Deliverable D2.3:
Collection of Best Practices

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6.2 Recommendations

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1 Summary

The objective of Work Task 2.3 has been to collect best practices examples and relevant initiatives of retrofit interventions at building and district scales that will inform the EFFESUS project repository.

It is an essential premise of EFFESUS that many of the retrofit solutions currently available are not acceptable for historic structures due to the necessity of preserving integrity and authenticity. “Therefore,” as the Description of Work states, “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.” It is implicit that ‘best practices’ is a targeted outcome of EFFESUS rather than pre-existing.

Contributions to the Work Task have been collated from 11 of the Consortium partners, and a clear outcome is that completed best practice examples are currently hard to find and few in number. At the same time, a diverse range of initiatives has commenced within the last few of years, some of which are at or near completion, are yet further of which are at the concept or planning stage.

The aim in undertaking this task has been to collate as broad a spectrum as possible of initiatives that indicate cutting edge solutions with potential application at urban district scale. Of the practices collated, state of the art district scale renewable energy systems appear to offer a major opportunity to limit damaging impacts on the heritage significance of individual and groups of buildings, and several of the best practice examples highlight these.

One manifest challenge is the discordance between conservation theory and practice coupled with the diversity of interpretations between different national heritage protective systems. Another is the evident risk of economic pressures driving retrofit solutions that may, and in some cases are, seriously compromising heritage protection objectives. This underlines the importance to the EFFESUS project of establishing clear parameters to support informed decisions.

Collecting best practices is a cumulative ongoing process. Deliverable 2.3 should be seen as a stage in this process, not a conclusion to it.
2 Objectives

Task 2.3 Collection of best practices (Leader: RODWELL; Participants: SANTIAGO, DWE, SCOTLAND, HOR-BER)

Objective of this task is to collect best practices examples and relevant initiatives, carried out at national and European level. Collection will be based on concluded and ongoing European projects and on National initiatives that are recognised as good practices. Each best practice will be listed, described and categorized. A technical and economic description will performed in order to identify the cost-benefit indicator. The practices identified will focus both on building and district interventions. The end users participating in this task (SCOTLAND and SANTIAGO) will be in charge of indicating the feasibility of the interventions identified with respect to conservation policies. DWE and HOR-BER will help to identify the technical solutions applied in the best practices examples and RODWELL will be the responsible of the overall collection of best practices and the editing of the corresponding report.
3 Achievements

3.1 Context and Qualifications

Work Task 2.3 embraces a single overarching task, “to collect best practices examples and relevant initiatives carried out at national and European level.”

It is explicit in Annex 1 of the Grant Agreement (Part A.1 Project summary, Abstract, p.3) that:

“… 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.”

Implicit, is the premise that ‘best practices’ is a targeted outcome of EFFESUS rather than pre-existing. If best practices were plentiful – in quantity, range, dissemination and adoption – there would be neither need nor justification for the EFFESUS project. The baseline assumption that EFFESUS is ‘cutting edge’, and that best practices are currently hard to find and few in number, has been borne out in undertaking Work Task 2.3.

Work Task 2.3 has been coincidental in time with other tasks within Work Packages 1 and 2 and input from these has been informative. Of particular (but not exclusive) relevance are aspects of Work Tasks 1.2 and 1.3. Correspondence with these has been facilitated by the fact that RODWELL and the four designated participants in Work Task 2.3 have been also been actively involved in those tasks.

Inherent in the overviews of both national cultural heritage legislation and international conservation charters and convention, for example, is the reality that there is no established European framework against which good practices in the energy efficiency and renewable energy fields may be assessed and recognised against compatibility with heritage values and conservation principles.

In this key area there are widely differing practices across Europe both between and within nations. There is also considerable disparity between the theoretical position as anticipated in national legislation and what actually happens when proposals are formulated and works carried out at district and building levels. There are multiple reasons for these variations, not least of which is the lack of coherent guidance at both policy and practical levels. This is one of the many challenges that the EFFESUS project seeks to address.

Thus, an underlying assumption in the wording of Annex 1, quoted above in section 2 ‘Objectives’, namely “recognised as good practices”, is not assured either at a national or European level. This has led to the anticipation that “…we should expect to articulate our own expectations and standards within the compass of EFFESUS” (Rodwell, 2013a; also, 2013b).
The achievable and agreed aim of Deliverable 2.3, therefore, is to represent a collection of ‘loose practices’ with the best available information to hand, that can serve as indicative benchmarks in the repository. This was confirmed at the EFFESUS Work Packages 1, 2 and 5 Coordination Meeting held in Madrid, 15th and 16th April 2013.

It is foreseen – in the essential interests of the ongoing 2012 to 2016 programme of EFFESUS – that the ‘work in progress’ nature of this present exercise will serve as the basis for a progressive accumulation of ‘best practices’ in the repository that will provide a point of continuous reference for the project. Simultaneously, this should inform our “… expectations and standards within the compass of EFFESUS” (Rodwell, 2013a).

Together with the designated WT2.3 participants (SANTIAGO, DWE, SCOTLAND, HOR-BER), and coupled with welcomed contributions from other EFFESUS consortium partners (FRAUNHOFER, D’APPOLONIA, HGO, EURAC, NTNU, GOUS, AMS), RODWELL has collected a spectrum of energy efficiency and renewable energy retrofit measures from the urban district to the detailed building scales from which indicative examples of ‘best practice’ may be extrapolated and critiqued.

In the main, these examples are ongoing rather than concluded. As such, there are widely differing levels of available information, especially economic. Identifying a coherent set of cost-benefit indicators is therefore not practical at this time. It is suggested that this aspect may be revisited later in the project, once a meaningful body of ‘best practices’ has been more fully confirmed and experienced over time.

### 3.2 Definitions

An important starting point for WT2.3 has been to define what is meant by ‘best practices’ as the benchmark against which to identify and critique examples.

In this, Work Task 2.3 has identified four main sub-headings:

- **Heritage Significance.** That is, respect for and compatibility with historic values and conservation principles. This may be assessed against visual and material impacts, embracing concept and design together with original or historically significant fabric.

- **Technical Compatibility.** Compatibility with the building fabric, including of moisture movement in relation to a building’s structure. This is essentially irrespective of a building’s occupancy, although it may be related to it.

- **Environmental Performance.** Indoor comfort conditions compatible with human occupancy, including impacts on ventilation and airtightness.

- **Energy Supply.** The visual and physical impacts of renewable energy installations and systems.

Of the above, Heritage Significance and Energy Supply relate to the urban district as well as the building (individual and group) scales. Technical Compatibility and Environmental Performance relate solely to the building scale.
4 Best Practice Examples

Examples have been collated from the various contributors listed under ‘Document History’ above. These are detailed at subsections below. The following is a summary chart:

Table 1: Best practice example

<table>
<thead>
<tr>
<th>SET</th>
<th>Heritage significance</th>
<th>Technical compatibility</th>
<th>Environmental performance</th>
<th>Energy supply</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET A (4.1)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Sets out the major potential for deflecting attention away from inappropriate retrofit measures by focusing on district scale renewable energy supply.</td>
</tr>
<tr>
<td>SET B (4.2)</td>
<td></td>
<td></td>
<td></td>
<td>X X</td>
<td>Metropolitan scale. Serious challenges to heritage significance. Unclear for Technical compatibility. Architect and economically driven.</td>
</tr>
<tr>
<td>SET C (4.3)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Key objective: energy self-sufficiency at historic urban district scale. New installation to be monitored during the EFFESUS project.</td>
</tr>
<tr>
<td>SET D (4.4)</td>
<td></td>
<td>X</td>
<td></td>
<td>X X X</td>
<td>Understanding of and compatibility with local climatic conditions have driven this example. Good overall methodology. Some detailed aspects of technical compatibility are open to question.</td>
</tr>
<tr>
<td>SET E (4.5)</td>
<td></td>
<td>X</td>
<td></td>
<td>X X X X</td>
<td>Urban district energy supply obviates the need for solar roof panels. CO$_2$ emissions from the heating plant not clear. More information will derive from the EFFESUS project Case Study.</td>
</tr>
<tr>
<td>SET F (4.6)</td>
<td></td>
<td>X</td>
<td></td>
<td>X X X X</td>
<td>Heritage significance considered, but some serious compromises.</td>
</tr>
<tr>
<td>SET G (4.7)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Focused on predominantly experimental renewable energy supply systems in different climatic zones. Positive results unclear. More information will derive from the EFFESUS project Case Study.</td>
</tr>
<tr>
<td>SET H (4.8)</td>
<td></td>
<td>X</td>
<td></td>
<td>X X X</td>
<td>An incomplete demonstration building under the EU project ‘School of the Future’. Seeks to recover lost heritage significance.</td>
</tr>
<tr>
<td>SET I (4.9)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>Case studies that show the practical application of the potential set out in Set A.</td>
</tr>
<tr>
<td>SET J (4.10)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>As Set J, but still at the planning stage.</td>
</tr>
<tr>
<td>SET K (4.11)</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>A collation of 12 examples from the UK and USA of measures covering all four categories and relevant for replication across Europe.</td>
</tr>
</tbody>
</table>
4.1 Urban District Renewable Energy Systems: a major potential

This example focuses on Energy Supply as the means by which Heritage Significance, Technical Compatibility, Environmental Performance may be realised to maximum positive advantage.

DWE presents a well argued case that energy supply and demand to historic urban districts should be considered as separate issues, with a focus on the supply of renewable energy at district scale rather than on retrofitting individual buildings.

Examples of retrofit systems using a wide variety of technologies (which are encompassed in Work Task 1.2 / Deliverable 1.2) are cited across several European countries. Also cited – but arguably less relevant – are energy systems for new ‘Eco’ urban districts in Germany (Freiburg), Sweden (Stockholm) and Ireland (Cloughjordan). In the main, the examples relate primarily to educational campuses and major new or redevelopment sites and complexes under single ownership or management.

DWE report that only a few of the cited projects focus on energy efficiency and the use of renewable energy in historic urban districts. DWE note, however, that as almost all the infrastructure for district energy networks is below ground in boreholes, thermal banks, pipes and ducts, lessons from the cited examples and their technologies are directly relevant and applicable to historic urban districts as not impacting on their above ground heritage significance.

As follows:

**Abbreviations**

- ATES - Aquifer Thermal Energy Storage
- BTES - Borehole Thermal Energy Storage
- CHP - Combined Heating and Power
- CCHP - Combined Cooling Heating and Power
- SEAP - Sustainable Energy Action Plans
- UTES - Underground Thermal Energy Storage

**Key Words**

Underground Thermal Energy Storage (UTES); Aquifer Thermal Energy Storage (ATES); Borehole Thermal Energy Storage (BTES); Interseasonal Heat Storage; Interseasonal Heat Transfer; Cogeneration / Combined Heating and Power (CHP); Trigeneration; Combined Cooling Heating and Power (CCHP); Distributed Heat Storage; District Energy Management System; District Heating Network; District Cooling Network; Geothermal Energy; Heat Recovery; Sustainable Districts; Thermalbank; Thermo Active Foundations; Chemical Energy Storage
4.1.1 Main concepts

Urban districts with a high proportion of historic buildings will best be able to meet the EU’s 2050 sustainable targets for CO\textsubscript{2} emissions reductions by using a higher proportion of renewable energy and relying less on energy demand reduction by retrofitting individual buildings. The restrictions on retrofitting historic buildings with retrofit measures for energy reduction means very few would be able to achieve the CO\textsubscript{2} reduction targets by reducing demand. The supply of renewable energy to historic urban districts is most cost effectively achieved by local district energy networks as the economies of scale and diversity of demand create a more efficient system.

This relieves the historic buildings from any pressure to implement \textit{inappropriate retrofitting measures} which could damage their value. It also avoids individual building owners from having to employ people or companies, with varying degrees of knowledge and skill, who might propose potentially inappropriate retrofitting and renewable energy systems for the buildings. They would simply be able to connect their building into a local district energy network which supplied them with, ideally, \textit{100\% renewable heating, cooling and electricity}.

