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Contents

1 Introduction

In order to disseminate the project results during the course of the project three international symposia have been held. This report compiles the proceedings of the events in Munich (Germany), Ferrara (Italy) and Anglet (France).

2 International Construction Trade Fair BAU 2015 (24.1.2015)

BAU is the World's Leading Trade Fair for Architecture, Materials and Systems in the construction industry. It is where future-oriented manufacturers come together with an audience of interested professionals. Their primary interests include the latest techniques, materials and applications that can be put to use in actual practice.

Being half way through its envisaged project run time and being able to show significant progress regarding technological developments, supply concepts for renewable energies as well as decision making strategies in the complex context of historic districts the outcomes have been presented to a professional audience in the B0 Forum of the BAU2015 for discussion.

2.1 The EFFESUS project: Energy Efficiency for EU Historic Districts

Isabel Rodriguez-Maribona, Tecnalia

Buildings have a significant impact on energy use and the environment. Across the European Union, they are responsible for approximately 40% of the energy consumption and 36% of CO2 emissions. The majority of buildings in Europe are located in cities, which accommodate around 73% of the population, a share which is expected to increase to over 80% by 2050. Growth in population, increasing demand for building services and high comfort levels assure that the upward trend in energy demand will continue in the future.

EFFESUS has adopted an inclusive definition of historic urban district: ‘a significant grouping of old buildings, built before 1945 and representative of the period of their construction or history, and comprising buildings which are not necessarily protected by heritage legislation’. The European building stock built before 1945 represents 23% of the total, and even if a reduced number of these buildings are officially listed, a substantial proportion possesses heritage significance.

The European Union has developed several programs, guidelines and directives on energy efficiency in buildings in order to harmonize instruments and criteria, such as the recast of the Energy Performance of Buildings Directive 2010/31/EU (EPBD), which strengthen energy performance requirements; or the European Recovery Plan which considers energy efficiency as one of the actions to be tackled to overcome the current crisis.

Most of the existing developments in energy efficiency address new constructions without dealing with the uniqueness of historic structures. New solutions typically address individual buildings without considering the urban dimension, where interconnections between buildings and other infrastructures enable different solutions. EFFESUS has been devised in order to reduce the environmental impact of Europe’s valuable urban heritage, by making significant improvements to its energy efficiency while preserving its cultural and historical values. The project brings together the expertise of 24 partners from 13 countries, 12 of them being small and medium enterprises. It develops and demonstrates, through case studies, a methodology for selecting and prioritising energy efficiency interventions based on existing as well as newly-developed cost-effective technologies and systems compatible with heritage values. This methodology is implemented in a Decision Support System, a set of tools and information models to facilitate an evidence-based diagnosis and decision-making.

2.2 Smart management and integration of renewable and energy efficiency solutions in historic buildings and districts

Patrick Schumacher, Fraunhofer IBP

Besides using less energy and energy efficiency solutions, renewable energies are the most important part to reduce fossil energy use and the related greenhouse gas emissions. Smart management systems like demand side management or load shifting help to increase the local generated energy. In our case study Santiago de Compostela we analysed and showed different solutions. First of all, we showed that also solar energy and biomass in historic districts might be practicable under specific circumstances. Further, district heating and cooling systems can supply an entire historic districts where an installation of solar systems or huge heat pumps are no more possible or allowed. Because renewable energies like solar and wind energy are fluctuated depend on local weather conditions, thermal and electrical storages are more and more a common solution and necessary. Different types of storages and their practicability for historic buildings and districts are analyzed. Furthermore energy efficient solutions like improved historic windows with a lower u-value are developed for the case study in Budapest. Five prototypes of new windows are modelled and evaluated. An evaluation of different historic buildings helps to analyze and simulate the potential of load shifting to increase the share of renewable energy (in this case wind energy from the coast). Three variations with different thermal storages and a new algorithm were developed. The result was a combination of simulation with different price signals and the real heat and cool demand of the historic building in Casa do Cabildo. With a lower price during higher wind, the building will heat up a bit more than usual. The results show, that historic buildings and districts can be also a part of a smart and very flexible energy system.

