

- a reversible internal insulation in some rare, carefully selected parts of the building
- the replacement of the major part of the windows, which are not of historic value
- the energetic enhancement of several original windows
- the insulation of the saddle roof and of the ceiling over the arcades
- the insulation of the slab on ground and the basement ceiling
- the installation of a controlled ventilation system with heat recovery

For the replacement of that part of windows, which are not of heritage value, the case study team developed, in collaboration with the local heritage office and the project partners, an energy efficient heritage compatible window prototype.

A solution for the reversibility of the internal insulation was developed and tested on-site, as well as two solutions for the installation of internal insulation in connection with wooden beam ceilings.

- Innovation: The SmartWin Historic Window

On-site measurements and energy simulations confirmed the importance of the role of window refurbishment in reducing energy waste.


3: SmartWin Historic Window

The major part of the original windows of the building was replaced by box-type windows in the 1950s/60s – which were not of historic value from conservator's point of view and should be replaced, reproducing the appearance of a historic window. For the development of such a new window the aim was to build a highly energy efficient window with Passive House quality and a window that answers to the heritage demands of the building.

The developed concept separates the demands and functions into two layers: one outer layer for the reproduction of the original historic window and an inner layer for high energy efficiency. In this way, it is possible to obtain the same appearance like the original historic window from outside in terms of frame dimensions, sash bars and mirroring by taking a single glazing, without any negative effect on the energy efficiency. Additionally, it allows also preserving the original old window and just adding the second energy efficient layer.

The developed window system is a very high-performance component – it achieved the same standard as a Passivhaus window.

The development process profited from a strong collaboration with the conservation office – through the multidisciplinary interaction the development of a solution was possible that answers to the heritage demands of the building. The conservator accompanied and evaluated every design step/interim solution. The application of the concept and the execution of the window prototype profited from the flexibility, experience and expertise of the small traditional window producer, which is able to tailor his facilities to the production of this individual adapted windows.

To learn more about "smartwin historic" window read the **E-guide on technical solutions for local governments**: www.3encult.wu

Financing

The 3ENCULT project funded the analysis and diagnosis work on-site, as well as the production and installation of the developed prototypes.

AFTER the end of Action

The building is still vacant and not renovated so far. The building owner, the Stiftung Südtiroler Sparkasse (foundation), plans to execute the refurbishment project in the next years. The building should become a museum, a "House of Photography", based on the utilization concept proposed in the ideas competition that was launched in November 2012.

The winner project foresees a reception, shop and café on ground floor, a digital gallery for citizens, old photographic studio in the basement and space for several different temporary and permanent photo exhibitions on the upper floors as well as a atelier for the city photographer and an apartment for the caretaker.

The energy concepts and the technologies developed within 3ENCULT will be considered in the refurbishment planning. The 3ENCULT responsible for the case study, EURAC, will probably accompany the implementation planning by guiding the "Integrated Design Process" of the refurbishment project in terms of regular workshops among all stakeholders, in which the results are presented and exchanged as a discussion basis for the decision-making.

Recommendations and replicability

- The Weigh house shows how a **close collaboration between research, business and monument protection** authority can lead to successful working relationship able to benefit both the protection of the building and its energy efficient retrofit.
- **Local authorities can be inspired** by research; they can take on board **pilot projects** and use them as flagship action in their sustainability processes. This includes successful integration in urban, climate and energy plans.
- Research, vision and innovation developed for "special buildings" can be used and translated into **innovation for products on a larger scale**, able to benefit also small and medium enterprises, producing high quality products.
- **The developed window system and the energy refurbishment concept is transferable and applicable** to other similar historic buildings types.

3.4 CS2: Palazzo D´Accursio - Bologna, Italy

About the building

- **How was the building chosen /why?**

Palazzo d'Accursio is particularly interesting for its relevance within the community – as headquarter of the city - and it is also very significant because of its museum function: the building does not only have to satisfy conservation and protection requirements for the collections contained, but also to guarantee health and comfort of the public and the personnel.

In addition, because of its development through the centuries, the building presents eight centuries of solutions and technologies used.

Built in the 13th century for storage purposes, Palazzo D´Accursio has been expanded over the centuries to become the institutional headquarter of the city.

Over the centuries it becomes an architectural complex within which several blocks and decorative apparatus develop, following the historical, political and artistic events of the city.

In 1425, following a fire, the part of the building that faces Maggiore Square was completed in a typical local late-Gothic style. In 1508, the walls were reinforced around the main nucleus with white and red merlons (the colours of the city). From 1513 until 1796 the city government (a senate appointed by the city and a Cardinal appointed directly by the Pope) was located in this Palazzo. At the end of the sixth century, the building almost presented the consistency of the current building.

4: Palazzo D´ Accursio, Bologna (Italy)

Nowadays, it is not only the seat of the municipality, but it also hosts the Arts Municipal Collections, housing paintings and furnishings from the Middle Ages to the 19th century.

The materials used for building the palace are typical of the area: brick for the bearing structures, with two or three heads; sandstone for the decorative pieces; and with marble to embellish the architecture. The structure of the roof is entirely made of wood (beams, trusses and joists and floorboards coverage) mostly tiled.

- Who is the owner of the building? How did he contribute?

The owner of the building is the Local Authority which fully engage in the retrofit of the building in all phases:

- approval by the local government administration
- approval of the cost by the administration
- approval of the project by the National Heritage Protection Agency
- review of the project by the office for anti-seismic safety
- and re-approval by the local government administration

The Local authority also engaged as local case study team (from tests to planning, to selecting technical solutions).

The policy context

In 2008 the Municipality of Bologna approved the new **Municipal Structural Plan** (Piano Strutturale Comunale - PSC), a planning tool defined by regional laws (L.R. 20/2000), valid for the mid-long term (around fifteen years).

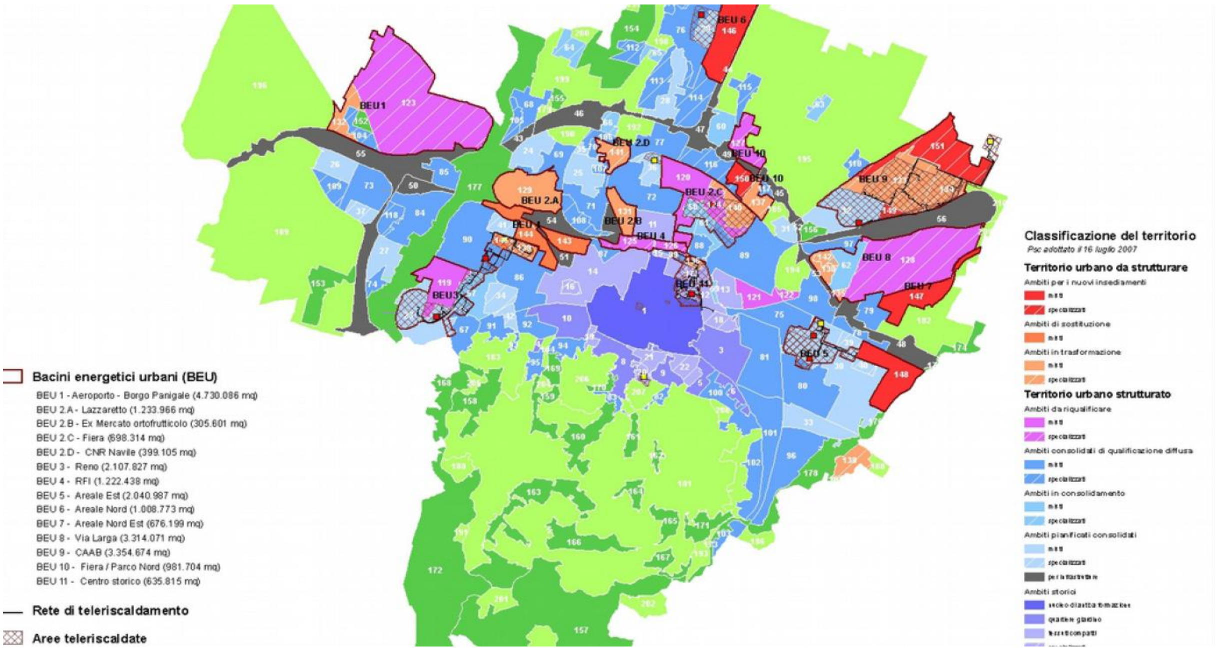
The Municipal Structural Plan is based on an environmental and territorial sustainability assessment (VALSAT) evaluating the environmental impact of proposed actions.

In the metropolitan area the PSC identified “Seven Sub-Cities”, which can be linked into a common programme of transformation.

The 2007 **Energy Plan of Bologna** (PEC) defined strategies for different areas of the city and evaluated the energy impact of new settlements and renewal projects.

The PEC selects homogeneous city’s areas (energy urban basins - BEU) for energetic, urban and environmental characteristics and defines a set of specific performance standards in each BEU, to bring a reduction of greenhouse gases emission in each new urban area identified in the Urban Plan.

This allowed an integration of energy plan strategies within the new city Urban Plan (PSC) and Building Code (RUE), in terms of specific rules and requirements for urban projects.



The PEC showed how most of greenhouse gases emissions of the city are determined by the **building sector** with an annual consumption for heating (170 Kwh/m2) a bit less than double the actual minimum standard for new buildings (90 kwh/m2). In the meantime electric consumption for summer cooling have increased at a quick rate in the last decade.

The residential sector is responsible for the highest percentage of emissions (34,9%) of the City of Bologna::

- 20.500 buildings: 22,4 % built before 1919, 68 % built between 1919 and 1971;
- 65 % of dwellings owned by occupants;
- 10.000 public dwellings;
- Half dwellings heated with autonomous heating;
- Rate of intervention on buildings: approximately 5% / year.