The fundamental concept is to \textit{separate supply and demand issues} to protect our historic urban districts. This usefully separates the objective of reducing CO\textsubscript{2} emissions from objectives to retrofit historic buildings for other reasons. The retrofitting of individual historic buildings can then be undertaken with the objectives of:

- Improving indoor environmental quality;
- Improving the durability of the building fabric as a conservation measure by improving its thermal and hygroscopic performance, reducing condensation risks and increasing its usability and value;
- Reducing the energy bills from the local renewable energy network with appropriate, carefully considered retrofitting measures since the CO\textsubscript{2} reduction target is already satisfied by the renewable energy network. Reducing the energy bills is then separated from the objective of reducing the CO\textsubscript{2} emissions.
- It should also be noted that retrofitting urban historic districts is as much a civil and civic undertaking as it is a technical task. A purely technical approach to urban districts with physical infrastructure for energy efficiency and renewable energy systems will not be sufficient if it fails to improve or maintain spatial qualities and urban character.

Urban district renewable energy networks can be designed to be very efficient due to:

\textbf{Economies of scale}: by sharing and spreading costs among many users the costs for all users are reduced. (Cloughjordan Ecovillage solar and biomass district heating)

\textbf{Diversity of demand}: the variety of building types, uses and occupancy creates a diversity of demand for energy over time which combine to \textit{average the demand in time and reduce peak loads} which allows for more efficient operation of the generating plant.

\textbf{Interseasonal energy storage}: combining district energy networks with interseasonal energy storage can effectively \textit{double the efficiency} of the renewable energy systems which can reduce the size and cost of the...
plant by almost 50%. Abundant summer heat, waste heat and cooling energy can all be stored cost effectively from summer to winter and distributed to buildings via district networks.

**Redistribution of Energy in Space and Time:** some buildings can reject their cooling load (heat) into the district energy network which can then redistribute the energy to another building which has a demand for heat. Excess thermal energy (heat or ‘coolth’) not required at one point in time can be stored to the interseasonal energy storage system until such time as it is needed.

The recovered energy from building systems or excess energy or from any RE systems on individual buildings can be supplied and sold to the district energy network rather than be wasted thus improving the efficiency of both the district network and any RE systems on the building.

**Innovative Efficient Technologies:** The scale of a district energy network combined with interseasonal energy storage creates the opportunity to use more complex and efficient renewable energy technologies which can in turn generate added values which can make the total investment very attractive with a very good ROI.

**District Energy Management:** To optimise the opportunities to move energy from one building to another and store it for periods in short and long term storage systems a district level energy management system can be used to optimise efficiency and control costs. A new ISO standard and proprietary software are available to assist in this task.

**Triple Play Opportunity:** Most district energy networks are operated as some form of ESCo which needs to use energy meters to charge for the energy used. These energy meters can be read for billing and system management remotely by an ICT cable infrastructure which is easily installed when the meter is connected. The cables run alongside the pipes under the pavement or road.

This cable can be used to deliver three additional services to each customer: 1) broadband, 2) cable TV and 3) telephone services. This is the “triple play”. The lines can be rented out to existing service providers or the ESCo can become a ‘triple play service provider’ thus generating a significant income stream for the ESCo. This increases the ROI and value of the ESCo and reduces the payback period. This makes district renewable energy networks a very attractive investment.

### 4.1.2 Renewable Energy Projects

A large variety of best practice examples for the application of energy efficiency and renewable energies in the EU with particular focus on district energy supply systems are available. However, only very few projects which focus on energy efficiency and the use of renewable energy at district level in historic urban districts are available. However as almost all the infrastructure of district energy networks are below ground in boreholes, thermalbanks, pipes and ducts the best practice examples and their technologies included here are directly applicable to historic urban districts.
The following list of Best Practice of Urban District renewable energy projects provides a selection of examples of renewable district energy technologies which form the basis of this report. These include completed projects, those under construction and proposals.

4.1.2.1 Completed Projects

Den Bosch, NL: This project has secured heating for a residential district through Aquifer Thermal Energy Storage (ATES) in the town of Den Bosch. Heat is extracted during the summer from nearby aquifers to be fed into homes during the winter in order to establish an energy balance - completed
(Ref. http://www.iftechnology.com/wm.cgi?id=238)

TU Eindhoven, NL: The University of Eindhoven campus secures 70% of its heating and cooling energy through Aquifer Thermal Energy Storage (ATES) - completed

Merton, London, UK: Borehole Thermal Energy Storage (BTES) technology is used for this community centre which stores heat during the summer to supply it to the building during the winter - completed
(Ref. http://www.icax.co.uk/Merton_Council.html)

Herfordshire, UK: This school uses asphalt paving solar collectors and interseasonal heat storage under the building to achieve complete energy self sufficiency. A separate cold store supplies cooling on demand – completed
(Ref. http://www.icax.co.uk/howe_dell_school.html)

Messestadt Riem, München, DE: Heat generation from geothermal wells for this developing district is part of the city’s programme to become Germany’s first city with district heating solely from renewable sources – completed

Aschheim, Feldkirchen, Kirchheim, München, DE: Residences and industries in three communities are supplied by a joined geothermal energy system, based on borehole thermal energy use - completed

Güssing, Burgenland, AT: Biomass from waste wood, sawdust, crops and oil, combined with energy from PV and solar panels provide a town of 4.000 inhabitants with almost 100% of heat and electricity through a district energy network. Gasification and combustion technologies used - completed
(Ref. http://www.gussingrenewable.com/htcms/en/wer-was-wie-wo-wann/was/carbon-recycling.html)
CTR Copenhagen, DK: The Metropolitan Copenhagen Heating Transmission Company (CTR) supplies five municipalities with heating, cooling and electricity through trigeneration (combined cooling, heating and power CCHP). The energy is generated from waste incineration - completed
(Ref. http://www.ctr.dk/images/Publikationer/Environmentally%20friendly%20district%20heating%20to%20greater%20cph.pdf)

Residential Retrofit St. Pauli, Hamburg, DE: Retrofitting of a historic apartment building to two different standards for direct comparison of performance. The building has been upgraded with external insulation where possible, internal insulation on ornated front façade, double-glazed windows, airtight envelope and ventilation with heat recovery - completed

4.1.2.2 Eco Communities and Villages

Hammarby Sjostad, Stockholm, Sweden: The following document comprises an energy model for the city of Hammarby near Stockholm which is based on the combination of biogas and biofuel, PV, CHP and wastewater use for cooling – completed.
(Ref. http://www.hammarbysjostad.se/inenglish/pdf/HS%20komb%20eng%20april%202011.pdf)

Freiburg, Germany: This document provides an overview of all the sustainability initiatives for the city of Freiburg including the use of cogeneration (CHP) for industrial and residential use – completed.

The Village, Cloughjordan, Tipperary, Ireland:
The Cloughjordan Ecovillage is a 67-acre site which is part of the town of Cloughjordan with planning permission for 123 dwellings and includes 50 acres of land for allotments, farming and woodland where organic food is grown for local consumption. To date 54 low energy homes, an eco-hostel for visitors and work units in a green enterprise centre have been built. The solar and wood powered community district heating system is the largest renewable energy network in Ireland and the UK and integrates a high specification broadband service. The site is served by a local train station. – completed district energy system, some buildings continue under construction.
(Ref. http://www.thevillage.ie)
4.1.2.3 Projects Under Construction

**Den Haag, NL:** Borehole Thermal Energy Storage (BTES) is being applied in a residential neighbourhood of Den Haag for 4,000 proposed homes. These will be provided with geothermal energy for heating – **under construction.**

**Oosterdokseiland, Amsterdam, NL:** The renewal of a brownfield harbour site will use Aquifer Thermal Energy Storage (ATES) technology to supply heating demand in the winter and cooling demand in the summer – **under construction.**

**Tweewaters, Leuven, BE:** A brownfield regeneration project for mixed use is using cogeneration (combined heat and power CHP) and thermal heat storage to provide approx. 80% of renewable heat and 100% of renewable electricity to the district – **under construction.**

**Kalasatama, Helsinki, FI:** A smart energy grid is under way for a district in Helsinki. This will be based on an energy network which is fed with renewable energy and which enables flows in different directions to allow the efficient distribution of generated energy. The overall concept uses the principle to trigeneration (combined cooling, heating and power CCHP) for optimal energy efficiency - **under construction.**

**Energy Bunker Wilhelmsburg, Hamburg, DE:** A disused WW2 bunker now serves as a shell for a biomass combined heat and power plant (CHP) including a water tank for heating/cooling storage, solar collectors and PV panels. It will provide heating for approximately 3,000 households and electricity for approximately 1,000 households. This scheme is part of a programme for an integrated energy network, which consists of local power plant that will function as a large and flexible virtual power station. – **under construction.**

4.1.2.4 Ongoing Projects

**E-Hub:** http://www.e-hub.org

The Energy Hub is a collaborative FP7 European project which aims to demonstrate the full potential of renewable energy by providing 100% on-site renewable energy within an "Energy Hub District."
An important result of the project will be a tool to assess new types of energy systems for existing or newly planned districts with the aim of achieving 100% on-site renewable energy. It is based on smart control of appliances and short term and long term storage of heat, cold and electricity. The E-Hub challenge is to control the integration of sustainable technologies, to recycle heat from summer to winter, to reduce waste and to work in balance with nature.

**EU CONCERTO Programme**: [http://concerto.eu/concerto/](http://concerto.eu/concerto/)

This EU research programme supports and documents energy solutions for cities and communities in 58 case studies. These case studies demonstrate mostly measures for energy efficiency and the use of renewable energies for newly built or post 1945 building stock, which excludes the EFFESUS definition of ‘historic urban districts’. Nonetheless, the indicated energy district distribution systems are theoretically also applicable for historic urban districts: Proposed.

“What all sites have in common is the aim to demonstrate that the optimisation of the building sector of whole communities is more efficient and cheaper than optimisation of each building individually.”

[http://concerto.eu/concerto/concerto-sites-a-projects/sites-con-sites/sites-con-sites-search-by-name.html](http://concerto.eu/concerto/concerto-sites-a-projects/sites-con-sites/sites-con-sites-search-by-name.html)

### 4.1.2.5 Selected Examples

**Ile de Nantes Concerto Project**

The Ile de Nantes project is a 20 year-long process promoting better energy use and district renewable energy systems are focused on the Ile de Nantes district, a 340 hectares-wide area where energy is at the heart of urban renewal: advanced energy standards in new construction, renewable energy systems and extensions of the district heating with heat from waste incineration are part of the local urban planning process.

![Figure 1: Aerial view of the Ile de Nantes](image)
Eindhoven Technical University Campus

Eindhoven Technical University's energy storage system is located on the university campus and is the largest ATES system in the Netherlands. The completed groundwater system comprises 24 warm and 24 cold wells, with a combined capacity of 3,000m³/h. The wells are connected to a distribution network, which supplies heat and cold to all the campus buildings connected to it. This system has reduced energy use on campus by 70%.

The Hague Southwest

A number of housing corporations are carrying out a large scale renovation and construction project that will provide 4,000 new homes in the southwest of the city. A technical and financial feasibility study was conducted on behalf of energy companies, Den Hague Municipality and the housing corporations. It was decided to use geothermal energy to heat all the buildings.
The borehole locations were determined on the basis of a comprehensive geological investigation. Drilling began in March 2010.

**Sustainable heating and cooling at Oosterdokseiland, Amsterdam, the Netherlands**

Oosterdokseiland (East Docks Island), east of Amsterdam’s Central Station and south of the river IJ, is being redeveloped. In addition to residential and office development, there are plans to build a public library, a hotel, a conference centre, a number of cafes and restaurants, and Amsterdam’s academy of music. The energy needed for heating and cooling will be generated using heat pumps and underground energy storage, combined with boilers.