2.3 Development of conservation compatible new materials for envelope retrofitting of historic buildings

Carsten Hermann, Historic Environment Scotland

As part of the EFFESUS project, new materials have been developed to retrofit existing building envelopes. The material developments include insulating lime mortars, aerogel cavity-fill insulation and radiant selective coatings. Building envelopes are that part of the building fabric which protects building occupants and content from the outdoor climate. The envelope provides shelter from rain and wind and helps to create a suitable indoor climate. The energy needed to maintain the indoor climate depends on the heat flow through the building envelope. Retrofits, therefore, aim at improving the thermal performance of building envelopes. To make new materials suitable for a conservation context, they must be usable in ways that do not damage a building's cultural significance. Established conservation principles can be used as indicators: significant building fabric should be retained, increased deterioration be prevented and interventions be reversible. In the following, the three materials mentioned above will be outlined.

The insulating lime mortar was developed by the Dutch partner, Bofimex, with the aim of producing a mortar suitable specifically for the porous substrates commonly found in historic buildings. Moisture permeability was one concern, matching the low elastic modulus of historical construction another. The new product had to be less costly than ordinary mortars, whilst achieve a better thermal performance. Initial research identified natural hydraulic lime as the ideal binder. After trialling various insulating fillers, expanded polystyrene (EPS) beads were selected. They achieve good thermal performance, are very stable and commercially available at low cost and in a variety of sizes. The new mortar, now named IsoCal, can be used externally or internally and be hand- or spray-applied. For aesthetic and technical reasons, a finishing coat is required.

Loose-fill aerogel insulation was developed for use as a cavity-fill insulation. The new material can be blown into cavities behind existing internal wall finishes, such as plaster on laths. The A. Proctor Group aimed at adapting and improving existing products to achieve lambda values lower than those achieved by many of the better-performing, conventional insulation products. At the same time, the new insulation is to be not much more costly than conventional retrofit measures. The loose-fill material was to be developed from an existing aerogel blanket product. Thermal performance testing showed that the aerogel fibres achieved a better performance when injected, compared to manual filling without compaction. Because of its loose-fill nature, the installation of the material, now called Spacefill, is easily reversible, but the production and handling requires special care with regard to dusting.

The development of radiant selective coatings was led by Acciona, with the idea of producing a coating for application on external, porous surfaces to reduce heat transfer by both conduction and radiation. The coating is designed for reflecting and buffering infrared radiation, to have only a minimal, visual impact and be cost effective and reversible. There are two principle ways in which such radiant selective coatings can perform: The coating can reflect outdoor radiation, thereby avoiding heat transfer to the substrates. Alternatively, the coating can also retain absorbed outdoor radiation, buffering it until such time when emitting back to the external environment is possible. Ideally, the coating will function in both ways, making it more suitable for changing environmental conditions. An extensive testing campaign was conducted resulting in a technically functioning product, which, however, proved to be non-reversible. To achieve easy removal, a coating-primer combination was developed, with primers frequently used in conservation.

The development of the three EFFESUS retrofit materials, discussed above, involved eleven partners from eight countries, in material design, prototype production and application, lab testing and outdoor trialling. IsoCal mortar is already available on the market and SpaceFill insulation is technically market-ready; the development of the radiant selective coatings has made good progress but will require further work to make it suitable specifically in a conservation context.

2.4 Strategies for decision making for improving energy efficiency in historic buildings at urban district scale

José Luis Izkara, Tecnalia

In order to ensure the continuity of the social and cultural diversity, urban conservation has been required to evolve from practices focused only on the physical conservation of buildings to more modern approaches including environmental and social factors. Nowadays, modern conservation policies are enforced to address the wellbeing of the inhabitants of historic cities along with the preservation of their built environment. As living urban ecosystems, historic cities are in constant evolution and development, and their preservation has to be addressed as an on-going process of renovation. The sustainable retrofitting of districts is about managing the change in a sustainable way and this can only be done through comprehensive strategies based on a multiscale approach.