The **Urban Building Code (RUE)** is characterized by setting performance to be obtained by buildings instead of defining solutions. The technical requirements about environmental quality of individual buildings and building complexes introduce additional elements to national and regional standards. PSC and RUE have integrated at different scales the PEC policies.

At an urban scale:
- study about relation with microclimate (orientation);
- integration of renewables;
- extension and requalification of urban district heating networks.

At a building scale:
- compulsory solar energy requirements
- GIS tool for solar energy availability;
- excellence energy standards for new parts of the city and large regeneration;
- local standards for efficiency of electric uses (cooling and lighting) in addition to national standards for thermal uses.

Bologna subscribed to the **Covenant of Mayors** in December 2008, and the 2007 Energy Plan (PEC) was taken as a guide for the development of Bologna´s SEAP, which, in 2011, was provided for the phase of consultation and for the definition of public/private agreements in order to give a concrete framework of rules, resources and timing for implementation. In May 2012 the SEAP was finally approved.

Bologna committed to a reduction in emissions of about 500.000 CO_2 tons / year, in six action areas: residences, services, industry, local energy production, mobility, City administration.

The actions on renovation of residential sector are by far the main challenge of the SEAP, because of the fractioned property and difficulty in investing. In addition, Bologna is a city with a vibrant City Centre with many residents, students and temporary population. 22,4 % of existing buildings have been built before 1919 and the city historical centre among biggest in Europe (approximately 400 hectares).

Stakeholders

The Local Authority led on the entire process and involved the **local university**, as well as **ENEA** (Agenzia Nazionale della Prevenzione) and **CNR** (Consiglio Nazionale delle Ricerche) – which supported with expertise on monitoring the level of humidity in museums.

The collection of data resulted to be quite complex, as the contract for provision of heating, as well as for the management of the building, is handled by an external company, with difficulties on providing data on energy consumption only.

The Regional Agency for Monument Protection was also very involved in the process, especially in communicating the results to the public.

Local associations and the community have been informed through media and open days for the community.

The relationship with **business** sector was intermitting and focused on partners within the consortium.

Sustainability criteria

The main sustainability criteria addressed is the **comfort and safety of the users**.

In Palazzo D´Accursio the City of Bologna aimed to reach the delicate microclimatic balance that has to be found for both people and objects hosted within this building. Structural safety has also to be guaranteed, as well as security, and fire-safety.

As part of the building hosts offices adequate standards for comfort are crucial and particularly lacking prior to the retrofit.

This building is **heritage for the citizens** that have the right to benefit and participating in sustaining its cultural, historical and aesthetical value. For this reason, criteria of protection of both the building and of the artworks contained within it – including frescos, and decorations – were deeply investigated to ensure correct humidity and ventilation

Implementation highlights

- **Technologies experimented / chosen**

The building has no structural problems. There are phenomena of raising moisture on the outer eastern and southern walls, both in brick, with the processes of salinization (presence of saltpetre). The sandstones should be kept in constant maintenance because the material is very pliable and easily degradable due to air pollution and acid rain.

Among the non-distructive investigations conducted: thermography, Ground Penetrating Radar testing, Blower Door Tests, Heat flow meter measurements; Hygrothermal monitoring with the use of wireless sensors (WSN); "Spot" measurements of expressive parameters of the Hygrothermal, visual and acoustic comfort; Psychrometric and lighting maps.

The monitoring and analysis of energy consumption in the selected areas were followed by a series of dynamic energy simulations, to evaluate the effectiveness of different technical solution. This aided in selecting the best performing energy and environmental solutions

Three types of intervention were selected:

- the replacement of all fixtures with a selective double-glaze;
- the replacement of the terracotta-tiled wood roof with a ventilated roof, providing a package of wood fiber insulation;
- the replacement of lighting
- the renovation of the limestone plasters.

The process of investigation of the building required the collaboration among several expertise including: experts on building conservation, urban planners, experts on installation of systems, specialists on retrofitting and energy efficiency, on monitoring and non-destructive investigations, on data collection and scenario simulation (both static and dynamic), experts on conservation of art collections, among others.

- **Innovation: LED wallwasher**

A revolutionary lighting concept has been devised under 3ENCULT that both protects surfaces and is aesthetically pleasing. As such, the concept meets both human and material requirements.

Physical and chemical reactions triggered by electromagnetic radiation may accelerate deterioration of materials. The newly conceptualised luminaire ‘wallwasher’ slows down the deterioration process that material undergoes. The light is intended for use on delicate surfaces such as frescoes, and can be adapted if particular risk to specific colours/materials is known.

The device developed by 3ENCULT partner BLL is made from energy-efficient LEDs and requires only minimal installation (anchors and rope-bearing, stand mounted, on floor or cornices), ideal for buildings in which invasive refurbishment is not an option. Additionally, the use of LEDs allows for superb colour rendering and is entirely glare free (it includes both vertical and lateral cut-off). It can also be tuned to reproduce the illumination given by incandescent lighting (2700K).

Developed for the particular demands of Palazzo D´Accursio, the Wallwasher have been jointly approved by the city, the local case study team and the curator of the building. It represents a great example of how business can cater innovation for cultural heritage´s specific needs, which can then be used on larger scale.

Financing

3ENCULT and the municipality of Bologna has provided the first funds to start up with the retrofit. The work will continue after the end of the project, with an extension of the investigations to the office spaces in the building.

The retrofit has become a pilot case within the **GovernEE project**, a complementary project funded by the Central Europe program, dealing with issues regarding, in particular, the governance in energy saving projects, as an example of technical-administrative management. The project also supported the cost of replacing the windows.

Maintenance, purchase of lights, and monitoring sensors and all other operations are funded by the city of Bologna.

For more information visit: www.3encult.eu, www.governeeproject.eu

AFTER the end of Action

This retrofit has allowed the city of Bologna to delineate multiple scenarios for the Local Action Plan for increasing energy efficiency in municipal buildings, in collaboration with several departments of the municipality. The Plan foresees activities also on selected historic buildings.

From the 1960s Bologna has developed a **continuous history of preservation of its cultural heritage**, utilizing as frontrunner, the urban master plan, to ensure regeneration, and conservation of the historic center, also trying to revert depopulation. The city has a big percentage of population that lives in the historic center, but only temporarily (i.e. students), at the same time is suffering for an increasing amount of citizens moving, and building, in the periphery of the city.

From one side, this leaves in the historic center only students and elderly who either cannot afford or are not interested in investing in renovations works, from the other, **depopulation** of the center leads to **a reduction of green areas, new constructions, and larger distances** – with more emissions, and new transport systems to be built – which all result in increased consumption of energy, waste and greenhouse gas emissions.

For this reason the city of Bologna is proactively taking the lead in integrating the historic center and its buildings into local energy and climate planning, and working to increase sustainability and quality of life for the community.

More information, here: http://www.comune.bologna.it/paes.

You can find more guidelines in "Recommendations for Local Governments on integrating energy efficient retrofit of historic buildings into urban sustainability", available in www.3encult.eu

The Final Scenario involving 87 buildings foresees energy savings for 13,5 GWh/year, photovoltaic production of 775,5 MWh/y, costs of 16,6 million euros and payback of 14,1 years.

While the economic crises and the lack of funds is slowing down the process, the municipality remains positive and highly committed to explore new funding opportunities to continue with the works.

The impact of the retrofit will be particularly visible, where Sala degli Stemmi, will be re-opened, after 14 years to the public, after the works. This is expected to have impact both on the community and on the tourist sector, and the city will disseminate and promote the results of the project.

For more information visit: www.3encult.eu, www.governeeproject.eu and http://www.comune.bologna.it/paes.

Recommendations and replicability

- The **relationship with business** interested in investing in development of innovation and prototypes can be highly fruitful. To ensure this beneficial collaboration is important for the local authority to look for support of researchers and experts be to provide options and information on what the optimal solution for the building would be, prior to deciding for specific technical solutions.

  Solutions need to be oriented at the protection of the building, and to consider cost / benefits. Innovation is not only the most costly option, as sometimes it is possible to improve energy efficiency simply restoring traditional solutions.
- Where innovation seems particularly **costly**, it is worth considering life cycle cost analysis of the solution implemented, as well as saving in costs and energy consumed for production, transport and recycling of the material substituted.
- **Monument protection agencies** can be reluctant to participate to the decision making process (i.e. to ensure impartiality in the evaluation of the restoration). Nonetheless, it is crucial to try to engage conservators at an early stage to avoid later rescheduling or drastic changes in the work.
- **Collaborate with local universities and research institutions.** Use the local resources and increase experience and knowledge for future young researchers and experts that will be able to have a positive impact in future directly on the territory.
- **Tests are crucial to the protection of the building and to its users**. Structural safety includes stability of the building against natural events (snow, wind, earthquakes). In Italy, is foreseen, a compulsory analysis of the seismic vulnerability of all buildings declared of so called “primary interest” (such as: libraries, schools, museums) in seismic areas (1 to 3 risk index).
- **Safety** in the usage addresses all issues related to utilization of the building as well as safety of the collections hosted. Fire alarms, smoke detectors, motion sensors, security alarm and safety shutters and glass able to stop UV rays – damaging frescos. All these interventions need to be **verified in advance for compatibility** with structural and aesthetic criteria, and to be potentially revertible.
- An important element to assess the internal microclimate is captured by temperature and relative humidity data. To gather this information extensive monitoring is required: it is crucial in order to detect fluctuations during different periods.

It is also crucial to evaluate the illumination: both sunlight and heat can cause damages. Non- destructive investigations and monitoring can provide indispensable information for the energy efficiency retrofit.