The store of energy, with a maximum cooling capacity of approximately 7MW, delivers around 11GWh of cooling in summer and around 9 GWh of heating in winter. This gives a maximum flow of approximately 1,000m³/h and 2,100,000m³ of pumped groundwater a year in both abstraction and infiltration.

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**Figure 4: Plan of The Hague Southwest borehole locations**

**Figure 5: View of Oosterdokseiland (East Docks Island)**
In winter, groundwater is extracted from the warm wells. The heat is transferred through heat exchangers installed in the control room to the cooled water distribution circuit, which carries the heat to the evaporators of the two-phase heat pumps. The cooled groundwater is re-infiltrated into the cold wells at a temperature of around 7°C.

In summer, cold groundwater is extracted from the cold wells in order to cool the buildings. Cold is transferred to the cooled water distribution circuit through heat exchangers. In addition to cooling provided by the wells, heat pumps can also be used as compression coolers. In this case, it’s possible to feed the condenser heat into the groundwater. Following the transfer of heat in the heat exchangers, the groundwater is re-infiltrated into the warm wells at an average temperature of around 18°C.

**Howe Dell School, Hatfield, UK**

This is the first building completed using the ICAX ‘**Interseasonal Heat Transfer’ and asphalt solar paving system in combination**. This exemplary new secondary school building aims for zero carbon and does not have a boiler for heating or hot water, everything is supplied by solar energy which is very cost effectively collected in the summer and stored in the ground below the school for supplying the building in the heating season.

![Figure 6: Howe Dell School with asphalt playing surface solar collector](image1)

![Figure 7: Laying the pipework for the ICAX asphalt solar collector paving](image2)
Energy Balance at Hinthamerpoort, Den Bosch, the Netherlands

In the Hinthamerpoort project in Den Bosch the customer only required heating. If the only operation carried out is the extraction of underground heat, there will be an energy deficit through underground cooling. As a result, the extraction temperature of water from the warm well will eventually fall below the required minimum extraction temperature, reducing the efficiency of the heat pump and it may even cause the pump to malfunction through the risk of freezing.

![Figure 8: Hinthamerpoort, Den Bosch, the Netherlands](image)

In order to establish an energy balance, it was decided to extract heat from nearby surface water during the summer. This warm water is then fed into the underground system in order to compensate for the water extracted to supply heating and a balance is achieved.

For this project, IF Technology designed the groundwater system and regeneration system, and applied for a permit under the Groundwater Act. The system was implemented in 2007.

4.1.2.6 Best Practice Urban District technologies

This survey of Best Practice examples of urban district renewable energy systems and technologies has enabled us to deduce some common principles, strategies and technologies that can be applied to historic urban districts. The ideal district energy network would integrate a number of systems to ensure the most cost effective and reliable supply of local renewable energy to buildings in urban districts. The main features of such a system would include:

1. Opportunities for network participants to use and supply energy from, and to, an integrated district energy network will enable the whole system to benefit from the diversity of demand that different building types, uses and occupancy require. This allows waste, excess, or recovered thermal energy to be distributed to other buildings which have a demand.
2. The supply of renewable energy from a **variety of local sources** which can compensate for any intermittency that is inherent in the use of many renewable energy technologies. An analysis of the local resources for renewable energy would identify the most cost effective sources to meet the demand.

3. **Technologies to store heat, cold and electrical energy** for short and long periods to meet the demand profile, diurnal or seasonal, and to provide energy supply security when energy supply from renewable is intermittent. The combination of **storage and local distribution** allows the **greatest efficiency and lowest cost** of supplying renewable energy to urban districts.

4. **Integrated solutions** which take a **systems approach** to urban districts can create synergies which **increase the value** and reduce the payback period thus making them **attractive investments for** a variety of stakeholders.

5. **Innovative business plans** and joint ventures between various stakeholders have been used to implement these Best Practice examples and are usually required to attract sufficient investment and coordination for the installation of the infrastructure of these complex systems.

The integrated smart grid project in Kalasatama, Helsinki in Finland is noteworthy as an integrated district energy network which combines the use of renewable energy and energy efficiency measures. This urban regeneration project in the disused ‘docklands’ area of Helsinki uses CCHP systems, energy storage and **demand side management** systems.

4.1.2.7 **District Technologies**

The technologies most commonly observed in these Best Practice examples includes:

- Borehole geothermal energy collection for heating and cooling
- Borehole interseasonal energy storage
- Thermal banks interseasonal heat storage
- District heating
- District cooling
- CHP
- CCHP
- Biomass boilers
- PV plants
- Solar thermal systems
- Sewage heat recovery
- Bio-gas district supply network
- Energy Management Systems

**District Heating Systems**

District heating systems are common and have a long history. There are many technologies which can supply thermal energy to the systems. Geothermal energy from boreholes can provide thermal energy at very high temperatures depending on the geology of the location. CHP (Combined Heat and Power) is very common and the EU defines the ‘recovered waste heat’ from electricity generation as renewable energy. Any of the biomass systems (AD, boilers, gasification, pyrolysis) and ‘waste to energy’ plants can supply renewable electricity and heat via bio-gas fired CHP plant.

ASHP’s (Air Source Heat Pump) can supply about 27% renewable heat on grid electricity and about 350% renewable energy when operated on renewable electricity. The benefit of this technology is the plant can be sited where it is not visible if it has access to outside air. It takes solar energy out of ambient air and concentrates it to a higher temperature. Large 1.4 MW units can supply directly to a district energy network.

Solar thermal paving systems can provide large areas of cost effective solar thermal collection using the public spaces of piazza, squares, courtyards, parking areas and roads in a district. ICAX Ltd. has pioneered the asphalt solar collector and it could be adapted to other paving finishes.

**District Cooling Systems**

Local lakes, rivers, the sea and aquifers can be a source of cooling water for renewable cooling energy in district cooling systems.
Absorption chillers and three stage chemical heat pumps can convert waste heat and renewable heat into cooling energy.

**District Electricity Systems**

Renewable or locally produced electricity can be used directly in private wire grids if the local regulator agrees. If this is not possible it can go directly into the grid with the necessary conditioning but probably at a lower price than selling to individual customers.

**District Bio-gas Systems**

The small bore single pipework for a bio-gas network is much less expensive to instal than insulated twin-pipe hot water pipework. It is therefore much cheaper to supply bio-gas to individual buildings than hot water from a centralised district heating system. The bio-gas can then be used in conventional boilers and systems already in existing buildings, but with no electricity generation.

**Energy Management to ISO 50001**

ISO 50001 is an International Standard that enables organizations to establish the systems and processes necessary to improve energy performance, including energy efficiency, use, and consumption. Implementation of this standard is intended to lead to reductions in greenhouse gas emissions, energy costs, and other related environmental impacts, through systematic management of energy. The ISO 50001 standard became internationally recognized in June 2011 and promises to reach over 500,000 organizations worldwide.

**Enerit ISO 50001 software** was the first software to meet the ISO50001 standard and was launched on the same day ISO 50001 came into effect. Enerit ISO 50001 software leads to the automation and implementation of the ISO 50001 standard, and the unique aspect of this software is that it goes beyond completing the standard allowing users to save energy in the long run. The Enerit ISO 50001 Software introduces two key benefits to customers:

Helping implement energy savings of 10% to 20% through no-cost, low cost measures;
Increased staff cooperation and reduced workload in implementing good energy practices that comply with ISO 50001 approaches.

**Case Study: University College Cork Campus, Ireland**

UCC became the first university in the world and also the first Public Sector Body in Ireland to achieve ISO 50001 certification. This was achieved in 4 months with the Enerit ISO 50001 software. This increased profile has resulted in additional support from UCC senior management, staff and students.

In the initial 6 months of implementing the ISO 50001 energy management system UCC achieved substantial energy savings: Electrical consumption reduced by 5.14% and Natural Gas reduced by an estimated 8%.

The University said they have been impressed by the new savings opportunities they have identified, many at low cost through the ISO 50001 approach. UCC estimate that in the first year, they will achieve **annual savings of 5.5% in electricity consumption and 8% in gas consumption.**
4.2 Paris: Retrofit at the Metropolitan Urban Scale

This example addresses both Environmental Performance and Energy Supply at the building (and group) scale, is unclear in relation to Technical Compatibility, and poses major challenges to Heritage Significance both visually and materially at all scales from the metropolitan and urban district down to individual building components. At present, implementation of the 2012–2017 retrofit and new building programme is at an early stage, and it is to be hoped that the indicative concepts will be substantially modified as the programme evolves. In collaboration with the Mairie de Paris, RODWELL proposes to monitor this through the duration of the EFFESUS project.

4.2.1 General information

The city of Paris is a metropolis of 2.2 million inhabitants covering 105 km$^2$ with an estimated Carbon footprint/Parisian equal to 11,000 tons CO$_2$ (2009). Paris, like other European cities, is in the process of upgrading the energy efficiency of its old buildings.

Promoted by 2007 Paris Climate Plan, this renovation has been guided by national regulations since the Grenelle Laws1. The architectural qualities of Paris are often used as an argument to block the necessary changes. Yet, the lessons gleaned from the first renovation experiences offer promising solutions and show that it is possible to reconcile transition and the preservation of the architectural heritage. Progress is being made with buildings in the public and commercial sectors as these sectors are subject to legally binding targets. However, renovation in the private housing sector, which represents nearly half of the city’s built stock and for which public measures are purely incentive-based, has been delayed due to the high cost of renovation work and the slow decision-making processes of Parisian co-ownership structures.

From the starting point of the 2007 Paris Climate Plan, targets have been set for 25% reductions in energy consumption and greenhouse gas emissions, and 25% supply of energy from renewable sources by 2020. More ambitious targets are set for 2050. The retrofit cost under the Paris Climate Plan has been estimated to average 23,000 € per dwelling.

4.2.2 Building stock and energy characteristics

The analysis reported here below was performed by the APUR - Atelier Parisien d’urbanisme (Paris Urban Planning Agency http://www.apur.org/) in March 2011 and the year 1950 was considered as a turning point.

Over-arching thermographic diagnosis of the city has been undertaken by APUR; to research the city’s diverse historic and newer urban districts, their building typologies, ages and ownership types. The conclusions are typical, concerning the relative thermal performance of older, pre-1900, traditionally constructed buildings (good, but not adequate) compared to early to late 20th century construction (worst in the third quarter). The thermographic diagnosis (aerial, carried out by helicopter) was used as the primary tool to determine the measures appropriate to differing typologies and age of buildings across the city.

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1 July2010: Grenelle 1, a planning law establishing the general principles of the government’s environmental programme, and Grenelle 2, a law specifically establishing all necessary positive law measures.
The buildings built before 1950, which account for a little less than two-thirds of the current built stock, are relatively carbon-light, especially those built before 1914. This comparatively favourable situation can be explained by the high inertia of the materials used for façades (such as dressed stone), the urban forms (dwellings with common walls, thus reducing the number of walls exposed to the outside air) and the heating systems (individual rather than collective, the latter having the disadvantage of taking responsibility away from the occupier). These old buildings are found in the centre of Paris (city mansions of the 17th and 18th centuries, Haussmannian and post-Haussmannian buildings), in the suburbs and along the Boulevards des Maréchaux that ring the city.

Then, post-1950 until 1975 (year of the first thermal regulations following the 1973 oil crisis), housing and offices became much more energy-greedy. They were built on a massive scale away from the city centre in the north, south and east of Paris and represent about one-fifth of the city’s built stock. It is these buildings (often social housing) that are most in need of energy retrofitting.

With the tightening of regulations, buildings constructed after 1975, particularly later than 1990, are a great deal more energy-efficient, and thus do not require as much major work to improve their thermal insulation.