The selection and implementation of these strategies can highly benefit from proper management of information and Decision Support Methodologies and Tools. Within the EFFESUS project a holistic methodological framework is under developement for supporting the decision maker to select and prioritise energy interventions for historic urban districts. This overall decision making framework will be afterwards implemented in the EFFESUS DSS (Decision Support System)

To support professionals in the strategic decision-making processes for retrofitting historic districts, the methodology requires two types of data inputs: location-specific data about the district, and technical data about available retrofit measures and associated assessment indicators. As the availability, completeness and quality of district data can vary significantly, the methodology has been developed so that it can perform assessments at different detail levels.

Where hardly any structured district data is available (or as initial decision phase), the methodology works with some minimum information about the district by assigning a district type to the district and comparing it against standard typologies saved in a transferable model together with suitable retrofit guidance. This way, the output is based on the district's climatic region and its typology. Only where sufficient data is available to generate a data model, the more advanced assessments of detail can be performed. The district will be reduced to a suitably small number of typical buildings, for which sufficient data is either already available or can be obtained reasonably easily. The assessment will be based on these typical buildings and extrapolate its assessment results to the whole district. At this level the methodology will analyse the impact of the various retrofit measures catalogued in the Technical Repository as if they were to be installed in the district. First multiscale heritage significance impact will be assessed to see the applicability of the different solutions. After difference scenarios will be generated using the user preferences and the energy consumption, the indoor environment, the cost and the carbon emissions will be estimated.

2.5 A Decision Support System for improving the energy efficiency in historic districts

Aris Georgoulis, Integrated Information Systems SA

The aim of this presentation was to demonstrate the objectives, the main functionalities and the advantages of the EFFESUS Decision Support System.

The EFFESUS DSS provides the following main functionalities:

- Access to information: the Level 0 options of the system provide information regarding energy improvements, energy and cultural heritage policies, general recommendations and best practices. This information is managed using a CMS that is integrated to the DSS tool.
- High level evaluation of districts: the creation of Level I projects allows to obtain solutions and recommendations for historic districts, just by providing some information about the main characteristics of the historic district.
- Multi-scale data model: the selection of representative buildings for energy interventions is accomplished by using a user friendly categorization tool that encapsulates the data model and provides to the user an easy and intuitive way for the identification of building typologies in his/her district. This Categorization tool supports statistical analysis of the building parameters, selection of buildings based on parameter and value ranges, generation of the typologies and selection of the representative typologies using a graphical user interface that also provides 3D Visualization.

- Building evaluation: for a detailed evaluation of buildings and districts based on building typologies the creation of Level II projects is needed. It assists the end-users to select buildings and solutions, prioritize the solutions and create intervention packages (scenarios). The solution compatibility analysis was based on heritage significance and impact. The system also calculates the main energy indicators based on the building characteristics.
- Solution Evaluation: the system provides intelligent solutions ranking using advanced Multi-Criteria Decision Analysis methodologies. The ranking is taking place in terms of thermal comfort, internal air quality, energy savings, cost and impact of each solution. The result is a list of rated solutions (from the list of applicable solutions) for energy interventions.

Finally, the main advantages of the EFFESUS Decision Support System were presented and discussed.

2.6 Case studies: demonstration of energy efficiency measures in historic buildings

María Casado Barrasa, Acciona Infraestructuras S.A.

The main objective was to present the applicability of the EFFESUS new materials and technologies through seven real case studies.

The main selection criteria for the cities have been:

- To represent different European areas and different climate conditions
- To belong to different historic periods, constructed using different materials and architectural and urban patterns
- To be classified with different levels of heritage protection
- To be strategically placed in Europe
- The respective municipalities are committed to supporting the case studies in their cities.

All the interventions performed in historic buildings need to fulfil three requirements:

- Retain the appearance of the building,
- Ensure reversibility and
- Don't affect the properties of the building and/or building envelope.