- Be creative in compiling **funding options**. More than one funding lines, and a combination of private and public funding can support your projects (i.e. PPP, ESCOs, ecc).
- Retrofit of historic building has great potential **economic and social impact** – take the opportunity to evaluate how you can integrate it in your climate, energy and urban planning.
- Assess how the intervention will impact on quality of life in the city, and on other services and sectors (i.e. Mobility, and tourism), and try to make the most of the project.
- Cultural heritage can become a **flagship project**. Local governments can include selected cultural heritage in their **SEAPs** with the aim of improving the sustainability of the building while protecting it, but also with the result of sensitizing local communities towards the issue while **reducing the energy bill**.
- Resilience to both climate change and to increasing tourism needs to be increasingly considered. It responds from one side to the need of preserving cities from natural disasters, but it also gives the chance to **secure urban cultural – and economic - assets**, that millions of tourists come to visit every year.

3.5 CS3: Palazzina della Viola - Bologna, Italy

About the building

- How was the building chosen /why?

The Palazzina is a XV century building with a high cultural value - a "jewel of the Renaissance art". It presents painted timber ceilings and the masonry walls are frescoed.

Property of the University of Bologna, when the project started the building was abandoned since a few years and presented structural deficiencies from the seismic viewpoint and problems related to energy efficiency (e.g. old windows with single glazing and deteriorated timber frames, no insulation from ground nor in the roof).

5: Palazzina della Viola, Bologna (Italy)

The Palazzina is now in use and it represents a success story within the 3ENCULT project, symbolizing the continuous joint effort and the crucial collaboration between scientists at the forefront of research and from very different disciplines, the technical office of the University and the City.

After a long refurbishment, whose planning has integrated the structural and energetic aspects of building revitalization, the construction is now the headquarters of the University's Department for International Student Exchange – a working area for exchange and multiculturalism of about 1,300 m^2.

The area hosts 40 employees who interact with around 5,000 international students and more than 2,000 exchange students annually.

- **Who is the owner of the building? How did he contribute?**

The University of Bologna is the owner of the building, and the regeneration of the area where it is situated is part of the Agreement between the University and the Municipality of Bologna.

The University led the research team engaging in the case study, both on the testing phase and on the monitoring phase – which continues successfully also after the end of the retrofit.

The policy context

See the description in CS2

Stakeholders

The Palazzina della Viola represents a particularly interesting example of collaboration within and between research departments of a University. Local authorities should consider collaborating actively with their local research institutes and universities.

Sustainability criteria

The priority of the intervention was given both to the **comfort of the users and preservation of the works of art** - heritage testimonies - inside the building.

The special destination of use of this building – able to cater for students and employees of the University – impacted on the required level of comfort as well as on safety and security measures (i.e. Fire alarms, smoke detectors, but also elevators for people with reduced mobility).

Second priority was given to **conservation**. In this case, preserving delicate original material had limited the energy savings, leading to a quite satisfying result of heating and cooling loads reduced by 12% and 30% respectively, simply by improving the air tightness of the many windows present.

Since the end of the refurbishment works in March 2012, an **extended and innovative cloud sensing network** was installed in the building. The **monitoring system**, developed by the DEIS Dept. of University of Bologna, provides valuable input for motoring and continuously improving the standards of comfort: making of the Palazzina **a living lab for improvement** of users´ comfort.

Implementation highlights

- **Technologies experimented / chosen**

Excessive light amount present in Palazzina because of the wide glass areas along with high temperature values represent both high risk for the decorations and uncomfortable conditions for users.

A wireless sensor network (WSN) was installed before the beginning of the restoration and later improved to monitor indoor conditions. Together with extended non-destructive structural and energetic investigations (http://www.unibo.it/docenti/camilla.colla), the wide set of acquired data contributed to assemble a thorough diagnose of the construction.

Following the refurbishment, post-intervention diagnoses are regularly performed in the building and are used to evaluate ways to improve both user comfort and energy efficiency. The monitoring system consists of about 40 nodes, each equipped with a number of sensors. These nodes are distributed throughout the four levels of the building.

The sensors continuously record energy and structural and environmental data, which is then stored in a database. The data is accessible in real-time through a website for data visualization and downloading, creating a valuable data bank for further studies. Light distribution maps, air temperature and relative humidity data have been obtained through a number of “movable” WSN nodes located on the first floor. These nodes are used to perform post-intervention diagnosis and facilitate greater analysis of employee behaviour and use of the building.

For more information visit: http://www-micrel.deis.unibo.it/sitonew/ and www.3encult.eu

Financing

The 3ENCULT project funded part of the tests and the monitoring. The University covered the other costs of the restructuring.

AFTER the end of Action

The innovative investigation and monitoring approach used in the Palazzina, which uses a combination of analog surveys, non-destructive testing and wireless sensor nodes as mobile nodes, is proving to be a reliable methodology with manifold advantages. The robust monitoring sensor technology may provide the ability to create interoperability between new applications and pre-existing subsystems in the future.

The collection at the same time of different environmental parameters without the need for using different and more expensive testing equipment is very valuable in order to increase the level of sustainability of the monitoring approach and to guarantee a continuous improvement of the comfort and energy efficiency level in the building.

The monitoring will continue to inform the status and sustainability in the longer term of the retrofit.

Recommendations and replicability

- **Communicating that significance** to everyone concerned with a place, particularly those whose actions may affect it, is essential if all are to act in awareness of its heritage values. This understanding should include policy makers, but also business and the citizens so to ensure cyclical renewal and repair.
- Local governments are not only a user of innovation but can proactively contribute to the development of new sustainable technical solutions through **promoting** their use and collaborating with research institutions.

  Furthermore, local governments act as beacon in **inspiring** citizens into investing and deploying sustainable innovation. Through making the public aware of the quality of the intervention applied to a trademark historic building, local authorities can educate the public and trigger **interest and awareness** in the community.

- **Ensure user's comfort.** High quality architecture and innovative technologies should meet in historic buildings to make sure both protection of the building and enhancement of the user comfort. This is especially important if the building is a school or an office building where occupiers spend most of their day.

  For this purpose, monitoring is a particularly important measure. It can be used to monitor energy consumption, but also **temperature, humidity, light, and air quality**, all parameters essential to comfort.

  The **well-being of artworks** is also essential in order to guarantee their preservation for future generations.

  Local governments should consider **comfort of users** both as a **ultimate goal** and as a **trigger** for proceeding with energy efficiency retrofit of historic buildings.

- **Train the staff working in public historic building** to assume an **energy efficient behaviour** in the building and make them aware of how to use **traditional solutions** to this aim. Aware users are usually more understanding and keen to contribute.

- Explore the use and take into account **traditional ways** of insulating or managing temperatures that are less invasive.

3.6 CS4: The Old Material Court of the Fortress - Copenhagen, Denmark

About the building

- How was the building chosen /why?

Restored in 1994-96, the main building, Building I of the Material Court of the Fortress, was brought back to its original shape of 1756.

Currently the Material Court has been converted to public office spaces, and the recent restoration and pilot project of the court has provided a unique material when it comes to analyze concrete results of energy and cultural heritage.

- Who is the owner of the building? How did he contribute?

Realdania,byg A&S owns a large number of historic buildings, worked closely together with the Danish Heritage Authority and experts from different fields during the retrofit process. The plan was developed in an iterative process, starting with numerous potential solutions which were then refined after several rounds of increasingly detailed analysis. The main objectives of the restoration were to reduce CO2 emissions, guarantee indoor comfort and provide guidelines for other office buildings.

As the restoration was already planned, many of the decision on the retrofit were already discussed. The methodology resulting from this case study stresses specifically this need for collaboration and multidisciplinary exchange (i.e. more feedback from conservators).

The policy context

The City of Copenhagen is committed to reduce its CO_2 emissions by 20% by 2015, meaning an emission reduction of approximately 500.000 tons, dropping from 2.500.000 to 2.000.000 CO_2. In Copenhagen, the goal of a 20 % reduction by 2015 was already achieved by 2011, when CO_2 emissions were reduced by 21 % compared to 2005. Today, Copenhagen emits 1.9 million tons of CO_2.

6: Old Material Court of the Fortress, Copenhagen (Denmark)

The Copenhagen Climate Plan was adopted in August 2009 unanimously by the city council, and foresaw the implementation of 50 activities. 34 of these activities were launched in 2010, and 44 during the first half of 2011, and they involve different sectors, from energy efficient renovation of municipal buildings (schools, kinder gardens etc.), to the increase of renewable energy sources, from establishing new small parks for re-creative purposes to further encouraging citizens to save energy. In 2010 an amount of DKK 28 million was assigned to the implementation of the plan, as well as 62.5 million DKK during 2011-13, for a total of 90.5 million DKK.

The object of Copenhagen's Climate Plan is now to contribute to a greener environment and to help Copenhagen becoming the world's first **Carbon neutral city by 2025**. The CPH 2025 Climate Plan layouts an holistic plan comprehensive of commitments and activities to be undertaken in four areas -energy consumption, energy production, mobility and the City administration. The CPH 2025 Climate Plan describes how the goal of carbon neutrality can be used to achieve a better quality of life for citizens, innovation, new jobs and investment through a joint collaboration between a local government, citizens and all stakeholders involved in the process

Stakeholders

A close cooperation between the University and the local case study team, together with the owner of the building. The **Local Authority** was not directly involved in the decision- making process, but was very supportive of the organization of a study tour, targeting other European local authorities, aimed at exploring cultural heritage and energy efficiency in Copenhagen.

During the tour participants explored not only the Old Material Court of the Fortress but two more outstanding examples of energy efficiency retrofit of cultural heritage in the city: the Matsekurene and the Osram building.