In summary from the analysis was clear that:

- Before 1950 buildings are less energy intensive but have architectural heritage constraints
- 1950-1975 buildings are energy-intensive and may have architectural constraints
- After 1975 buildings are gradually less energy intensive

![Figure 11: Energy consumptions for Parisian dwellings (heating + hot water) [kWh/m2/year]](Source: Atelier Parisien d’urbanisme)

Paris is an old city whose built environment is undergoing very slow renewal (each year, new constructions account for only 1% of its built stock) but which needs radical renovation in order to meet energy efficiency targets. However, the French capital is endowed with an exceptional architectural heritage, which has made it the world’s most popular city for tourists but which also has called for increasing regulatory protection over the last hundred years.

If we take into account the fact that all buildings located near a listed historic monument or site are subject to controls of government departments whenever requests for building or works permits are examined, it is clear...
that almost all Paris buildings are part of the city’s protected landscape and heritage. In addition, public opinion is increasingly keen on preserving this heritage.

Some put forward the argument of preserving these heritage assets to block changes that are motivated by environmental considerations. However, alleged architectural obstacles should not serve as an alibi. Recent examples of the renovation of buildings from all periods (Ancien Régime, Haussmannian, inter-war period, the 1970s…) show that a knowledgeable combination of techniques to insulate a building’s shell, improve heating system performance and produce renewable energies can bring about a spectacular reduction (up to 80%) in energy consumption and carbon emissions.

**4.2.3 Examples of interventions realized**

The implementation of the retrofit programme for Paris, however (as also for France generally), contains an explicit and substantial level of compromise with heritage values. Whereas the majority of Paris is subject to varying levels of protection at building and district scales, compromise affects even the highest category of protected buildings: for monuments, historic windows, for example, can be replaced with new ‘energy efficient’ patterns.

At urban district level, regulatory control is in the hands of state appointed architects. Notwithstanding, sample ‘best practices’ (as deemed by the authorities) for a historic building (namely pre-1945) include the fitting of solar panels not solely to the roof of one building but also to its street façade. In this, it may be considered that political and other pressures have over-ridden compatibility with heritage significance.

More favourable examples are cited below:
## 1926 post-Haussmannian building, 161 rue de la Convention 75015

<table>
<thead>
<tr>
<th>Owner</th>
<th>SGIM</th>
</tr>
</thead>
</table>
| Intervention| • An extra level is added to the previous roof,  
• Solar panels on the terrace,  
• Outside and inside shutters,  
• Double-glazed windows,  
• New terrace available for all inhabitants with view on Eiffel tower |
| Achievements| Energy consumption drops from 446 kWh/m²/year to 95 kWh/m²/year. |
| Architect   | Marc Bénard |

## 1960 building, Tour Bois le Prêtre, Porte Pouchet 75017

<table>
<thead>
<tr>
<th>Owner</th>
<th>Paris Habitat</th>
</tr>
</thead>
</table>
| Intervention| This building was to be preserved, as part of Paris post-war heritage and its image was enhanced in particular by:  
• adding loggias all around its four façades which brings in light,  
• increases space (used as greened balconies),  
• insulates dwellings. |
| Achievements| In all, 50% of energy is saved. |
| Architect   | This building, constructed by architect Raymond Lopez, was first renovated in 1990 and then in 2011 by architects Frédéric Druot, Anne Lacaton, Jean Philippe Vassal with Hélène Françoise Jourda |
### Brick building (1936), 29 rue Pierre Nicole - 75005

<table>
<thead>
<tr>
<th>Owner</th>
<th>SGiM</th>
</tr>
</thead>
</table>
| **Intervention** | • External thermal insulation for courtyard façades,  
• Energy efficient windows and shutters,  
• Solar panels on roofs,  
• Efficient urban heating,  
• Mechanic ventilation. |
| **Achievements** | Energy consumption falls from 210 to 79 KWH / m² / year |
| **Architect** | Atelier Jerôme Leroy |

### 17th century building in the Marais district, 74 rue de la Verrerie 75004

<table>
<thead>
<tr>
<th>Owner</th>
<th>SGiM</th>
</tr>
</thead>
</table>
| **Intervention** | • Façade on street,  
• Inside insulation,  
• Double windows,  
• New façade on courtyard. |
| **Architect** | François Brugel |

The lessons to be learnt from these examples point above all to the vital need for audits and in-depth studies (including historical studies) so as to understand the thermal behavior of buildings. Secondly, works need to be decided on in a concerted manner, bringing together architects, representatives from the Ministry of Culture and the City of Paris, thermal engineering firms and occupiers. Technical solutions are now emerging: thin-layer insulation that can be adapted to ornate street façades; solar panels that blend in with the Parisian zinc roofs; wastewater heat recovery to supplement heating systems and simple energy-consumption monitoring systems in dwellings to cite the most important.

In summary, this Paris example contains useful concluded and ongoing diagnosis at the scale of a metropolitan historic city, the methodologies for which are relevant and applicable to other European cities from large to
smaller scale. However, there are aspects of the implementation that have been derived from diagnosis that are significantly at variance with the EFFESUS requirement that interventions should be compatible with heritage values.

Further details about this Set B are contained in the related annexes, where the studies performed by APUR have been collected. The annexes comprise (in English) an overview text dated 24\textsuperscript{th} January 2013, the lecture poster and two presentations that were given by Dr. Hélène de Largentaye, Conseillère chargée du patrimoine et du développement durable Direction de l'Urbanisme, Mairie de Paris, on 15\textsuperscript{th} March 2013 in Cambridge, which RODWELL attended; also, a supplementary presentation (in French) on the Village Saint-Paul urban block in Paris’s historic Marais quarter.

GOUAS has provided information concerning the former Abbaye de Fontevraud, which may be regarded as a historic urban district in terms of its scale, complexity and historical significance.

This example is focused on self-sufficiency of renewable Energy Supply, and as such it achieves the additional advantage of energy security for the site. The installations have been carefully integrated into the complex, and thereby also protect the Heritage Significance of the complex at the urban district scale. As yet, in respect of the buildings, no information has been sourced under the headings of Technical Compatibility and Environmental Performance.

In April 2012, a major programme of conversion to renewable energy was commenced across the whole site, aimed at achieving 100% self-sufficiency in heating and electricity by means of a combination of biomass boilers (using wood from local forests) and photovoltaic cells. This is being achieved by the careful integration within the complex of new infrastructure, including two boilers each with 500kW capacity and 92 PV panels.

The objectives identified in the program of energy conversion:

- Decrease by 2 energy consumption compared to 2011
- Decrease by 4 contribution to the greenhouse gas emissions compared to 2011
- Cover 90% of energy needs from renewable energy
- Ensure 100% supply through local resources
It makes use of **renewable energies, wood heating and photovoltaic panels**, which will replace fuel and electric heating.

In concrete terms, the project's ecological objective is to **halve the Abbey's energy consumption and quarter its greenhouse gas emissions – all the while providing 100% energy supplies to the premises.**

This centre is the first building to be built at the Abbey for almost a century. Its location at the foot of the hill opposite the abbey church chevet calls for **complete integration in the site – through its partly buried design.**

It will house a wood-burning room, technical service workshops, an educational room (for understanding how the system works and retracing the site's energy history) and storage areas. The photovoltaic panels are due to be put on the roof in terraces, covered with a lawn on which a scenic area will be used for hosting open-air concerts and performances.

The work is expected to be completed by the summer of 2013.
4.4 Retrofitting vernacular heritage, Greece

This example (provided by AMS) focuses on Heritage Significance, Technical Compatibility and Environmental Performance. Whereas it does not specifically refer to Energy Supply, the main thrust is to reduce demand, both for heating and cooling, by prioritising and improving on traditional constructional methods and passive systems.

Metsovo, northern Greece, is a representative traditional village (population in 2001, 3,195) at relatively high altitude (1100–1300m), subject to a continental climate, prolonged cold winters, warm summer months, and above average rainfall.

Metsovo has been subject to specific district and building protection since 1975. The threat and reality of incompatible interventions at all scales, from new building typologies in the urban fabric to visually and technically incompatible interventions to the fabric of traditional buildings, have led to a series of theoretical studies aimed at achieving energy efficiency retrofit measures that accord with the heritage significance of the settlement.

The studies provided by AMS embrace the considerable variation in detailed traditional construction, from solid stone masonry (typically at the lower floor level of two-storey houses) to infilled timber framed walls (at the upper level).
Figure 16: Bioclimatic attributes of the vernacular architecture

Generally, the main structure of the houses is oriented south or southeast, and of special interest is the difference between winter and summer rooms. The building users live in different rooms (which have different orientation and size of openings) in order to ensure the best possible conditions of comfort. Consequently, the whole family during winter uses the winter living-room or “ondas”, while during summer the family lives in “chotziare” room which has more openings providing ventilation.

Traditional buildings in Metsovo are made of stone walls that have high thermal mass, while the interior walls, floors and ceilings are made of wood (ceilings provide insulation).

Figure 17: Bioclimatic attributes of the vernacular architecture of the settlement (a)
The traditional buildings in Metsovo therefore exhibit a defensive and compact form, and high thermal mass emerges as a design priority and orientation relative to the sun is less important.

Regarding openings, their size, their orientation and their arrangement, favour ventilation, exploitation of light and solar heat gains depending on the season. The shutters act as either mobile insulation elements in the winter or solar protection elements in the summer. The overhangs from the roofs offer protection to the walls and windows. Furthermore, the slope in the roofs promotes the rapid removal of snow and contributes thereby to the corresponding reduce heat losses.

Finally, the fireplaces are an important part of any house, serving for heating during the winter, while the hearth skylights provide lighting at times when the shutters remain closed.

4.4.1 Interventions leading to low energy consumption buildings

Traditional masonry and interventions

According to traditional standards, the exterior masonry was made of locally-sourced natural stone with a thickness of 0.50 to 0.70m, the outside area was uncoated, whereas internally only the main areas of use were coated.

The calculations conducted, indicated that the masonry has U-value varying from 2.10 to 2.60 kcal/m²h°C which is considered as quite high and unacceptable in accordance with the provisions of the Greek thermal...
insulation regulations. The software tool WinMONA was used to calculate traditional buildings’ thermal performance.

**Interventions to improve the energy performance**

By applying expanded polystyrene and a coated brick layer or plasterboard to the internal wall of stonemasonry, a reduction of U-value is achieved. The new U-values are of the order of 0.445-0.550 kcal/m²h°C (corresponding to 1/5 of the initial rate), which are acceptable. However, in this case there is a decrease of the effective area of the space, but as shown in the table below this is very small particularly in the case where plasterboard is applied (better thermal performance for the same thickness insulation).

In the case of timber framed walls where their main material is hardwood which has good insulating properties, the U coefficient of these traditional components is close enough to the current requirements. However, this is a lightweight construction in terms of heat capacity and susceptible to moisture (this is probably why over the years this technique was abandoned by traditional builders).

<table>
<thead>
<tr>
<th>Type of additions</th>
<th>New Uvalue</th>
<th>Thickness of addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>polystyrene 6.00cm</td>
<td>0.447 kcal/m²h°C</td>
<td>17.50cm</td>
</tr>
<tr>
<td>brickwork 9.00cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coating 2.50cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>polystyrene 5.00cm</td>
<td>0.545 kcal/m²h°C</td>
<td>7.50cm</td>
</tr>
<tr>
<td>double plasterboard 2.50cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>polystyrene 6.00cm</td>
<td>0.471 kcal/m²h°C</td>
<td>8.50cm</td>
</tr>
<tr>
<td>double plasterboard 2.50cm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Openings**

Concerning openings, traditional frames were wooden with shutters. Today the use of wooden frames is imposed by legislation which determines the building conditions and limitations in Metsovo.

After a site survey, it was deduced that the use of aluminium or synthetic frames was requested by the residents to the objective of energy improvement of their homes and reduction of heating costs. There are cases in which the wooden windows frames have been replaced with aluminium ones or aluminium frames have been added externally. In both cases these actions are arbitrary. Moreover, the removal of limitations regarding the size and proportions of the openings is frequently requested by the residents.