The demonstrations in the EFFESUS case studies have been classified into two categories:

1. Rehabilitation/intervention
2. Study and analysis

This presentation at BAU 2015 was focused on the cases studies under the first category. In particular the following innovations have been tested, under different case studies:

- Istanbul, Turkey: radiation selective coatings for outdoors .Local partner: Sampas Nanotechnology.
- Glasgow, United Kingdom: aerogel as blown-in insulation for use in cavities behind existing wall finishes. Local partner: Historic Environment Scotland.
- Benediktbeuern, Germany: new thermal insulating mortars for use as plaster and render. Local partner: Fraunhofer IBP
- Budapest, Hungary: windows with improved insulation and ventilation; intelligent indoor climate solutions. Local partner: HORBER
- Santiago de Compostela, Spain: implementation of new control strategies to decrease the primary energy demand in historic buildings and district. Local partner: Consorcio de Santiago.

The intervention proposed and the monitoring plan of each case study was presented.

Due to the fact that only one project partner is the owner of the demonstration site and therefore communication with other partners involved can be delayed a Project Management Planning protocol has been prepared. The objective of this planning protocol was to guide the participants in each of the five EFFESUS demonstration activities towards achieving a successful implementation of the innovations developed in the project in the selected heritage buildings.

2.7 Existing and replicable technologies for energy efficiency improvements in historic districts

Alexandra Troi, EURAC research

An important task within EFFESUS was to collect in a structured way existing and replicable solutions for energy efficiency improvements in historic buildings.

Actually, we do not start at zero today. A first step should usually be to understand and recover, where possible, old architectural solutions. Traditional architecture has found passive solutions for local climate – from passive solar heating over smart use of thermal mass to architectural details supporting shading in the right moment and strengthening air movement. In oceanic climate (like e.g. Scotland) with its short cool summers and mild rainy winters, high precipitation and often strong winds, windows are large to allow light and sun to enter and equipped with shutters to prevent heat loss and protect from rain. In warm Mediterranean climate with warm dry summers and mild humid winters, heavy construction materials prevail, which shift temperature peaks from the afternoon to the night, where the heat can be rejected more easily. Small apertures reduce solar heat loads in summer, light colours reduce heat absorption, ventilation paths – on building and district scale – allow for passive cooling.

When it comes to energy supply, priority should be given to sustainable and renewable energy sources – be it the sun, wind, biomass, geothermal energy or efficiency enhancement like combined heat and power plants and (seasonal) storage. District heating (and cooling) systems will often allow to use renewable energy without direct impact on the heritage buildings themselves. However, also on the heritage building itself low impact interventions are possible – major issue is usually the right integration and design. For solar technologies we should e.g. think well about where and how to integrate solar panels, use areas which are not visible to the viewers, prefer a detached architectural element, avoid scattering and follow existing architectural lines – sometimes it might even be possible to follow traditional functions as e.g. the eave flashing. Actually, both PV and solar thermal panels are available with various surfaces: shiny and dull, black and coloured, with patterns… Choose carefully the right technology for aesthetical integration!

Before choosing the right energy supply, we should however see how the energy demand of the building could be reduced. The right approach is here to look always at the whole building, with an open mind and an interdisciplinary team. To support the process, within EFFESUS a database has been developed, which – guided by retrofit steps – describes existing technologies: for each of these a short description is provided (WHAT), advantages and disadvantages are described (WHY) as well as conditions WHEN to apply them, conservation aspects illustrated (WHERE) as well as the range of energy saving potential and respective costs. Of course, in the database the information needed to do an assessment in the specific case is given – not the assessment itself. This is true both for the evaluation of economic aspects, of the energy saving potential and especially for compatibility with the fabric itself as well as for conservation principles.

The lecture also points out the importance to mind the detail when intervening on the specific building –showing e.g. the hygrothermal risk in the cold corner after applying interior insulation, and how it can be solved.