The Masteskurene and Mærsehuset - The "Masting sheds and top sail" building complex has been a great success, with new life breathed into the building complex whilst retaining its character. The project was nominated for the Mies van der Rohe Prize as good example of renovation that preserves an historical trademark and meets the users' needs;

The Osram Building –a shining example to both Copenhagen and the rest of the world of the energy savings that can be achieved through sustainable retrofitting. The building, previously used for the manufacturing of light bulbs, has been extensively "energy renovated" while retaining respect for the building's unique history. Situated in the Haraldsgade neighbourhood, the building was renovated as part of the Integrated Haraldsgade Urban Renewal Scheme[4] - a five year plan funded by the City of Copenhagen and the Danish Ministry of the Interior and Social Affairs.

The five-year **urban renewal project** is holistic, and aimed to improve the district physically, culturally and socially. The scheme would have been in accordance with the needs of the local residents, including them in the discussion: residents were engaged in the preparation of the neighbourhood plan together. Residents also play a central role as representatives in the scheme's steering committee, which decided the projects to be financed.

A **multidisciplinary group considered the building, including architects, structural engineers, the heritage authority and the building owners**. Issues of the renovation were considered, such as the change in rental opportunities and maintenance requirements, risk assessment, functionality and shape of the building, energy efficiency and more. After consideration optimal solutions were decided on to achieve an excellent standard of sustainability, whilst preserving the integrity of the building. The building stands as a prime example to other building owners both in Copenhagen and further afield.

Sustainability criteria

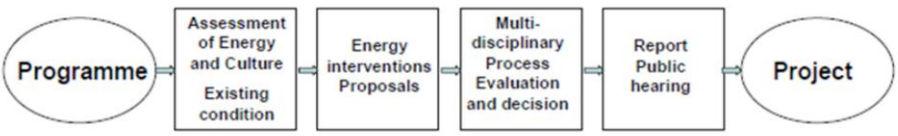
The multidisciplinary and inclusive approach used thorough the retrofit, as well as the development of a coherent methodology targeting specifically sustainability criteria is a clear highlight of CS4. The methodology that considers the overall environmental and social impact on the building and on its districts it is addressed below.

In Denmark, buildings "listed" as preservation-worthy by the national Heritage Agency are exempt from mandatory energy efficiency improvements. **This case study proves that it is possible to reduce the CO_2 emissions in listed buildings by 20 percent without compromising their historic value**. Thus even listed buildings can play a role in achieving ambitious goals such as carbon neutrality.

Implementation highlights

- **Innovation: 3ENCULT new methodology for Environmental Impact Assessment**

The Royal Danish Academy of Fine Arts has developed a new methodology based on Environmental Impact Assessment (EIA). The methodology is being applied to the eight case studies selected by the 3ENCULT project, representing a diverse, and comprehensive, mix of European built heritage (urban and rural, cold and warm climates, humid lowlands and dry mountain areas).



7: 3ENCULT´s methodology for Environmental Impact Assessment

The new 3ENCULT methodology aims at providing guidelines for identifying and better integrating cultural and energy

[4] http://www.covenant-capacity.eu/fileadmin/uploads/se/Events/osram_pr%C3%A6sentation_26062012.pdf

indicators within conservation works of built heritage. Through doing so, environmental, social and political decision-making is supported. This methodology has been developed as an instrument that identifies different stakeholders' perspectives as part of a process that includes energy and culture in environmental impact assessment. This process also involves public participation.

This methodology, developed on the basis of a survey conducted by 3ENCULT, wishes to identify and find a balance between the value of cultural heritage and energy efficiency. In doing so the methodology refers to European and international cultural charters and conventions, as well as to energy standards and directives. The identified indicators will be integrated in scenarios and setups for the democratic process, public hearings and decision-making. Scenarios will include passive and active energy retrofit solutions to be evaluated in a multidisciplinary decision forum, and will take into account local and even universal environmental impact assessment.

To learn more about the methodology visit www.3encult.eu

Financing

Funds were provided by Realdania Byg A&S of the Realdania foundation, owning a large number of historic buildings.

AFTER the end of Action

The office space retrofitted will be sold or rented to return the investment.

The foundation owns more historic building which can be retrofitted in an energy efficient way and wishes to invest in similar activities, also in relations to the city´s strategy on climate and carbon emission reduction.

The city is listing this case study among its flagship projects for sustainability.

Recommendations and replicability

- **Change in the historic environment is inevitable**. Natural processes, time and usage, and people's responses to social, economic and technological change, have an impact of the relationship with cultural heritage.

  It is crucial to consider the characteristics of the building, and what is needed to ensure its protection, and at the same time to assess the **best possible usage**, which will allow the community's interest into continuing appreciating and protecting its value.

  Explore traditional solutions: energy efficiency does not always come from the newest technologies – explore with conservators if historic techniques can be reapplied to the building (e.g.: cooling, shading)

- It is crucial to remember that buildings are part of the urban texture in which they are located. Every conservation decision should be based on the understanding that it will **impact** not only on the building but also on the **urban fabric**, and that it might influence the usage and the interaction with the building. Local governments should be aware of this and engage appropriate experts in drafting the best possible integrated strategy, which should include energy, climate, mobility, biodiversity aspects.

➢ The regeneration of a derelict area can not only bring positive effects on individuals but also contribute to creating a **favorable environment for business and investments**. This can result in better services, more jobs and in an increased integration among the inhabitants.

For this purpose local governments should always consider the buildings that they decide to retrofit as part of an overarching and inclusive urban planning strategy – including green **spaces, better transport and mobility, cultural and social facilities able to foster sense of community around the historic buildings** being retrofitted.

A useful exercise could also be to consider whether the building can continue or change its usage to host a facility able to meet the needs listed above.

3.7 CS5: Monumental School – Innsbruck, Austria

About the building

- How was the building chosen /why?

This school is listed as one of the most important examples of early modern architecture in Tyrol (1929-1931). In connection with the reform of the Austrian school system and the introduction of the “Hauptschule“at the end of the 1920`s, new types of school were planned to meet modern criteria such as air and light.

The school opened on the 25th of October in 1931, and it is a perfect example of the the architectural culture developed under the principles of the “New Objectivity”[5]. The building is still in use, and has recently become a “Neue Mittelschule”.

The retrofit of this building is part of a larger plan by the city of Innsbruck, which has recently decided to retrofit step-by-step twelve school buildings with cultural value. Of particular cultural interest, the building has been selected by 3ENCULT for the specific demands of comfort that a middle school requests in order to provide adequate learning environment for pupils.

- Who is the owner of the building? How did he contribute?

The owner of the building is Innsbruck IIG immobilien geschäft, the Real estate of the city of Innsbruck.

The relationship with the owner has been overall close and fruitful, especially in identifying energy and comfort demands.

The policy context

The city of Innsbruck supports energy upgrades of residential buildings since 1 January 2013. The Innsbruck Energy Development Plan, launched in 2009, aims at implementing a

[5] Hambrusch H., Moroder J., Schlorhaufer B. (1998): Franz Baumann, Architekt der Moderne in Tirol.- Wien and Bozen, page 188.

wide range of measures to reduce energy consumption and increase renewable by 2025. Among the measures implemented, the Innsbruck Sonnenscheine project, were citizens can purchase shares of solar energy. Pilot projects are being implemented by the city in collaboration with business, but funding is offered to individuals, for retrofits that serve to reduce the demand for heating and soundproofing as well as eco -friendly measures, when the building permit at least dates back 10 years. The city offers professional energy consulting, also able in collaboration with the urban planning department, able to give advice also on measures to be implemented in historic and listed buildings.
Stakeholders
The work in the case study took place in close collaboration with the **facility manager**. This collaboration proved to be particularly important to better assess the performance of the building and to capture the feedback from the pupils daily experiencing the comfort level. The **director of the school** was also particularly supportive of the work being done, and supported the activities liaising with students and teachers. **IIG, the building owner** was deeply involved in the retrofit, and promoted the work through disseminating the results – mostly to the outside. Technologies and solutions such as the active overflow were not communicated to their full extent, especially within the sectors and working groups in IIG. The **business sector** was highly involved in the development of the prototypes, and their interest in researching was crucial to develop optimized solutions. The companies involved were not only part of the 3ENCULT. Prototypes developed included: sound absorbers, other lighting, insulations, artificial light/daylight redirection Interventions improving the energy efficiency of the building were also discussed with the **Austrian Authority for Cultural Heritage BDA**. One main objective within the **discussions between owner, architect and authorities of cultural heritage is the vision of the restored school building**, the balance between restoration and adaption to the necessary demands of an up-to-date school preserving the specific atmosphere and characteristics of a building of the 30ties.
Sustainability criteria
The main sustainability criteria considered, beside the **conservation of the building**, were: - Comfort of the students - Energy efficiency - Ratio cost of energy/ benefits - Sustainability of the materials These criteria were followed through a thorough measurement and monitoring of the temperature, day light, and more. Innovative solutions and sustainable materials were used to ensure that the target comfort was reached limiting the impact in terms of emissions and energy consumption. Sustainability was both a request form the owner and a specific aim of the case study team,

which took into consideration the importance of guaranteeing adequate leaning environment and, at the same to decrease the energy bills.

The aim was to reduce the impact of typical construction-flaws due to improper workmanship and a lack of knowledge and experience with this type of building, which were causing damages within the construction, and needed to be taken in consideration:

The built in elements still exist and are intended to be restored. The **original colors** and **flooring materials** (linoleum) were detected and are intended to be recovered. The dialogue is still an ongoing fruitful process.