Given the above two requests, a simple thermal study was performed. The contribution of the openings to the heat loss of a small ground floor building with area of 25.0 m² was evaluated, in the following cases:

- (a): wooden frame with sufficient area for building lighting with moderate U–value.
- (b): aluminium frame with the same area as in the first case and low U–value.
- (c): aluminium frame with increased area and low U–value.
Table 3: Contribution of windows to energy loss

<table>
<thead>
<tr>
<th>Opening area (m²)</th>
<th>Kof frames (kcal/m²h°C)</th>
<th>Percentage of thermal losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.88</td>
<td>3.20</td>
<td>17%</td>
</tr>
<tr>
<td>2.88</td>
<td>2.20</td>
<td>12%</td>
</tr>
<tr>
<td>5.76</td>
<td>2.20</td>
<td>22%</td>
</tr>
</tbody>
</table>

From the following figures, the importance of the size of the openings can be deduced. If the request of the residents regarding the use of aluminium frames and the creation of large openings had been accepted, then the heat losses would have been much larger and thus there would have been no benefits in terms of heating costs. Therefore the construction of wooden frames with low thermal transmittance is recommended. It is worth noting that wooden windows with double glazed units are more efficient than those of aluminium.

Table 4: Percentage of heat loss (a) (b) (c)

| Percentage of heat loss (a) | Percentage of heat loss (b) | Percentage of heat loss (c) |

Table 5: The allocation of rooms between vernacular and contemporary house

<table>
<thead>
<tr>
<th>Traditional residential spaces</th>
<th>Contemporary residential spaces &amp; orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ondas</td>
<td>living room (S, SW) kitchen (N)</td>
</tr>
<tr>
<td>Sarai</td>
<td>dining room (S) entrance (N)</td>
</tr>
<tr>
<td>Chotziareas</td>
<td>bedroom (S, SE) bathroom (N)</td>
</tr>
</tbody>
</table>
Spatial arrangement
Regarding the layout of the internal space, whereas lifestyles and user needs have changed, the old traditional houses can be adapted to modern standards. Also modern construction can follow the bioclimatic principles which were adopted in traditional architecture.
Indicatively, the small residence could follow the configuration of the three-room vernacular dwelling as shown in the table below.

Table 6: Systems and principles of bioclimatic design that could be applied to contemporary architecture of Metsovo settlement

<table>
<thead>
<tr>
<th>Systems of bioclimatic design</th>
<th>Applicable in the village of Metsovo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial Location</td>
<td>Favourable or in line with the insulation, the view and the slope</td>
</tr>
<tr>
<td>Usage of vegetation</td>
<td>Capable for wind protection in the winter, shading and cooling in summer</td>
</tr>
<tr>
<td>Building Shape</td>
<td>Defensive</td>
</tr>
<tr>
<td>Volume-Plasticity</td>
<td>Compact, cubic volumes, self-shadowing of the bulk building and roof protrusion</td>
</tr>
<tr>
<td>Thermal Barrier</td>
<td>Strong</td>
</tr>
<tr>
<td>Internal spaces’ arrangement</td>
<td>Orientation based on the functions of each space Ratio of window area – space area Creation of thermal zones</td>
</tr>
<tr>
<td>Building envelope</td>
<td>Increased thermal insulation(internal or in the core of the walls) Preventing thermal bridges Usage of special glazing Movable insulation openings (shutters) Heat capacity (concrete, stone, slab) Breathable walls Green roof Selective orientation and size of openings</td>
</tr>
<tr>
<td>Passive solar systems</td>
<td>Direct insulation: windows, skylights Greenhouses Atrium Insulated with passive thermal integrated system after studying the placement of a solar collector</td>
</tr>
<tr>
<td>Cooling</td>
<td>Penetrating, nightly, vertical, hybrid ventilation Ventilation chimney (with the essential morphological configuration) Direct evaporative cooling (use of water bodies) Cooling from the ground (direct and indirect)</td>
</tr>
</tbody>
</table>

Understanding and taking full advantage of the local climatic conditions is a key aspect of the Metsovo example and whereas certain of the technical solutions and materials that are proposed may be open to question (such as expanded polystyrene), this example evidences a good overall methodology.

NOTE: Upon receipt from AMS, this Metsovo example was shared with NTNU as leader of Work Task 2.4, Recovering old architectural solutions and strategies.
4.5 Examples from Visby

This example (provided by HGO) prioritises Heritage Significance and Energy Supply and subsumes Technical Compatibility and Environmental Performance. The urban district renewable energy system obviates the need for solar panel installations on individual roofs, thus protecting the overall integrity of the street and higher level views across and within the district. Solutions to individual buildings reflect varied heritage significance parameters according to whether buildings are protected in their own right.

The four examples comprise:

Urban district renewable energy and infrastructure, serving most buildings in the town and served by wood chip burning plants sited outside the historic district. As such, it offers a sound example for a self-contained small town with supporting land and forests. CO₂ emissions from the plant may be an issue.

Two recent examples of interior retrofit to buildings protected both externally and internally as historic monuments: one, with internally applied wall insulation; the other, with internally applied double pane secondary glazing, without affecting the original external glazing.

The fourth, a recent example of exterior insulation applied to a building in the protected historic district but which is not protected as a building in its own right.
### Table 7: examples from Visby

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Category</th>
<th>Description</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The historic town of Visby</td>
<td>Renewable energy systems and infrastructure at district level.</td>
<td>District heating is available to most buildings in the historic town. The main source of energy is wood chips. The heat is generated at plants located outside the historic town.</td>
<td><a href="http://www.gotlandsenergi.se/fjarrvarme.pab">http://www.gotlandsenergi.se/fjarrvarme.pab</a></td>
</tr>
<tr>
<td>2</td>
<td>Gamla apoteket (&quot;The old pharmacy&quot;)</td>
<td>Buildings protected externally and/or internally as historic monuments</td>
<td>This is a listed monument and commercial apartment building with full (sufficient) functionality for the users. Interior insulation has been applied.</td>
<td>HGO/Tor Brostrom</td>
</tr>
<tr>
<td>3</td>
<td>Donnerska huset</td>
<td>Buildings protected externally and/or internally as historic monuments</td>
<td>Modern double pane glass has been added to the old windows on the inside without affecting the original external glazing.</td>
<td>HGO/Tor Brostrom</td>
</tr>
<tr>
<td>4</td>
<td>House at Klinttorget</td>
<td>Buildings within protected historic districts but not protected as historic monuments in their own right.</td>
<td>Exterior insulation has been added</td>
<td>HGO/Tor Brostrom</td>
</tr>
</tbody>
</table>

![Figure 21: Bioclimatic Donnerska huset](image1.jpg)  
![Figure 22: Bioclimatic House at Klinttorget](image2.jpg)

HGO note the difficulty in obtaining numerical details on costs and benefits at this time.

Visby is one of the seven EFFESUS Case Studies. As such, fuller information will be incorporated into EFFESUS during the course of the project.
4.6 Examples from Hungary and Austria

These nine examples cover the range of issues at the scale of major institutional and commercial projects. The Graz example is the most comprehensive in its focus on savings in energy consumption, but serious reservations exist concerning its compatibility with Heritage Significance; major alterations have impacted both externally and internally, and detailed information about important aspects of Technical Compatibility and Environmental performance are not disclosed.

HOR-BER has collated nine examples of major recent retro-fit projects in Hungary (8) and Austria (1). These include the two buildings that were included in the site visits during the EFFESUS Budapest meeting (K210 Room, Budapest University of Technology and Economics, and the Liszt Ferenc Academy of Music).

These display a range of retro-fit and architectural solutions in the context of large scale projects of conservation, reuse and conversion of buildings in historic districts (both protected and unprotected in their own right), in which Heritage Significance has mostly been protected at the external envelope of the buildings as seen from street level, but compromised internally and at roof level.

In the Budapest cases, replacing the original external windows in protected buildings has been accepted in certain cases, with especial concern to improve their acoustic insulation from street noise as well as their thermal performance. In the case of the Museum of Literature, refurbishment of the existing structural windows has involved reglazing using an insulating glass composition 3-8-3 mm with black TREMCO Swiggle spacers, which are stated as ‘hardly visible and therefore recommended for historic applications in several European countries’. The embodied energy in the manufacture of such glazing is not stated in these examples.
4.6.1 Academy of Music, Ligeti György building

Type of use: education – university building
Location: Budapest, Hungary (7th district)
Date of realization: 2011
Category: building exterior (TYPE 2), building interior areas (TYPE 3)
Architects: Mányi István’s Architect Studio Ltd.
Protection level: not protected

SUMMARY OF RETROFITTING MEASURES:

- window replacement (three-layer glazing) – special care for the sound insulation,
- accessibility for the whole building,
- build a new building in the interior while the facades remain “untouched”,
- shading: ceramic pattern burnt in the glass wall (significant design element at the same time),
- intensive green roof (above the ground-floor),
- glass rooftop to allow natural light (above the ground-floor),
- two levels in addition (in the attic).

FURTHER INFORMATION:

Link: http://epiteszforum.hu/zenedoboz-a-zeneakademia-korszerusitese-manyi-studio

On the map: http://goo.gl/maps/czqcB

Figure 23: Academy of Music, Ligeti György building
4.6.2 Paris Department Store

Type of use: shopping mall
Location: Budapest, Hungary (6th district)
Date of realization: 2007-2009
Category: building exterior (TYPE 2), building interior areas (TYPE 3)
Architects: TIBA Architecture Studio
Protection level: under monumental protection

SUMMARY OF RETROFITTING MEASURES:

- window replacement
- roof level extension
- new steel structure under the glass roof
- reinforcement of the concrete structures
- new staircases and elevator

FURTHER INFORMATION:


On the map: http://goo.gl/maps/N3j7Y

Figure 24: Paris Department Store
4.6.3 **Liszt Ferenc Academy of Music**

Visited during partner meeting in Budapest

**Type of use:** education – university building, concerts  
**Location:** Budapest, Hungary (6th district)  
**Date of realization:** 2013  
**Category:** building exterior (TYPE 2), building interior areas (TYPE 3)  
**Architects:** Éva Magyari, Béla Pazár, Ferenc Potzner  
**Protection level:** under monumental protection

**SUMMARY OF RETROFITTING MEASURES:**

- replacement of the windows (special care for the sound insulation)  
- partition walls (sound insulation)

**FURTHER INFORMATION:**

On the map: http://goo.gl/maps/2Ih6M

*Figure 25: Liszt Ferenc Academy of Music*
4.6.4 **CEU – Central European University**

Interesting, because one of few urban block/building ensemble retrofittings; further development in process of planning currently; extension and retrofitting.