Final conclusion: Even if there is still a lot which can be improved and further developed, there are numerous existing solutions which can be applied to energetically improve our historic buildings in a conservation compatible way! It is a matter of investing a bit more effort in the design phase and choosing the right solution for the specific building.

3 Salone dell'Economia, della Conservazione, delle Tecnologie e della Valorizzazione dei Beni Culturali e Ambientali, Ferrara, Italy (8.4.2016)

The "Salone dell'Economia, della Conservazione, delle Tecnologie e della Valorizzazione dei Beni Culturali e Ambientali" (Exhibition of Economy, Conservation, Technology and Promotion of Cultural and Environmental Heritage) in Ferrara is an yearly event (XIII edition – 2016) aimed at presenting the most recent restoration solutions as well as technologies for historical building conservation. The following partners of the EFFESUS consortium (CNR-ISAC; EURAC; RED and Fraunhofer) participated at the event with a stand and a workshop. The two-hours Symposium was held on April 8th. Gunnar Grün (Fraunhofer) introduced the project as a whole. Ing. Luc Pockelé (RED) presented the solutions for a smart management and the integration of renewable energy efficient solutions in historic building and district. Dr. Alexandra Troi (EURAC) showed the different technologies developed in the project for the retrofit of historic building envelope. Finally, Dr. Adriana Bernardi (CNR-ISAC) introduced the Decision Support System functionalities and the application of the categorization methodology in Venice.

3.1 The EFFESUS project: Energy Efficiency for EU Historic Districts

Gunnar Grün, Fraunhofer IBP

The European Union has set high goals for the next years: The Member States have committed themselves to saving 20 percent of their primary energy consumption by 2020 and thus reduce CO2 emissions. Accordingly, a main focus of Europe's effort is to increase the energy efficiency of buildings, whether new or existing. Historic buildings or districts have so far, unfortunately, received little attention. For this reason, the current EU project EFFESUS (EU Energy Efficiency for Historic Districts´ Sustainability) has been initiated with a total budget of 6.7 million euro. Central to the project is the consideration of Europe's historical neighborhoods and monuments considering all energy aspects. The focus will be both on the energy efficiency of individual buildings, building ensembles and districts, as well as their energy supply from renewable sources.

The EFFESUS concept is to reduce the environmental impact of Europe's valuable urban heritage by making significant improvements to its energy efficiency while conserving and even promoting the cultural, historic, urban and architectural values of European's historic cities. The overall objective is to develop and demonstrate, through case studies, a methodology and criteria for selecting and prioritizing energy efficiency interventions. These will be based on existing and new cost-effective technologies and systems compatible with heritage values, and thus significantly improve the life cycle energy efficiency in the rehabilitation of historic districts. The selected case studies are located in cities with different climate zones and range from Santiago de Compostela to Genova, Budapest and Istanbul, from Bamberg, to Visby and Glasgow.

EFFESUS scientific and technical objectives are to

1. Derive a European historic district categorization and multi-scale data model for the assessment and management of energy use,
2. Develop cost effective technologies and systems for significantly improving energy efficiency of historic buildings and districts,
3. Implement methodologies and tools to assess energy retrofitting interventions in historic cities,
4. Overcome technical and non-technical barriers for the implementation of energy efficiency solutions in the historic building context.

3.2 Smart management and integration of renewable and energy efficiency solutions in historic buildings and districts

Luc Pockelé, R.E.D.

The repository of energy efficient solutions in historic buildings and districts as well as the integration of renewable energy is a cornerstone for the development of the Decision Support System. The build up towards and the realization of this repository is explained through the presentation of the workflow followed within the project.

The inventory of existing solutions and their compatibility with historic values are shown across the different categories considered such as the thermal performance of the external envelope, air tightness, ventilation, energy storage and many more. Then a typical format of a retrofit measure is given as an example. All retrofit measures are respecting this format.

A similar approach has been followed for the integration of renewable energy solutions. The results are shown in an overview table.

Then, the structure of the repository itself, an SQL database, is presented with its major building blocks.