Implementation highlights

- Technologies experimented / chosen

Main issues to be tackled within the building: high heating energy demand and severe overheating problems due to large un-shaded glazing areas; air quality problem. Low thermal comfort.

The retrofit aimed at implementing and (energetic) refurbishment, that was already decided prior to the project start, and that foresaw:

- efficient windows with integrated shading
- internal/ insulation of walls and roof
- ventilation system with heat recovery

All solutions implemented were discussed with the Protection Authority, many of them reaching a good compromise between conservation and energy efficiency.

The **existing windows** were only partly original and already damaged and generally in a bad state, unprotected against fire impact and presenting severe thermal bridges. Nonetheless the windows, worth of preservation, were maintained, even if the effort to repair/restore them was much higher than to rebuild them.

The original box-type windows went through a process of demounting/repairing/restoring/improving/mounting in one of the rooms, they were painted, and the roller blinds repaired, in the other room. Where this was not possible, they were rebuilt according to the original construction.

To reduce the leakages and heat transition in the layer of the inner wings additional window seals were added, and the thermal quality of the glazing (double glazing instead of existing single glazing) was improved.

Where the windows had been demounted, the steel columns between the windows elements were painted, with a fire protecting coat, capable to resist 90 minutes of fire impact and also isolation added to reduce the thermal bridges.

The old blinds were replaced by new daylight guiding venetian blinds, supporting the artificial lighting in an energy efficient way.

Concerning the **heating system**, the conservators assessed that the original tube-radiators are essential elements of the interior design and they must be preserved.

To provide pupils and teachers with an optimized comfort, the existing problems with dry air and discomfort were addressed through optimizing the radiators. Within the thermal refurbishment the flow temperature needed to be lowered to a level, which allows a feasible integration of renewable energies. The thermal mass of the radiators needed to be reduced, and the thermal mass of the floor slabs needed to be used as a thermal buffer to prevent expensive active cooling.

To this aim, in both rooms, the heating distribution was separated from the main distribution line: a heat exchanger and circulation pump was interposed between main distribution line and separated heating circuit to simulate lower flow temperature.

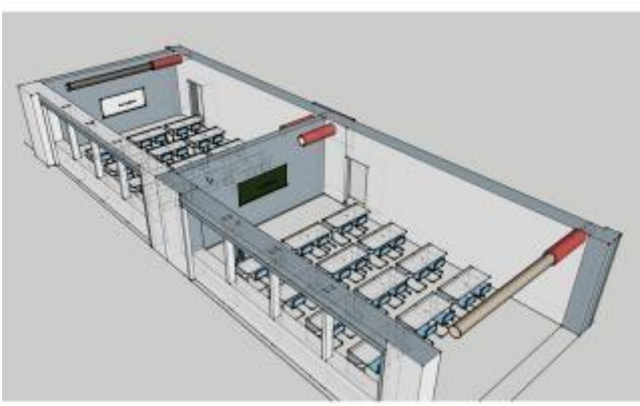
The ceilings were kept free from interventions (as acoustic drywall suspended ceilings) to keep them in use as thermal buffer.

Room 1: inlets mounted in the radiators, reducing the volume of the heating water to a third, improving the adjustability, flow temperature lowered to 45°C adapted to reduced heat demand (interior insulation and improved thermal quality of window line),

Room 2: flow temperature 55°C adapted to reduced heat demand (only interior insulation).

- **Innovation: Active overflow**

A new minimally invasive ventilation system for school buildings was installed in this case study. The dual aim of this system is to preserve the architectural value of the building while guaranteeing scholars´ comfort.



8: Monumental School, Innsbruck (Austria) – active overflow

The ventilation system was designed to be integrated into historic buildings, through guaranteeing minimal invasiveness (structurally) with maximum reversibility. For this purpose the principle of "active overflow", which is already used in refurbished dwellings, is an optimal energy efficient solution that can also be applied to school buildings. The idea is simple: fresh air is supplied into the corridor and stair case, with fans actively flowing the air from the corridor into the classrooms. The corridors and stair cases acts as the supply air ductwork and only the exhaust air ductwork is needed. The supply and exhaust air is linked to heat recovery.. Silencers are also needed to prevent noise.

Two 3ENCULT partners, the University of Innsbruck together with the company ATREA, are testing the first prototypes of active overflow elements with vans and silencers in the Hötting school. The prototypes aim for the obvious advantage - to avoid the need for ducts in the corridor or for the installation of a vertical shaft to provide fresh air.

The heat recovery system is instead placed in the attic and the fresh air is distributed via the open staircase and corridors. Driven by a fan through a silencer the air is then distributed through textile ducts, which can be removed and washed as needed. The flow rate of the central unit is controlled by CO_2-sensor in the corridor and the fans in the classrooms are switched on according to a schedule one hour before the start of lessons. Motion control sensors switch off the fans after a delay of 45 minutes.

With a special focus on cultural heritage, this minimally invasive strategy is a big advantage to combine together preservation aspects and user comfort at the same time, but it can be modified and used also in buildings that are not cultural heritage.

Financing

Part of the work has been funded by the owner, while the 3ENCULT project partly paid for the prototype developed and the work on site.

National funds for lighthouse renovation have also been applied for, and in addition the project SINFONIA co-funds the retrofit of the school.

AFTER the end of Action

The renovation of the building NMS Hötting provides a good practice example of how research informs practical implementation.

The 3ENCULT´s two prototype class rooms will be monitored for one year, for both energy and comfort and IAQ to help to optimise solutions for full scale renovation of the whole building. Substantial energy savings can be achieved in the rest of the building, through reduction of transmission heat losses, the installation of an innovative ventilation system with heat recovery, as well as the implementation of energy efficient solutions for lighting.

Starting in 2014, the "Smart Cities´ & Communities´" SINFONIA project will build upon the work done so far. Hötting school is included as one of the pilot projects.

This demonstration project will be carried out in the cities of Innsbruck (Austria) and Bolzano (Italy) within a five year project period. Building renovation, introducing district heating and cooling networks and smart grids will all be addressed by the project. Residential houses and schools with a total floor area of 66,000 m² in Innsbruck will be renovated to very low energetic need (EnerPHit standard) with additional renewable energy sources like photovoltaic and solar thermal energy drawn upon. Specifically, 390 m² (50 kWpeak) of photovoltaic panels will be installed on the roof of the Innsbruck school.

Furthermore, the school will continue being a flagship project for the Region, where experts and local authorities are visiting the building top know more about the solutions implemented. International visitors are also taking interest in the school, which has become a provider for peer-to-peer exchanges, through the PassREg Project.

Recommendations and replicability

- **Prototypes developed**, and especially the active overflow can be used in a wide range of cases, and not only for schools: assess and exchange with experts, conservators and researchers to identify what innovative solutions can be applied to your building
- **Recycle materials** when possible, it is sustainable and it can reduce costs. In this case study the original radiators have been preserved through the addition of plastic tubes to decrease cross section of the tubes – preservation can cheaper than changing solution
- **The collaboration with research and industry is necessary** to ensure innovation. With the support of researchers you can identify wide range of solutions and then look for products that match a good balance between innovation and costs.
- Implement your retrofit on **small scale** to ensure how it can be replicated on a **large scale.** This procedure reduces costs of potential mistakes.
- Engage in the discussion all **relevant departments** in your local government as well as relevant stakeholders. Good communication can provide solutions already tested and contribute to disseminate the outcomes.
- Explore within your local government what strategies are being used by other

departments, you might find in-house experts on specific funding schemes, national, European and private.

- Local governments are not only a user of innovation but can proactively contribute to the development of new sustainable technical solutions through **promoting** their use and collaborating with research institutions.

  Furthermore, local governments act as beacon in **inspiring** citizens into investing and deploying sustainable innovation. Through making the public aware of the quality of the intervention applied to a trademark historic building, local authorities can educate the public and trigger **interest and awareness** in the community.

- **Prefer not invasive and sustainable techniques/ solutions**. Natural ventilation and day lighting for example improve the building occupants' health and well-being without the use of active technology. Consider the potential for:
  - Passive solutions (resulting from design and change in user behaviour)
  - Active energy solutions, meaning improving energy efficiency (technologies) and generating renewable energy for electricity, space and water heating or space cooling.

3.8 CS6: Warehouse City & Others – Germany

About the buildings

- **How was the building chosen /why?**

This case study is the combination of several buildings.

- **Schinkelspeicher** in Potsdam,
- **Wilhelminian building** in Dresden,
- **Baroque building** in Görlitz, and
- **Renaissance building** in Freiberg

The focus of the Case study is the comparison of performance of different innovative, but already market available solutions for interior insulations within these four different historic buildings - Four different systems have been with a special adapted glue mortar, a thermal insulation and a surface moisture regulation plaster.

- **Schinkelspeicher Building in Potsdam**

  Owner: Speicherstadt GmbH

It is a building complex, located in the centre of Potsdam and was built in 1688. Used as storage space for corn and grains. The Schinkelspeicher ´s remarkable early industrial design defines the historic value of this construction.

The case study team performed several tests including: energy balance, moisture status report, evaluation of horizontal structural waterproofing, analysis of constructive details and documentation prior to the start of the intervention. The aim of this study was to analyze a interior insulation system planned with a focus on possible condensation and critical moisture contents in wood construction, and the risk of mold growth.

After completion, the Warehouse City should achieve the newest technological energy standards (heating and cooling) based on renewable energy, and it will become a place for optimisation, demonstration and teaching the close nexus between renewable energies and buildings.

- **Wilhelminian "Gründerzeit Villa", in Dresden**

  Owner: Dr. Frank Zinsser (private)

A listed Wilhelminian style building situated in Dresden built in 1870 and altered in 1912. The house was designed to host for one family with only – with three lordly in the upper floor. The aim of the retrofit was the preservation of the original building character and the respect of its constructive demands.