Type of use: education building, university, library, public spaces on the ground floor
Location: Budapest, Hungary (5th district)
Date of realization: 1995
Category: urban district (TYPE 1) – urban block
Architects: several studios

**SUMMARY OF RETROFITTING MEASURES:**

- extension, new buildings in the courtyard,
- retrofitting of the windows,
- renovation of the facade,
- glass roof above the courtyard

**FURTHER INFORMATION:**


On the map: http://goo.gl/maps/ssm4a

![Figure 26: CEU – Central Europe University](image)
4.6.5 **Apponyi Mansion, Medina**

Type of use: hotel  
Location: Medina, Hungary  
Date of realization: 2009-2011  
Category: building exterior (TYPE 2), building interior areas (TYPE 3)  
Architects: VLM Architects (Csaba Molnár, Árpád Vilics, Olivér Lantos, Orsolya Maza)  
Protection level: under monumental protection

**SUMMARY OF RETROFITTING MEASURES:**

- air heating system supplemented with heat pump system  
- rebuilding of the northern wing  
- renovation of the hunting lodge  
- recovery of the whole roof structure, partition walls, vaults, interior ceilings, cladding  
- reconstruction of the facade  
- window replacement: new windows, satisfying the thermal and vapor requirements, ensuring the authentic appearance at the same time  
- recovering the ornaments in the interior  
- authentic building materials, conventional structures and solutions

**FURTHER INFORMATION:**

[http://farsangterv.blog.hu/2012/02/29/24_muemlek_epulet_energiatudatos_felujitasa_tabudontes](http://farsangterv.blog.hu/2012/02/29/24_muemlek_epulet_energiatudatos_felujitasa_tabudontes)

Publication: Várak, Kastélyok, Templomok magazine, June 2012

On the map: [http://goo.gl/maps/J1VOj](http://goo.gl/maps/J1VOj)

*Figure 27: Apponyi Mansion, Medina*
4.6.6 Károlyi Palota

Type of use: museum (Museum of Literature)
Location: Budapest, Hungary (5th district)
Date of realization: 1996-2000
Category: building exterior (TYPE 2), building interior areas (TYPE 3)
Architects: first phase, MÜÉP Építőmérnöki Kft; second phase, König és Wagner Építészek Kft; implementation: Gödöllői Architekton Építő- és Műemlékfelújító Rt.
Protection level: under monumental protection

SUMMARY OF RETROFITTING MEASURES:

- renovation of the facade and the roof
- replacement of building engineering equipment
- restoration of the historic interior spaces
- window refurbishment:
  - before the refurbishment survey, extended to documenting the structural elements, typical details, variations and deviations between types.
  - within the three basic types – plank-case windows, joined window and sash-windows – 32 sub-types have been identified by shape, dimension and divisions (number of leaves).
  - decrease of air-tightness
  - increase sound and thermal insulation, resistance to rain
  - insulating glass composition 3-8-3 mm, using a spacer non-metallic in color and surface: the black TREMCO Swiggle spacer. This spacer is hardly visible and therefore recommended for historic applications in several European countries.

FURTHER INFORMATION:
On the map: http://goo.gl/maps/XkkRj

Figure 28: Károlyi Palota
4.6.7 **Franciscan Monastery, Graz, Austria**

Interesting example, well documented and available energy retrofitting measures; no EFFESUS partner from Austria – good source for examples; building ensemble, retrofitting measures applied to the whole.

Type of use: residential, public spaces, sacral spaces  
Location: Graz, Austria  
Date of realization: 2010  
Category: urban district (TYPE 1) – building ensemble  
Architect: Michael Lingenhöle  
Protection level: under monumental protection

![Image of Franciscan Monastery, Graz, Austria](image-url)  

**Figure 29: Franciscan Monastery, Graz, Austria**

**SUMMARY OF RETROFITTING MEASURES:**

- **1. Step:** energy efficiency measures  
  - desiccation of the walls  
  - insulation where possible  
  - rooms used as buffers  
  - renovation of box-type windows  
  - “warming” tints  

  *Savings after the first step up to 25%.*

- **2. Step:** solar thermal energy use  
  - for hot water and heating  
  - component heating (to dry and pre-temperate the walls)  
  - low temperature heating  
  - supply of adjacent buildings
Savings after the second step up to 50%.

3. Step: heating system, heat pump
- solar- and water-coupled heat pump
- annual use efficiency > 5
- 3 storage tanks with together 15 m³
- central heating room inside the building
- two pipes distribution (flow/return flow)
- three decentralized tiled stoves

Savings after the third step up to 92%.

4. Step: power generation
- photovoltaics (at buildings)
- or green power investments
- or green power (wind, PV) purchase

Rest: Around 8% of the original consumption.

**Table 8: Franciscan monastery (Graz, Austria) retrofitting**

<table>
<thead>
<tr>
<th></th>
<th>Before renovation</th>
<th>After renovation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross floor area</strong></td>
<td>3590 m²</td>
<td>3585 m²</td>
</tr>
<tr>
<td><strong>A/V ratio</strong></td>
<td>0,53 /m</td>
<td>0,36 /m</td>
</tr>
<tr>
<td><strong>Energy key figure</strong></td>
<td>198 kWh/m²a</td>
<td>85,38 kWh/m²a</td>
</tr>
<tr>
<td><strong>Heating requirement</strong></td>
<td>711307 kWh</td>
<td>329774 kWh</td>
</tr>
<tr>
<td><strong>Heating load</strong></td>
<td>256,4 kW</td>
<td>42,4 kW</td>
</tr>
</tbody>
</table>

**FURTHER INFORMATION:**


General information: [http://www.franziskaner-graz.at/](http://www.franziskaner-graz.at/)

On the map: [http://goo.gl/maps/WfNxy](http://goo.gl/maps/WfNxy)
Figure 30: Energy flow chart; situation in 2008
4.6.8 K210 BME University public hall

Visited during Budapest partner meeting.

Type of use: education, exhibition, conferences, workshop
Location: Budapest, Hungary (11th district)
Date of realization: 2010
Category: building interior area (TYPE 3)
Architect: Tamás Szentirmai, János Vági
Protection level: under monumental protection

SUMMARY OF RETROFITTING MEASURES:

- leaves the building’s historical elements and values untouched
- functions built in an enormous piece of furniture installed in the space, which is a variable installment
- big folding shutters on the windows (inside)
- window replacement
- acoustic cladding
- new wooden floor
- use of direct and indirect lightning

FURTHER INFORMATION:

All information, plans etc. available at/via university

Link: http://www.archdaily.com/132429/k201-public-hall-tamas-szentirmai-janos-vagi

On the map: http://goo.gl/maps/HfDUH

Figure 31: K210 BME University public hall
4.6.9 **Partial reconstruction of the building in Budapest at 22 Sas Street**

**Type of use:** office building  
**Location:** Budapest, Hungary (5th district)  
**Date of realization:** 2009  
**Category:** building exterior (TYPE 2), building interior areas (TYPE 3)  
**Architect:** Tamás Németh, László Bodnár, Sára Horváth, Tijana Dimitrijevic, Anita Farkas, Julianna Füzi, Imre Orbán  
**Protection level:** under monumental protection  

**SUMMARY OF RETROFITTING MEASURES:**

- Reconstruction of interior spaces of 3 floors, new area for customer service and offices  
- Minor corrections on facade  
- Replacement of building engineering equipment  
- Air-source heat pump system  
- Fully automated HVC systems  
- New staircases and elevator  
- New glass roof above courtyard  
- Window refurbishment with new insulating glass on the inner windows  

**FURTHER INFORMATION:**

- Link: [http://horber.hu/data/sas_utca_22.html](http://horber.hu/data/sas_utca_22.html)  
- On the map: [http://goo.gl/maps/dIyjh](http://goo.gl/maps/dIyjh)

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**Figure 32:** Partial reconstruction of the building in Budapest at 22 Sas Street
4.7 Examples from Spain

This example focuses primarily on Energy Supply systems and varied experimental projects across different climatic zones in the Spanish mainland and island.

SANTIAGO has collated twelve cases examining preventative conservation practices, energy efficiency retrofit measures and predominantly experimental renewable energy installation. The buildings embrace a wide range of traditional construction and craft skills, including natural stone in wall and paving and adobe (compacted earth block).

Renewable energy systems include:

The award-winning Lodging of Gotarrendura, Ávila: roof mounted solar panels for hot water and photovoltaics for electricity.

The Mataró urban network distribution of heat through hot water piping: primary energy sourced from the leftover facilities of wastewater treatment and solid waste; and latterly, the incorporation into the system of the supply of cold water for air conditioning buildings.

An urban district housing project in Madrid that is investigating the viability of installing combined geo-thermal heating and cooling infrastructure into the renovated setting (public spaces) of protected buildings.

A concept for a major planned solar powered hot water system for the city of Barcelona, which fell short of its targets: ‘thermal solar energy was only seen as a futuristic source of energy which was not possible to use in urban residential areas.’


Objectives:

- To establish a preventative system for conservation and maintenance of paving in the walled area of Santiago de Compostela, extendible to rest of the historic city’s pavements.
- To promote constant low intensity action as a logical conservation method.
- To link conservation activity with valued use of traditional trades and research the updating of these trades from the point of view of technical innovation and the new economic, productive and social realities.
- To organise recording of operations carried out and drawing up of compilation documents for analysis, diagnosis and prescription, which make data available for future decision making.
- To use training as a link between these objectives.

Achievements: Near 3,000 actions have been carried out which mean intervention on more than 5,000 m² of paving with repercussions on a much greater surface area.

Training of specialised professionals in conservation of traditional granite flagstone paving with a high degree of placement in employment.

The creation of a Tender Document and a Price Basis that are already used as a reference by the City Council and other bodies that intervene in the Historic City.
**Involved Parts:** As promoters: Consorcio de la Ciudad de Santiago (Santiago Consortium) and Fundación Laboral de la Construcción.

As collaborator: Santiago Council through the OCiHR (Office for the Historic City and Rehabilitation) participating in the programming of activities, coordinating all programme relations with the different municipal departments and enterprises involved, collaborating in communication with affected citizens, and in general supervision of the Maintenance Service operations.

![Figure 33: Maintenance of historic city paving, Santiago de Compostela](image)

**Total cost of project funding:** The operational costs of the programme in technical assistance, external works, workshop creation, etc. are included in the Consorcio de Santiago’s budgets and paid directly by the Consorcio itself or through the Fundación Laboral de la Construcción by virtue of the collaborations agreements signed. In the period 2012-2013, these amount to approximately 240,307,93 €.

The costs corresponding to training activity are co-funded by the Consorcio de Santiago and Fundación Laboral de la Construcción in virtue of the aforementioned agreements, by the Xunta de Galicia through the office for employment promotion of the Department for Work and Welfare (Consellería de Traballo e Benestar), and by the European Social Fund.

In the period 2008-2012, these amount to approximately 850,991,19 €. The costs for the maintenance service and works are included in the Consorcio de Santiago’s budgets.

**Relevance In The European Context:** The project proposes to transform the habits for intervention on the historic city paving by substituting rehabilitation criteria, on occasions excessively linked to town planning, for those typical of maintenance and preventative conservation, which are more in keeping with the anonymous dynamics which cause public spaces to become more formalised and, without doubt, are much more efficient.

We know that the preventative conservation of the historic flagstone paving is the guarantee that they can be passed on to future generations and this must be supported by two strategies:

- Firstly, constant and normalised maintenance and preventative conservation, which is the aim of this
- Secondly, a study of the mobility of people and goods in the historic centre that will allow pedestrianisation and traffic restrictions to be consolidated in the historic centre, which the Consorcio has programmed to deal with within the framework of the Master Plan they are promoting for urban Infrastructures in the Historic city.

We are convinced that these are universal problems and that the normalisation of a maintenance programme such as this one, which is in the context of a city that is a World Heritage Site, and which has shown itself to be efficient in economic terms and sustainability, provides values that can be exportable or can serve as a reference to other conservation works on historic paving.

www.consorciodesantiago.org

4.7.2 “To have is to hold” Preventive Maintenance Program of historic city buildings (2006-2013), Santiago

The Consortium and the Council of Santiago launched an innovative program of grants to subsidise the maintenance of the exterior of the building envelope, windows and wooden galleries of the Historical City. Small maintenance on historic cities is what has guaranteed its preservation over time. Unfortunately in recent years the crisis of historic cities is coupled among other factors to the loss of this habit and maintenance custom that has shifted to other goods such as cars.

The Consortium Technical Office, through Project Workshop, deals with the development of Maintenance Plans for each building that is requested, in which are included the tasks to be performed and their costs. The aid amounts to 50% of maintenance cost and the Consortium will deliver the subsidy to the extent that will be running the schedule of tasks defined in the Plan.

In the first open call during the month of July 2006, there were 36 applications.

4.7.3 Lodging of Gotarrendura, Ávila

The renovation of this building in Gotarrendura for conversion into lodging has brought significant benefits to the municipality, in addition to preserving local heritage, has won several national awards. Also known for being a premier tourist Gotarrendura and the first lodging for pilgrims in the province of Ávila.