The Effesus project also has a large demonstration part. Next to several innovative retrofit measures for the envelope, two smart management cases are covered. The different algorithms, developed for indoor climate control at reduced energy consumption in a classroom in the Budapest University of Technology and Economics, are explained step by step. Then the corresponding building energy management system, built on purpose for this demonstration case, is shown. Finally, the integration of renewable energy from a nearby wind farm with the operation of a heat pump in a museum in Santiago de Compostela is highlighted by means of a block diagram.

3.3 Development of conservation compatible replicable technologies for envelope retrofitting of historic buildings

Alexandra Troi, EURAC research

In historic buildings, as in most existing buildings, the building envelope is crucial for their energy performance: walls are often thick, but they nevertheless conduct heat very well; single glazed windows lead to very low surface temperature, and are often not airtight at all. However, the criteria to be considered when selecting the appropriate retrofit measures go beyond the potential increase in energy performance; they also include the reversibility of the intervention, the possibility to conserve original material and, importantly, the aesthetic impact that a retrofit intervention might have.

Within the EFFESUS project, several pioneering small and medium enterprises (SMEs) together with research partners have developed four innovative solutions to improve the envelope performance specifically in historic buildings: aerogel insulation, insulating mortar, radiant reflective coating, and optimised windows.

The developed aerogel insulation is blown into the spaces, just a few centimetres in depth, of an existing wall structure – for example behind the “plaster on laths” finishing in Scottish tenement houses or wooden panelling in Alpine farm houses – thereby retaining the original surfaces and avoiding the loss of both original material and the evidence of traditional building techniques. Even the thin aerogel layer can reduce the heat transfer to about one third of the original wall, as has been shown both in the stone-wall prototype tested at INTENT lab and on-site in the Scottish case study.

Appropriate for both the interior and exterior – and often uneven – surfaces of historic buildings is the formulated insulation mortar. Based on natural hydraulic lime (NHL5), it is compatible with most historic structures; the EPS filler makes it both energetically and economically very interesting. It has successfully passed the driving rain and temperature stress in the EOTA wall test, and was examined outdoors in Holzkirchen and indoors in the case study building Benediktbeuren.

Interesting for historic buildings in hot climates is the radiation selective coating. Thanks to the high infrared (IR) reflection it reduces the amount of solar heat absorbed by the envelope – be it the exterior wall or the roof – and thus reduces the cooling need within the building without intrusive impact on the building fabric. Even though the aim to get a both reversible and transparent product has not yet been achieved, the application simulations show what can be expected in future in terms of overall-year energy performance improvement.

For original windows, a number of improvement options ranging from thermal shading and low-emissivity films, to thin multilayered glazing, and the concept for a supply air window, have been investigated. They can be applied individually or in combination; for each window and building the right solution has to be selected taking a balanced account of all issues.

The products were also applied at the different EFFESUS case studies, which allowed not only to measure actual on-site performance, but also to gain valuable experience on practical issues of applicability and ease of handling.

3.4 Strategies and Demonstrations for improving energy efficiency in historic buildings at urban district scale

Adriana Bernardi, National Research Council

An introduction of the Decision Support System functionalities as well as the application of the categorization methodology in Venice is given. For this latter the objectives and results are presented.

An overview of the DSS structure highlights the importance of the DSS tool in the identification and classification of energy-related interventions, above all for the Historical District. The different inputs and the four output levels available in the Decision Support System are presented. The Decision Making Criteria and Constraints are shown, highlighting the Heritage Significance as being very important for the tool application into Historical District.

Furthermore, the new technologies developed during EFFESUS project to be added in the database used into the DSS for Energy Saving are presented. In particular the intervention, monitoring system and the evaluation stage for each case study (Istanbul, Glasgow, Budapest, Benediktbuern and Santiago De Compostela) is described:

- Istanbul case study (Kallavi St, Beyoglu District): brief description of two radiation selective coatings applied on different substrates placed on the roof of the building and of eight lime mortar samples, eight Istanbul stones and five metal plates mounted in outside. Monitoring System and evaluation objectives.
- Glasgow Case study (traditional tenement building, in the Yorker district): Brief description of the aerogel installed in the test room. Description of the continuous monitoring system installed in reference and test room and objective of the manual campaigns performed in February 2016. Evaluation objectives.