The owner proved especially interested in preserving the historic features f the building, and asked to focus on an energetic sustainable retrofit mainly to reduce heating costs, in order to create affordable living space over a long-term basis.

The energy efficient retrofit has been implemented through improvement of the insulation and through amelioration of the heating systems - via geothermal energy.

The challenge was to insulate the façade. A **capillary active and diffusion permeable interior insulation ("IQ-Therm Insulation Board")** was applied, which consisting of PU-foam panels and mineral components, could ensures the transport of moisture inside the wall.

- **Barock building in Görlitz**

  Owner: Dipl.-Ing. Janet Conrad (private)

This listed historic building –known as the Handwerk15- in Görlitz is a part of the oldest settlement area of Görlitz in Saxony. The main structure was built in 1250, in 1726 the building burned down completely and it was then reconstructed.

The outside walls consist of old masonry, plaster, while the ceiling presents wooden beams. The renovation of the building started in 2004 and it was completed in 2011. The building continued to be used for residential purpose.

In this case the case study team applied diffusion-open capillary active interior insulation systems with "**calcium silicate**", in combination with a **conventional thermal insulation plaster** on the outside.

- **Renaissance building in Freiberg**

  Owner: H. Neuhaus (private)

The "Renaissance Style Building" in Freiberg is a listed building constructed in the 16th century. It is situated in the historic center of Freiberg, in Saxony. It is an outstanding example of medieval stock of in the city.

The building includes different types of construction techniques, which varies according to the time of creation. The basement dates back to the middle Ages, while the ground floor was built during the Renaissance.

The renovation objective is to turn a 500 years old listed building into a nearly zero energy consumption residence, making of it an attractive and healthier living space right in the historic center of the city.

The retrofit aimed was to balance the preservation of the construction with today's demands on energy saving and living.

With the renaissance building in Freiberg, the case study team investigated both the **calculation method and measurements necessary to reach a passive house standard** after the renovation.

9: Case study 6 - Schinkelspeicher Building (Potsdam), Wilhelminian "Gründerzeit Villa"(Dresden), Barock building (Görlitz), Renaissance building (Freiberg) - Germany

The policy context

In the current **strategy 20-20-20**, the European Union's goal is to reduce by 20% the Greenhouse Gas Emissions (1990 levels), by 20% the energy consumption, an to increase by 20% the use of Renewable Energy Sources.

In the **Energy Efficiency Plan 2011**[6], the European Commission states that energy efficiency is the most cost effective ways to enhance security of energy supply, and to reduce emissions of greenhouse gas and other pollutants. This is why in 2007, the EU has set itself a target for saving 20 percent of its energy consumption by 2020.

Buildings currently represent almost **40% of total final energy consumption** and, therefore, can make a crucial contribution to these targets, therefore a great potential lies in the built sector.

The European Commission´s strategy focuses on instruments to trigger the renovation

[6] http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

process in public and private buildings, and on ways to improve the energy performance of the appliances used in them and to foster energy efficiency in households and the industry.

Many local authorities have joined this process, and have committed to the 20-20-20 strategy, through preparing coherent Sustainable Energy Action Plans. This plans include retrofitting of public buildings, and increasingly, link to creation of climate funds or ESCOs able to provide support to residents willing to invest in energy efficient retrofits and in RES installation.

To learn more, read: "Recommendations for Local Governments on integrating energy efficient retrofit of historic buildings into policy and planning", available at www.3encult.eu.

Stakeholders

The **University** researched and conducted the retrofit, in close cooperation with team of **architects, conservator and building engineers**.

Business partners developed ad hoc insulation materials to respond at the specific requests of the case study team. The collaboration was very fruitful, and the business partners invested time and resources into developing new ad hoc products.

The **owners** – as three of the buildings are privately owned – accompanied the process every step of the way, and requested to be informed and engaged in the detection of appropriate solutions.

Sustainability criteria

Sustainability was addressed both in the **planning phase and the implementation**. This was not only a fundamental prerequisite for the researchers implementing the retrofit but also for the owners, who consider it important to achieve **protection of the building** and **reduction of the costs**.

Among the considerations taken into account:

- The energy measures and maintenance activities contribute to the sustainable reconstruction of cultural heritage as well as the restoration, as they are a prerequisite for continuation and (re-) use of these historic buildings
- Historic buildings could be saved from decay through ensuring better and more appealing comfort conditions
- Where possible it is important to use environmentally-sound materials: in Potsdam a fully ecological loam cork insulation system was applied on the timber framed construction.

Implementation highlights

- **What technologies have you researched/ experimented/ chosen for your building?**

The issue of **moisture accumulation** - due to temperature difference between the inner and outer wall, allowing water vapor to diffuse into the construction – can potentially cause mould and moisture damage. This can be addressed by using:

- **diffusion brake interior insulation** and
- **diffusion-open, capillary-active interior insulation systems**

The cost of classic interior insulation depends on the insulation type and thickness, and varies between €60 and €240 per square meter, including personnel costs. The solution developed in 3ENCULT is called iQ-Therm with the components iQ-Fix, iQ-Tex, iQ-Top and iQ-paint. It needs around €75, up to €150, depending on the thickness of the insulation. At high performance the insulation has small thickness, leading to more usable living space and less space consumption. In comparison to conventional insulation, the time for workmanship could be reduced remarkably by 25 percent, which supports acceptance by processors. The product is sturdy, construction-tolerant and provides a sustainable solution.

- **Innovation: iQ-Therm – 'Intelligent' Interior Insulation for Historic Buildings**

The iQ-Therm system provides an effective way to refurbish buildings from the inside. The product provides intelligent interior insulation, significantly upgrading a building's insulation properties whilst allowing it to remain fully breathable. The system is targeted at buildings where external wall insulation is not viable due to conservation restrictions, or where traditional wall insulation methods cannot be adopted.

The iQ-Therm System also manages to stop rain water from causing damage - even if driving rain penetrates the facade, the system enables it to dry. At no time does moisture form on the surface of the interior wall, which could lead to infestation with mould.

Presented as a prize winning innovation at the Munich Bau exhibition in Germany, this intelligent insulation consists of a breathable rigid polyurethane foam panel, added to the structure walls either with a lime-cement based or - for a better reversibility - a loam based adhesive mortar (originally tested in 3ENCULT). The system is then rendered and painted with compatible products to offer a solution which solves condensation, mould and heat loss issues With an immense capacity to store and transport moisture, the system buffers peak moisture loads in the air of the room, regulating the climate.

Over the long term, buildings can dry out and make significant energy savings. This is monitored in two other 3ENCULT case studies: the Monumental School in Innsbruck (Austria) and a Wilhelminian-style villa in Dresden (Germany).

Financing

Information not available – private buildings.

AFTER the end of Action

The re-building and restoration of the Schinkelspeichers already completed. The first inhabitants move in and the monitoring of the energy requirement and use can start. There will be build 137 apartments and 15 business units with about 18.500 m² rentable area.

All the other buildings are private; they will be managed by the respective owners.

Recommendations and replicability

- The properties of the construction have to always be considered when selecting the insulation. A diffusion open and capillary active insulation system should be dimensioned so to avoid condensation (surface), or to limit it (inside), and it requires appropriate drying potential towards the inside.
- Original materials should be preserved where possible, and new material should be specific to each installation.

- The application of measurement techniques enables the collection of important hygrothermal performance parameters, such as the reduction of thermal transmission losses and the control of the moisture behavior and it is crucial in energy efficiency retrofit. assessment of energetic renovation
- The thermal and hygrothermal behavior of the construction and the entire building will be affected by the following parameters: air temperature, relative humidity or partial pressure of water vapor, direct and indirect radiation, and diffuse sky radiation, driving rain and air pressure. A quantification of these external climatic parameters is required for building physical components and the building design.
- The use of new material technologies in historical monuments should be accompanied by an advanced evaluation of renovation methods such as building physics laboratory tests and application of modern simulation tools.
- Sustainable re-development of districts consists of an integration of historic and new buildings, and their link to their surroundings.
- Where feasible connecting the buildings to **district heating and cooling systems**, or can use co-generation or other renewable energy sources. A sustainable option is also to **purchase locally produced renewable energy**.
- Although most places of heritage value are in use, often the relationship between use and heritage values can range from mutual support (in the normal situation of use justifying appropriate maintenance) to conflict.

  The **shared public and private interest in sustaining heritage** in use demands mutual co-operation and respect between owners or managers and regulators. The best use for heritage building is one that is both capable of sustaining the place and the values it represents, and avoids or minimizes harm to its values in its setting.

  The exchange between owners and policy makers is crucial to ensure adequate protection of the heritage buildings, as informed owners will be able to retrofit more adequately their historic buildings.

3.9 CS7: Industrial Engineering School - Béjar/Salamanca, Spain

About the building

- How was the building chosen /why?

The building was built in 1968 and it is one of the emblems of the city. It belong to the category of industrial heritage - defined by “The Nizhny Tagil Charter for the Industrial Heritage, 2003” as a symbol of a culture that is of great historical, technological, social, architectural or scientific value**.**

The building is still used as Scholl of engineering, and it suffered of:

- Overheating during the hottest months of the year, especially in the east facade of the building, in spite of the air-based cooling systems installed in the rooms with this trouble. Moreover, this air-based cooling systems are manual controlled, which

results in a inefficient cooling strategy and, in most cases, a lack of comfort in the room.
- Inefficient heating: The heating system is composed of radiators installed in all the rooms of the building and supplied by one main gas oil boiler and other auxiliary boiler. The building has 2 heating circuits, one for the north of the building (east façade) and the other for the south of the building (west façade).