The building is a clear example of the typical construction of the region of La Morana, to which it belongs. The adobe (compacted earth block) has been combined with renewable energy systems installed in the roof of the building, providing hot water to the lodging, and produce electricity that is sold to the grid and whose economic benefits were allocated to the creation of a job for cleaning and maintenance.

The hostel has been studied many times as an example of sustainable building, energy conservation and efficiency. There are several universities and European projects, in collaboration with the Energy Agency of the Provincial Avila of Avila, who have come to know this building, thus contributing in education and environmental awareness.

Besides being an eco-building, the hostel has greatly improved the quality of life of the inhabitants, as they have an appropriate place in which to develop courses, activities, meetings, etc.. It has helped to increase tourism in the municipality, giving accommodation to over 160 pilgrims each year who travel the route of the Camiño de Santiago from East-Southeast.
Total investment: 185,000 euros.
http://www.gotarrendura.es

4.7.4 **Conditioned houses with renewable energy, Mataró**

Since 2003, Mataró Sustainable Energy, S.A. (MESSA) operates an urban network distribution of heat through hot water piping. Primary energy for water heating use come from leftover facilities of wastewater treatment and solid waste and, therefore, they are all renewable energies. Since 2010, moreover, the system incorporates the supply of cold water for air conditioning of buildings. This expanded service is essential to meet the demands of tertiary activity buildings and residential buildings, due to the specific weather of the area.

The experience presented as good practice in the fight against climate change in the area of housing is precisely the incorporation of this segment of the domestic demand centralized distribution network, both hot water for heating and cold water for air conditioning.

This conceptual step has required technological and socio-cultural adaptations, because of the special characteristics of this demand, and all without giving up the advantages already known in air conditioning commercial buildings.

This real experience raises expectations to include dwellings in a dynamic energy saving and effective participation in the fight against climate change.

Total investment: 10,800,000 €.
http://www.messa.cat

4.7.5 **Bioclimatic Urban areas on the Island of Tenerife, Granadilla de Abona**

The Technological Institute of Renewable Energies (ITER) has over 20 years promoting research and technological development in the field of renewable energy. The technological walk, wind tunnel, visitors center and urbanization bioclimatic part of this stage of research and dissemination of techniques based on energy conservation and sustainability.

In order to make this experience accessible to scientific, technical and non-technical audiences, bioclimatic houses are offered on a short stay. To complement a regularly organized Open Days, in which detailed information is given through guided tours. Monitoring and in situ study of this scale urbanization takes place from 2008 through the Program for the Promotion of Research Technology (PROFIT). Both the implementation of a home automation and monitoring system, as the direct experience of visitors using the houses, allow us the analysis of different architectural patterns within the same geographical area. All data are available at the visitor center included in the ITER.

Total investment: 62,723 € (ITER S.A.), 125,448 € (Science and Innovation Ministry). http://www.iter.es

4.7.6 **Protection and renovation of the historic city and integration with the natural environment, Santiago**

Since the early nineties Santiago de Compostela has been facing the challenge of urban renewal and environmental regeneration of the historic World Heritage city. This initiative, based on urban planning, has received the European Prize for Urban Development 1997-1998 of the European Commission and the European Council of Town Planners, along with other national and international recognitions.
In the context of a complex urban policy, urban recovery pays special attention to two important problems in contemporary historical cities: the preservation of residential uses with improved housing conditions of the population and environmental regeneration of open spaces that survived marginalized.

More than 650 interventions with public help have propelled a widespread renovation process with a demanding environmental and heritage criterion, inducing more than 400 interventions of private initiative. A stable dynamics for optimism makes aiming for comprehensive renovation.

The recovery policy of spaces (more than 18 ha of new parks) has set up two green corridors including public waterways, trees and vegetation, historic gardens and ethnographic elements.

All this in a city of pilgrimage destination for millions of travelers who add to the enjoyment of heritage the immersion in a historical city with all its attributes, including the most fragile and valuable: the people who use it casually twelve centuries past and the nature in which it has sprouted.

Total Investment: 27,102,650 €.

http://habitat.aq.upm.es/bpes/onu02/bp205.html

4.7.7 Mixed Tutelary Housing for young people with Manager of Energy Efficiency and Educational System I3CON, Madrid

The Municipal Housing and Land Company (EMVS) has developed a new concept of mixed service building applicable to spaces occupied by old parks cleaning facilities in consolidated urban areas of central Madrid. In addition, the provision of parking for residents improves mobility conditions of the neighborhood, and the relocation of cleaning canton minimizes its impact and greatly improves operability.

Another very important aspect of the project was to verify the economic viability, within the adjusted setting of protected housing, of construction of collective housing using air conditioning systems with geothermal source. The geothermal HVAC system, linked to the use of inertial capacity of soil and utilization of air conditioning inertial devices, does not arise as an accessory to conventional air conditioning systems, but as a full alternative to them, being much more efficient in consumption and energy costs and more competitive in installation cost.

Furthermore, the Energy Efficiency Manager Project (developed in the framework of the Connected Urban Development (CUD)), which is actively involved in reducing carbon emissions in urban areas, has been implemented in the first two levels in this building, coupling integration policies, innovation and sustainability in different fields.

The educational system “Industrialised, Integrated and Intelligent Construction” (I3CON) aims to promote sustainable self-management of housing through information and alerting users about energy and water consumption and indoor climate. It is a system developed within the European R & D, involving 25 European partners from 14 countries and is funded by the Sixth Framework Programme of European Commission.

Total investment: 896,233 €.

http://www.emvs.es
4.7.8 Photovoltaic School Network, Pamplona

In 1998 the city of Pamplona created the municipal service called Energy Agency. Among the targets was the city's involvement in saving energy and promoting renewable energy. And in the field of renewable energy, particularly in solar energy, Pamplona has significant potential for exploitation.

However, far from using this potential energy, the use of the sun as an energy generator in those years was minimal and dominated the use of non-renewable and dirty energies.

With the aim of promoting the use of solar energy and closer to the citizen, in June 2001 was born the Photovoltaic Schools Network Project, a project involving the creation of a network of solar photovoltaic installations in municipal schools which are added pedagogical applications.

The most visible impact of this project is environmental, because it has avoided the emission into the atmosphere of more than 47,000 kg of CO$_2$, which would have required 5,110 mature trees annually being grown naturally. Furthermore, the demonstration effect of this network has not only increased awareness and interest of citizens, but has promoted the implementation of numerous solar systems.

The main lesson that provides this good practice is its ability to include in a single project technology and education, gender equality and social inclusion, empowerment and leadership of the municipality, sustainable urban development association of local and regional public authorities with the private sector.

Total investment: 233,232 €.

http://habitat.aq.upm.es/bpes/onu06/bp0556.html

4.7.9 Sustainable energy management and responsible consumption in municipal facilities, San Fernando de Henares

San Fernando de Henares (39,000 inhabitants, 16 km southwest of Madrid-Spain), before 2001 is a developing residential and industrial town, with good level of electrical infrastructure services, water, gas and telecommunications. Energy supplies are composed of electricity, natural gas, fuel oil and bottled gas, mainly. Until 2001 there was no renewable energy source or control over energy expense.

On the other hand, there is a significant rate of school failure in obligatory education in municipality, causing a lack of training among young people seeking their first job, causing conditions on social and family structure.

In 2001 actions are established in order to intend rationalization of energy consumption, promoting renewable energy and promoting the training of young people without adequate professional training and getting social reintegration as installers of photovoltaic solar and thermal systems.

In late 2003 it has been gotten the proper training of 15 young professional in that area, the installation of 40 kW peak photovoltaic solar panels on public buildings generating 56,800 kWh/a, installation of 220 m2 of solar thermal for Municipal pool water heating and carrying out an energy audit of public buildings and outdoor lighting with a potential saving of 860,000 kWh/a.

In addition, the council has drafted a Solar Ordinance and reduced taxes on companies that use renewable energy. As a result is expected to decrease 93,263 t/a of emissions (CO$_x$, NO$_x$, SO$_x$).

Total investment: 614,357 €.

http://habitat.aq.upm.es/bpes/ou04/bp1248.html
4.7.10 Barnamil, 1,000 m² of hot water solar panels for the year 2000, Barcelona

The Barnamil Campaign (BC) is designed on Barcelona city (BCN) and its metropolitan area. The project began in June 1997 and has a goal of installing 1000 m² of solar panels for domestic hot water by the year 2000. In BCN total demand for domestic hot water could be supplied by covering a mere 3% of building area. However in 1997 the area covered of solar panels didn't even reach 200 m². Thermal solar energy TSE was only seen as a futuristic source of energy which was not possible to use in urban residential areas. In addition environmental and social impact of the traditional energy model was not recognised.

Six months after project start up, the most significant impact has been:
- Increase in public awareness regarding social/environmental impact of traditional energy consumption model.
- Understanding of the importance of individual responsible energy consumption regarding a healthy environment and a more just balance between North/South (N/S).
- Put into action a network of diverse, local, experienced, voluntary organisations to promote TSE, including environmental, trade union, resident associations, women groups, cooperatives, N/S solidarity groups, others.
- Increase in demand for info and free quotes on TSE installation for individuals & community groups.
- Achieved improved relations between demand and suppliers so reducing previously high transaction costs. Consequent reduction in BCN CO2 emissions.
- Total investment: 89085 €.

http://habitat.aq.upm.es/bpes/onu98/bp447.html

4.7.11 Municipal Plan on Climate Change in Noain-Valle de Elorz, Navarra

The Municipal Plan on Climate Change comes as the culmination of a series of actions carried around savings and energy efficiency in the municipality. The main objective of the City of Noain-Valley Elorz when implementing these actions, framed within the Local Agenda 21 was not only consume less energy, but the fight against climate change.

The actions initiated in 2004 began with three subsequent energy audits and implementation of the respective corrective measures. This led to conduct a Municipal Energy Plan covering all municipal facilities which is currently running. In turn, and in parallel, it has been conducted several renewable energy facilities, awareness campaigns and information to citizens and workers of the City, several actions have been undertaken to save water and making reforestation in the Valley of Elorz.

Thus, among the achievements, is the implementation of eight municipal renewable energy facilities and the changing trend of energy consumption in these municipal (in 2006, electricity consumption in these units decreased by 10%, and in June 2007 1 %). Also, the township population is getting more concerned, as 80 of the 130 families who have participated in the program Kyoto Homes of Environmental Resource Center Foundation of Navarre (CRANA) were people from Noain-Elorz Valley. Moreover, since 2003, have planted 31,169 trees and shrubs, both in mountain reforestation as linear plantations in Elorz Valley.

Total investment: 1,103,079 €.

http://habitat.aq.upm.es/bpes/onu10/bp2646.html
4.7.12 Renovation of "Tinería" neighbourhood, Lugo

The Council of Housing and Land invests 31 million euros between 2005 and 2010 in the physical and social neighborhood of A Tinería, in the historic center of Lugo. This is not an isolated practice in rehabilitation since it’s been developed alongside other historic centers of Galicia (Vigo, Ourense, etc). The main objective is to improve urban life of the neighborhood, which promotes a sense of identity that contributes to the economic and social regeneration.

A total of 52 buildings have been acquired in the neighborhood of A Tinería, which will house 70 protected dwellings devoted to rent, preferably for young people under 35, whose income does not exceed 1.700 euros per month. Currently, 13 of these buildings are now renovated and the process has been initiated for the award of 36 dwellings that were requested by 410 people.

The recovery of the neighborhood includes intervention in the Pazo de Doña Urraca and its environment, the Execution Unit 8 with a budget of 2.3 million euros for the renovation of the building as a center for research, documentation and research of social services; the intergenerational construction of 2 buildings with 11 apartments for young people under 35 and over 60 years as well as a day center for the elderly.