- Budapest Case study (University of technology and Economics): brief description of the intervention as well as the continuous monitoring system and manual campaigns performed in March 2016. Objectives of the evaluation.
- Benediktbuern case study (Benediktbuern Monastery, Güttinger room): brief description of the application of ISOCAL insulating mortar on the inner surface ot the exterior wall. Monitoring system and evaluation objectives. Preliminary conclusions.
- Santiago de Compostela case study (Museum “Casa do Cabildo”, plaza de Platerias): brief description of the intervention and monitoring system. Evaluation objectives.

4 Sustainable Places, Anglet, France (29.6.2016)

4.1 EFFESUS: ENERGY EFFICIENCY FOR EU HISTORIC DISTRICTS SUSTAINABILITY

Alessandra Gandini, Aitziber Egusquiza Ortega, Isabel Rodriguez-Maribona, Tecnalia

Europe can become the leader in CO2 emission reduction by applying innovative solutions to its built cultural heritage. According to the European Recovery Plan one of the actions that needs to be taken to tackle the current crisis, is investing in energy efficiency. Historic urban buildings consume 4% of all energy and are responsible for 3% of CO2 emissions. Therefore, improving energy efficiency in historic buildings and historic districts is essential. Nevertheless, most of the current developments in energy efficiency address new construction without dealing with the unique problems of historic structures. A number of technologies and products have been developed, however many of the solutions are not acceptable for historic structures due to the necessity of preserving integrity and authenticity. Therefore, the main goal of EFFESUS is to develop and demonstrate through case studies a methodology for assessing and selecting energy efficiency interventions, based on existing and new technologies that are compatible with heritage values. A Decision Support System will be a primary deliverable. The environment in historic buildings and urban districts is controlled differently from modern cities and accordingly the project will also develop a multi-scale data model for the management of energy. In addition, new noninvasive, reversible yet cost-effective technologies for significantly improving thermal properties will also be developed. Finally, existing regulations and building policies may not fit cultural heritage specificities so the EFFESUS project will also address these nontechnical barriers. These outcomes will be achieved through 10 work packages, performed by an interdisciplinary consortium of 23 partners from 13 countries. Due to the attractiveness of this niche market, 36 % of the project budget is allocated to SMEs, which will work together with large companies, research institutions and end users throughout the duration of the project.

The seven EFFESUS case studies are essential to the research project, as they will, at real scale, demonstrate the suitability of the new technologies developed through EFFESUS as well as validate Decision Support System (DSS), a software tool. The selected cities will be good practice examples to promote the overall use of EFFESUS technologies all over Europe and beyond. The EFFESUS case studies are in: Santiago de Compostela, Glasgow, Visby, Bamberg / Benediktbeuern, Genoa, Budapest, Istanbul.

The main selection criteria for the cities have been:

- To represent different European areas (North, South, West and East), as well as different climate conditions
- To belong to different historic periods, and are constructed using different materials and architectural and urban patterns.
- To be classified with different levels of heritage protection, demonstrating the relationship of protection status and suitable energy efficiency interventions
- To be strategically placed in Europe so that they could contribute to the wide-spread use of EFFESUS technologies in Europe and beyond
- The respective municipalities are committed to supporting the case studies in their cities

The interventions in the different case studies have been classed into three categories:

- Urban intervention: Implementation of new and existing technologies at urban district level (e.g. smart grids, photovoltaic, lighting, energy storage, district heating)
- Building intervention: Application of new and existing products and systems at building level (e.g. insulating mortars and coatings, aerogel insulation, traditional passive solutions, improved indoor climate control systems, secondary glazing/windows)
- Study: Analysis of the existing municipal documents and data to prepare the building stock model and validate the DSS software tool