- **Who is the owner of the building? How did he contribute?**

The building is owned by the University, and it is managed by it.

The University was directly involved, as well as the building manager thorough the project. This facilitated both the administrative work (less bureaucracy), the access to the data, and the assessment of the comfort inside the building.

9: Industrial Engineering School, Béjar/Salamanca (Spain)

The policy context

The town of Bejar has not developed an official energy action plan, but the city council has proven to be very keen to engage in both implementing energy efficiency measures, and instilling RES technologies in this building – the approval of the measure was given high priority.

There is not known plan for retrofitting districts within the cities as result of this intervention, but nonetheless the project might have triggered interest in continuing towards carbon reduction and energy efficiency (e.g. change in lighting system).

Stakeholders

The **University of Salamanca**- both as administration and as research institution has highly contributed to the project.

The **manager of the building** was also consulted in order to both ensure appropriate maintenance of the monitoring system installed and to collect additional information on the behavior of the building – including collecting feedback from students.

The **Local authority** was not included in the process. Only interaction was related to potential interventions on the façade, which was not implemented.

Private business was consulted in order to develop optimized strategies for the installation of renewable. This included project partners researching innovative products (e.g. solar glazing).

The students were involved, and asked to comment to the comfort prior and after the retrofit. The possibility of a survey was considered, but instead the building manager was able to provide a list of complaints and feedbacks. Furthermore, students were involved in leaning and experiencing first hand technologies for energy efficiency and RES.

Sustainability criteria

The case studies wanted to focus on clean energy and comfort of the students, as well teaching them firsthand about energy efficiency and renewable energies, and how they can be implemented to reduce costs and increase comfort.

For this purpose photovoltaic cells have been planned to be installed in one laboratory, for teaching purposes (not yet implemented).

The case study team also aimed at exploring as much as possible, the possibility in using and integrating RES, which includes: biomass boilers with controller strategy and photovoltaic panels. The under-exploitation of the sun light was particularly taken into account.

Energy efficiency is also at the core or the research, both to ensure reduction of the emission and to decrease energy bills, where the savings can be reinvested in the school.

The reflection on sustainability was jointly requested by the University and by the project partners.

Implementation highlights

- **Technologies experimented / chosen**

The School is a large building with different climate conditions, particularly complex to monitor, in order to achieve a more efficient working and a comfortable ambient in the rooms.

Despite of the many hours of sunlight, the natural sunlight was not fully exploited, resulting in waste of energy through unnecessary artificial lighting. In addition, the artificial lighting installation was oversized in corridors and halls, and with manual control.

In several areas of the building, the external doors don't close perfectly, allowing for thermal loss. The working of the overall heating system is managed remotely using a time scheduler, from 7 AM to 7 PM and, additionally, there are two external temperature sensors, which manage the on/off of each circuit depending on the temperature.

To solve this issues, the case study team applied the following innovative measures:

- Freely Programmable Modules in LonWorks sensor protocol
- Building Management System/ZigBee

And explored:

- Use of biomass boilers instead of diesel boilers, which did not succeeded due to constraints the space for conservation of the pellets and space in the building
- Use of PV, due to the high level of sun radiation during the day

- **Innovation: "ZigBee"**

A novel Building Management System (BMS) has been developed in this case study to gather monitoring information from a sensors network, known as "ZigBee". The system displays the behavior of the building in terms of the parameters measured, and then calculates the best approach to take based on control algorithms.

The great innovation of the BMS is the capability to communicate in an easy way with the ZigBee sensors through user input. The BMS includes a mixture of technologies, both old and new, that are seamlessly integrated into the architectural make up of the building. Google Web Toolkit is used for the Graphical User Interface. Mixing the new technologies, including successfully gathering and integrating data from the ZigBee sensors, is the main challenged faced.

Financing

The research was funded through the 3ENCULT project, while the University paid for the extra installations that will be taking place in the near future (e.g. boilers).

After the end of 3ENCULT, the University will maintain the current installations. There are still question marks in regard to the future maintenance of the BMS, which the University is now using through a facilitated website.

AFTER the end of Action

As of now the idea of increasing progressively the comfort in the building remains the aim of the owner. To improve the effectiveness of the monitoring, not only the staff but also students should be trained on characteristics of the monitoring and effectiveness of the sensors (now only maintenance)

After the end of the project, the maintenance staff of the case study would like to continue the maintenance of the systems. Currently, there are two BMSs deployed, the LonWorks control and the ZigBee monitoring (ZigBee sensors do not allow actuation commands). Thus, there are two Web applications for the access and the control allows staff to manage the set-points for temperature, as well as, start and stop the fan-coils manually. Both BMSs are user-friendly without the requirement of expertise for managing them, therefore, no additional details are required for maintenance.

The control algorithm in the case study integrates the redistribution of the luminaires in the test room jointly a control detecting presence in several points of the room (setting up a grid) and lighting level in order to switch on/off the lights. The cooling system is proprietary therefore the implementation of the cooling control algorithm required a combination sw/hw. The lighting control algorithm was deployed in an open standard protocol (LonWorks aforementioned).

Through the detection of presence and temperature levels, the HVAC system is switched on/off. Both algorithms can be extrapolated to the remaining rooms of the building or another building with a SmartServer aforementioned. In fact, the University has redistributed the luminaries in some classrooms after checking the reduction of the consumption in the test room, as well as, the achievement of the comfort level.

Furthermore, the case study aims to have a social/ training impact through the installation of PVs for student to explore, which will hopefully be implemented in the near future. This will increase the familiarity with sustainable technologies and fosters replicability at home.

Recommendations and replicability

- The monitoring system can be adapted and replicated. The complexity of installation pays off thanks to the quite complete analysis provided, and the relatively low costs:

  Freely Programmable Modules (FPM): That is a set of tools included into the LonWorks sensor network installed in the case study. This sensor network covers both comfort and thermal/electricity consumption with a good cost-effectiveness. FPM is not used in a broad field and it avoids hardware costs for additional installations because these tools are integrated into the SmartServer. It could be programmed in a common programming language (such as C++) and integrated in the controller; therefore it is replicable in any case with the constraint of the need of the SmartServer.

  Building Management System: The deployment of the combined ZigBee sensor network and the BMS has been completed and it is stable. Jointly the innovations mentioned in the article of the newsletter, another feature is the replicability and scalability of the system which makes use of free license technologies. The only requirement is the usage of ZigBee sensors developed by Unibo.

  TRNSYS/PHPP: The building has been simulated in both well-established tools, but additionally a comparison between them has been carried out in order to understand the behaviour of each tool.

- It is crucial to train owner and staff when lacking of technical expertise. This could also help them in better understanding why it is important to engage in energy efficnt retrofits.
- The intervention could be used a beacon project for more university buildings and public buildings
- Cover all possible solutions and explore the best options without bias.

3.10 CS8: Strickbau, Appenzell (Switzerland)

About the building

- **How was the building chosen /why?**

The building is a two-storey log house, built in 1630: is a good sample of a typical log house. It is characterised by layered wooden beams enmeshed at the corners with a so-called dovetail connection to give the building strength.

Log house is one of the most original types of construction in Switzerland and it was used up to the late 1800s. Today it still forms the basis of most houses in Appenzell.

A block construction characterized in its angles by a unique regional design. Today, these houses are predominantly riveted with panelling or shingles, with wide ribbon windows and colourful facades. The traditional features of these houses have been replaced with modern solutions and materials. Because the log house will be destroyed at the end of the two-year study period, it was considered a unique opportunity to adapt interior insulation and find solutions and responses relating to situation and thickness of insulation etc.

10: Strickbau, Appenzell (Switzerland)

The house is especially in need of repairs on the shell of the shingles. The wooden top floors are partially built on a brick-built basement in quarry stone method. The constructive framework of the basement is visually intact.

In this case study the researchers focused on:

- analyzing behaviour of wooden constructions after extreme interventions.
- using destructive analysis techniques - particularly on a extensive monitoring of room climate, energy and the thermal hygric behavior of the construction
- testing different thermal and moisture conditions

The owner of the building is a private, a farmer that moved out of this house after building a new one in its replacement. The owner is particularly collaborative and supportive, and has frequently taken an interest in controlling the works, and in supporting the team.

The policy context

In Switzerland, SwissEnergy makes a major contribution to the achievement of the following targets:

- general reduction in end consumption through greater energy efficiency in terms of combustibles, fossil fuel and electricity.
- 20% reduction in 1990 levels of CO_2 emissions and consumption of fossil fuels by 2020.
- a minimum 50% increase in the share of renewable energy in total final energy consumption. Rising demand for electricity should be covered as far as possible by electricity generated from renewable sources.

Furthermore in Switzerland, many citizens are taking part to the 2000-watt society (2,000-Watt Society) introduced in 1998 by the Swiss Federal Institute of Technology in Zürich, which inspires citizens to reduce their overall average energy consumption to no more than 2,000 watts (48 kilowatt-hours per day) by the year 2050 - without lowering their standard of living.

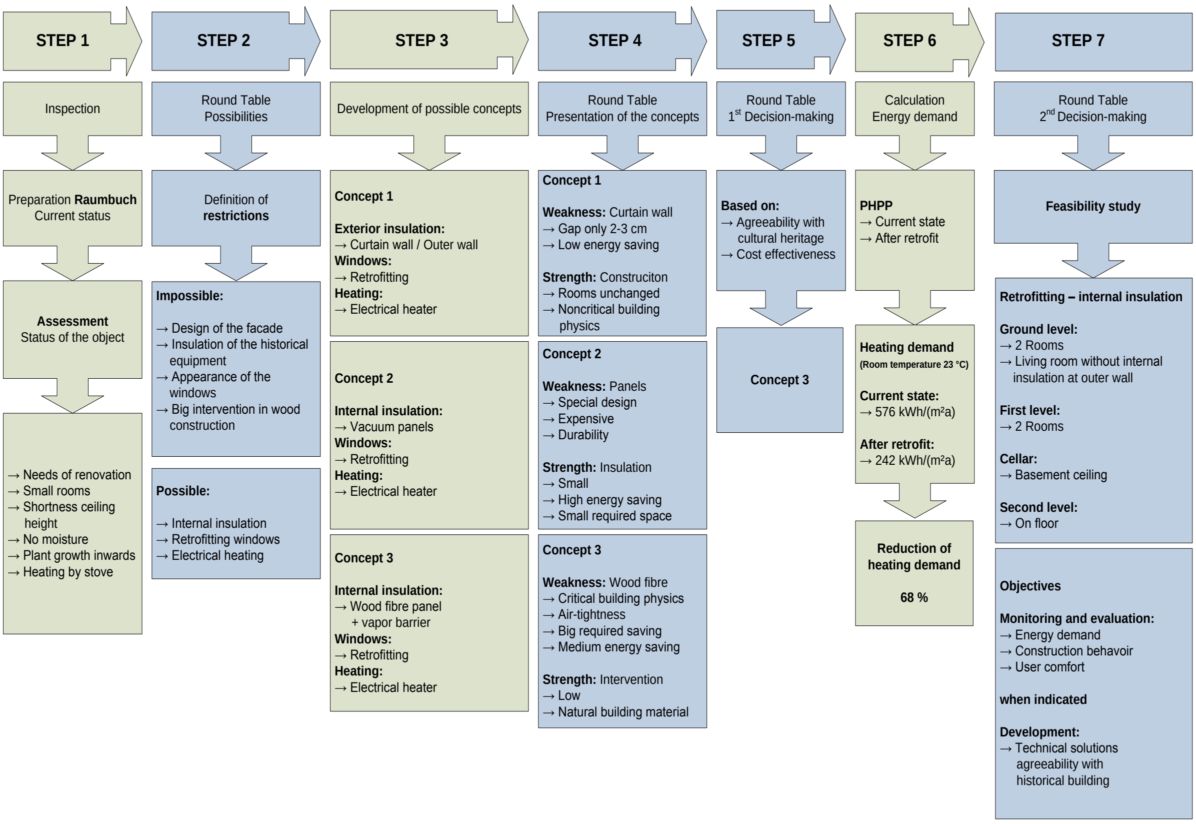
The canton of Appenzell Ausserhoden has the highest proportion of historic residential building in Switzerland. A law requires that for every new farm house being built, the existing farm building has to be demolished.

This is to preserve the landscape with single, detached, farm houses. Nonetheless the most unique Strickbau buildings can be declared historic monuments and be preserved, through the fulfillment of at least one out of six criteria, related to their historical or folkloristic importance.

Stakeholders

The case study team is composed of researchers for the **University**. The cantonal **monument preservation** and conservation authority and the project partner Institute for building research of ETH Zürich have also been actively involved in the project.

A **decision- making plan** by stages was developed to optimize solution for the energy retrofit measures and conservation. See plan below.



11: Decision- making plan, Strickbau, Appenzell (Switzerland)

The **owner** has taken interest in supporting the investigations.

No business was involved but **local craftsmen** were interested.

Sustainability criteria

The case study aims to tackle the challenge of using modern features, while respecting historic architecture, through exploring ways to optimize the **energy efficiency** of the old buildings, in line with **Swiss monument conservation guidelines**.

Beside **reduction of heating demand**, amelioration of the and comfort, the case study focus on improving the chances of retrofit of these building that are increasingly demolished – with an increase in energy consumption and in emission through the need of building a new construction, as well as in **demolition**, recycling and **disposal** of the materials discarded, in addition to the **transport** of new and old materials used.

By reducing energy inefficiencies the project is aiming to help reduce greenhouse gas emissions, while also reducing costs and improving living comfort.

The traditional Strickbau buildings are built with **massive wood**, hence very robust and much better suited for the climate where they are located. Re-becoming familiar with traditional materials and techniques will increase the potential for conservation and widen the range of potentially low costs solutions available.

Through this retrofit, the case helps rediscovering **lost craftsmen techniques** and trigger interest in restarting training and capacity building for these traditional skills, potentially resulting into new jobs creation.

Implementation highlights

- ### Technologies experimented / chosen

Comprehensive testing was conducted in the planning process and after the execution of energetic restoration measures. Among the solutions experimented and discussed: **airtightness**, by adding new windows and finding solutions for moisture transport, adequate **inner insulation** such as wood-wool-panels, to identify a suitable solution.

To simulate real usage conditions, four insulated rooms were equipped with electrical heaters and humidifiers. These cause a more or less pronounced moisture problem causing mold damage within the construction. To prevent such damage, a comprehensive monitoring system was installed accompanying the assembly of the internal insulation. More than 200 sensors for detecting temperature and relative humidity were applied, plus further sensors for detecting the out- and inside pressure conditions.

To analyze the coupled heat and moisture behavior of the internal insulated construction, extensive numerical calculations were performed using the software program DELPHIN (version 5.6.5). To take account of the external weather conditions, a test reference year for the location of Appenzell was generated with the help of the software METEONORM.

- ### Innovation: Stripping down the building

The building was progressively “stripped down” within the two years of the project, to allow installation of interior insulation for analysis purposes.

An interior insulation measuring concept was developed and experimentally examined together with the preservation agency. A comprehensive monitoring was developed to calculate record and evaluate temperature and moisture in selected areas of the construction. This allowed to analyze and to evaluate structural-physical behavior of the insulated construction, in all rooms subject to the ambient climates.

Wooden-dowels were used to improve air tightness.

On all exterior walls, wooden facing layers have been attached, while wood fiber insulating boards have been installed in the space between the timber frames, a vapor retarder was subsequently installed.

Thanks to this installations, and to the detailed monitoring of their impact on the structure, it was possible to develop some guidelines on additional measures for the protection of the structure, in case of internal insulation installed:

- Mandatory ventilation system, so that no excessive room moisture can form during cold weather periods.
- Installation of heating cables in the endangered areas. With these, it is possible to increase the surface temperature enough that condensation cannot form.

Financing

Not applicable to this case study - feasibility study. To know more about funds for retrofits in Switzerland visit: http://www.svizzeraenergia.ch/it (IT, DE, FR)

AFTER the end of Action

The results of the studies will deliver an important contribution for the transfer of considerable knowledge gained from the day-to-day planning work of developing measures of energetic retrofitting of log houses in the building stock.

The building will be **demolished** in the next months, but the office of conservation and the ETH Zürich will organize workshops with the local government and also with owners and handcrafts in the upcoming period to inform on technologies, and on possibilities to preserve these buildings and the **surrounding landscape**.

Recommendations and replicability

- The preservation of historical buildings can only be assured through their continued use. Investigations are needed to identify ways not only of improving energy efficiency according to the special requirements of conservations in existing buildings, but also ways of creating a significant improvement of the residential usability. This will increase the chances of preserving the building by adjusting the conditions to modern living standards in similar constructions.
- Traditional techniques are often not longer taught. It is possible to revive these techniques creating new skills and new job opportunities.
- Stickbau can withstand its relatively high humidity thanks to its corner connections that have no excess endings and therefore present no weak spots. Many historic building, similarly, have characteristics and features that suit perfectly their climate conditions. Retrofitting these buildings can guarantee success on the long term, and a positive impact in terms of life cycle cost analysis.
- Internal insulation is a good way to make a building energy efficient, but before installing such insulation, make sure, that an expert in building physics investigates the building and the proposed measures of energy retrofitting.
- Energy retrofit of historic building usually does not reach a passive house standard, however, it can contribute to a cantonal energy saving.
- Sustainability is also about protecting through modernizing – as mean for conservation. In this case, people living in old Strickbau buildings need to be informed on how they can improve their energy efficiency and renovate their houses easily to achieve the same level of comfort as new homes, this way they will be more keen to avoid building a new construction in favor of a restoration.

4 Brief conclusions

The minimum energy savings in buildings can make a considerable contribution to the reduction of GHG emissions, but to make this process sustainable, is necessary to take into account a comprehensive, rigorous approach, that includes historic and listed buildings into a wider climate and sustainability strategy, and that fully takes into account both social and economic considerations as well as biodiversity and environment.

Historic buildings are landmarks in many European cities. Communities recognize themselves and their history in their walls. They also have a great economic potential that supports entire **service industries**. All these must be considered while aiming for a sustainable approach to urban development or reclaim.

The maintenance and reuse of the historic fabric, in particular of historic buildings and the historic centre contributes to **the efficient handling of natural resources** through reducing the need/ consumption of new materials (e.g. for construction), reducing the use of land, facilitating “urban development with short distances” (historic urban areas are usually a compact urban structure and are located in the city centre or nearby, reducing the length of transport ways/ less commuting. At the same time, attractive historic urban areas contribute to the decreasing suburbanization trends, with an inversion of depopulation of historic centers.

An attractive and lively historic urban fabric can contribute not only to the quality of life of the community, but also **enhance local and regional economic competitiveness**, creating a better environment for businesses and tourist sector. The facilitation towards a stronger economy would be able to create employment in the EU, alongside with inclusive social and environmental policies.

From past to future – it is important to consider that retrofitted buildings have best chance to survive: new functions and uses keep maintaining the building “alive” – retrofitting and protecting a building that is being used, it is a more valuable investment.

Making cultural heritage part of smart urban strategies is a efficient way to both protect the building, the community´s history, making of heritage a valuable contributor to local sustainability.