Total investment: 15.800.000 €.

http://conselleriavivenda.xunta.es/web/igvs/111
4.8 Example from Norway

This example (provided by NTNU) embraces Heritage Significance, Technical Compatibility, Environmental Performance and Energy Supply. Emphasis has been placed on replacing all windows, a policy that is critiqued for example by DWE in Section 4.12 below. From the available information, however, the windows at Brandengen School are not the original ones and the new patterns seek to recover the aesthetic appearance of the originals – researched from old photographs.

4.8.1 Reducing energy consumption in a historical school building

Introduction

This project is part-way through its 2011–2015 programme, and results will be better known at a later stage. Brandengen Primary School in Drammen is a demonstration building within the EU project «School of the Future» (SoF). The EU project, which focus area is retrofitting, started in 2011 and will run for 5 years. Four demonstration buildings are included, one in each of the participating countries Denmark, Germany, Italy and Norway. Brandengen School has historical valuable buildings from 1914, and the municipality emphasizes that the retrofitting should be carried out in accordance with the expectations of the conservation authorities.

![Figure 34: Before and after retroflying interventions](image)

Objectives

The overall aim is to achieve future high performance building levels when retrofitting school buildings, i.e. low energy consumption and good indoor climate conditions. The general energy target for the demonstration buildings is to reduce the energy consumption by 75 %. The target figure set for Brandengen School is somewhat lower because of the restrictions associated with the historical buildings. Expected energy savings are calculated to 67 %.

<table>
<thead>
<tr>
<th>Total energy use</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandengen School before retrofitting</td>
<td>208 kWh/m²a</td>
</tr>
<tr>
<td>National regulation TEK 10 energy frame Brandengen</td>
<td>120 kWh/m²a</td>
</tr>
<tr>
<td>School with planned retrofit measures [Dokka 2011]</td>
<td>68 kWh/m²a</td>
</tr>
<tr>
<td>Estimated energy savings at Brandengen School</td>
<td>67 %</td>
</tr>
</tbody>
</table>

Method

The EU project is based on close cooperation between research institutes and industrial companies, represented by the «Advisory and Evaluation Group» involved in the planning of the demonstration buildings.
This group of expert advisers has developed programs for measurement of energy consumption and quality of the indoor environment. The group work together with the building owners and their consultants to find solutions for considerable reduction of energy consumption, utilisation of renewable energy sources, and improvement of the indoor environment. Various alternatives will be assessed utilising simulation tools. The building’s environmental footprint will be assessed by calculating potential greenhouse gas emissions (CO₂ equivalents).

Tailored training seminars will be developed, aiming to provide operators with necessary background information about building energy management systems, and also provide teachers with training material to help to make their pupils more aware of energy efficiency and the quality of indoor environment.

Reducing energy consumption and increasing indoor comfort

In order to reduce the energy consumption a three step strategy is emphasized, i.e. initially apply energy efficiency measures to reduce heating and cooling demand, and then utilize renewable energy resources, and lastly meet remaining demand with an effective energy supply system.

For Brandengen School the first step includes additional insulation in the attic, in the basement, and on the inner side of external walls, as well as replacement of windows and doors. The second step concerns utilizing passive solar gains, and at the same time avoid overheating. The third step concerns the old oil burners, which will be replaced by a geothermal heat pump with annual system efficiency (COP) of 2.7. A bio-oil or bio-diesel burner will be installed for peak loads.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Facade/ wall</td>
<td>0.80</td>
<td>0.12</td>
<td>0.07</td>
<td>87 %</td>
</tr>
<tr>
<td>Roof</td>
<td>0.36</td>
<td>0.13</td>
<td>0.10</td>
<td>44 %</td>
</tr>
<tr>
<td>Ground floor</td>
<td>0.14</td>
<td>0.15</td>
<td>0.01</td>
<td>94 %</td>
</tr>
<tr>
<td>Glazing</td>
<td>2.4</td>
<td>1.2</td>
<td>0.0</td>
<td>69 %</td>
</tr>
<tr>
<td>Average U-value</td>
<td>0.03</td>
<td>0.27</td>
<td>0.01</td>
<td>96 %</td>
</tr>
<tr>
<td>Glazing g total solar energy transmittance of glazing</td>
<td>0.74</td>
<td>0.62</td>
<td>0.52</td>
<td>26 %</td>
</tr>
<tr>
<td>Shading Fs Shading correction factor</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0%</td>
</tr>
</tbody>
</table>

Figure 35: Envelope design criteria (Source: Dokka 2011)

Heat leakage from the roof has caused icicles in winter. Icicles have to be removed because they can harm people when falling down, and they can also harm the rain gutters if they are allowed to gain weight. Previous winter Drammen had to spend one million Norwegian kroner to remove the icicles from poor insulated
municipal buildings. Two expert advisers from SINTEF were involved in finding solutions to avoid heat leakage and moist problems.
The wall between the mansard windows, and the floor in the attic, got additional insulation of 30 cm mineral wool. Vents were installed to provide outdoor air to flow into the attic; to cool the attic and to remove moist. In 2001–2003 a ventilation system was installed and ventilation ducts were placed in the attic. These ducts were not insulated. In the autumn 2011 a layer of 10 cm insulation were wrapped around the ducts.

Window replacement
The windows have been replaced at different times since 1965. As the windows have caused high heating costs and not contributed to an optimal indoor climate, the municipality decided to replace all windows installed after 1965, aiming for new high performance windows, which also pay respect to the historic aspects of the buildings' aesthetics. Existing original windows are being refurbished. Most of the original windows are located along corridors, where the indoor temperature requirements are not as strict as in classrooms.

Design criteria for new windows
Design criteria for new windows were elaborated in co-operation between the architect N. Herland, a+form, the window manufacturer NorDan, and S. Tangen from SoF Advisory and Evaluation Group. Searching for modern high performance windows the following criteria were required:

- Looking similar to the original windows from 1914
- Long life expectation
- U-value ≤ 0.8 W/m²K (at affordable price)
- Affordable operational and maintenance costs

Description of chosen window solution
«Passive house» windows from NorDan were chosen to be installed. As these windows substantially decrease heat losses (U-value ~ 0.8 W/m²), they will contribute to both better indoor thermal comfort and reduced energy bill. Thanks to the glazing's low solar energy transmittance (g-value = 27 on south and west façades), the exterior sunscreen devices can be removed from the façades, in order to restore the façades aesthetics as close as possible to that of the original historic look. This is the only certified Norwegian passive house window. SINTEF is the approval body.
The old windows had wooden frames and bars. The new windows have wooden frames (split/insulated) with exterior aluminium cladding. The selected aluminium clip bars have a look closely to the original wooden bars with glazing putty. To get a similar look as the old painted frames, the aluminium profiles got a lacquer finish of 30 % gloss, which is less bright than standard. As outdoor play can be quite rough, the windows on ground floor got duplex bars.

**Figure 37: Passive house windows from NorDan. Note the insulated frames in the vertical section**  
(Source: NorDan 2012)

**Figure 38: Photos showing the original windows from 1914 and the new ones installed in 2012**

**Ventilation and electric lighting**

In 2001–2003 refurbishment work was carried out, regarding ventilation and lighting. Balanced ventilation systems with rotating heat recovery were installed in the main building and the building for school and leisure time arrangement. Also new lighting fixtures with T5 technology and presence detectors were installed. During the EU project period the old heating air ventilation system in the activity building (gym) will be replaced with a modern, balanced, demand controlled ventilation system with high efficient heat recovery (83 % or more) and low energy demand for fans (SFP < 1,5 kW/m³/s).
Control and monitoring
The building energy management system (BEMS) will be used to control space heating, ventilation, and lighting, according to demand, and to monitor the energy consumption. Measured values will be compared with design data, and in that way allow for assessments of the heating and ventilation systems’ efficiency. The monitoring technology is based on electronic bus communication technology and is integrated in the BEMS system. Additionally the user acceptance and the user behaviour will be analysed. Sporadic comfort questionnaires and accompanying interviews with different user groups (pupils, teachers, and caretaker) will be carried out. A survey was carried out on 20th of December to uncover the status of the indoor environment before retrofitting. A questionnaire about temperature, drafts and air quality was filled in by pupils, accompanied by measurements of room temperatures, CO₂ concentrations and air change rates. A new survey will be performed after retrofitting, at the same weather conditions, so it can be compared with the survey before the retrofitting. There exists no survey of indoor environment in summer time before retrofitting. Anyhow; the indoor spring/autumn conditions will be investigated after retrofitting.

Preliminary conclusions and further work
So far the façades, attic and roof cladding are retrofitted according to the project objectives. When starting the project, there were worries about passive house windows being too expensive. But negotiations with the contractor resulted in prices for state of the art windows that were slightly higher than conventional windows. Both the contractor and the window manufacturer wanted to contribute to make a demonstration building, making Brandengen School a showcase on their ability. Also for more ordinary, comprehensive retrofitting the future might show that upgrading with passive house windows can be economically affordable, compared with conventional windows.

Additional insulation of exterior walls
A study will be carried out to investigate the possibilities for extra insulation of the brick façades. The external walls consist of double masonry structure. So far it is suggested that it might be possible to install a layer of 2cm super insulation on the inner side of the façades, but there are concerns regarding condensation. Expert advisers, dealing with new insulation materials, will be consulted.

Combined ditch for drainage and heat pump pipelines?
It is recommendable to dig up the ground and place drainage ducts along the main building, and to insulate the cellar walls under the ground. New drainage is necessary to maintain the building, and insulation will bring along the possibility to get better use of the basement areas. It will be investigated if one of the ditches can serve a dual purpose; if heat pump pipelines can be placed there as well.

Optimizing energy supply
A heat pump will be connected to the existing pipelines in the main building. The activity building (gym) will get new pipelines. The ambition is to make the heat pump system as efficient as possible. An investigation will be conducted regarding pressure control. The question is if it is possible to drop pumps and shunts in the outgoing
pipelines, and in stead go for a good pressure control of one main pump. Further; the ambition is to utilize renewable energy sources, like bio, for peak loads and standby unit.

Acknowledgements
«School of the Future» is a collaborative project within the 7th Framework Program of the European Union in the energy sector. Hans Erhorn from the Fraunhofer Institute of Building Physics is the coordinator.
4.9 Geothermal applications in historic urban districts in Genoa

This example focuses on Energy Supply as the means to satisfy the buildings’ energy demands unobtrusively, avoiding impacts on the external visual as well as material Heritage Significance. The limits of geothermal applications are noted, the costs are relatively high but the projected pay-back times encouragingly short. Whereas the House of Sailors has the advantage of external land, the INPS city centre project was only possible as part of a larger, comprehensive refurbishment project to the building.

D’APPOLONIA has provided two cases studies of geothermal applications in Genoa, emphasising that the use of geothermal probes has no impact on the urban landscape but that installation problems technically depend on the possibilities of piling or of open areas to create vertical or horizontal systems. Plants that use geothermal probes can also be applied in historic contexts. They have no impact on the landscape but application problems from a technical point are related to the possibility of pilings or have open areas to create vertical or horizontal systems. The limits of application are given by:

- the morphology of the area,
- the possibility to carry out excavations or drilling,
- the installation costs,
- the lack of knowledge and dissemination practices on current construction theories.

4.9.1 Case Study "House of Sailors" - Nursing Home G. Bettolo Camogli – Genova Italy

The nursing home G. Bettolo in Camogli is a building of the early twentieth century, situated on a block embankment upstream of Aurelia near the center of Camogli and the sea. The intervention of inclusion of geothermal probes, sponsored by the Technical INPS province of Genoa, (designed by eng. Enrica Cattaneo), has been designed taking into account of site logistics, indeed it was necessary to use (to reach the terrace) means of small size and therefore less able to drilling.

![Image of the nursing home G. Bettolo in Camogli](image)

**Figure 39: The nursing home G. Bettolo in Camogli**

The system designed in 2006 and developed during the 2007-2008 is now in use and meets the needs of heating and cooling of the building of 11,000 m³, produces 120-130 kWe and it cost 180,000 €. The probes are brought up to a depth of 110 mt, the system employs turbines Swedish and has been realized, as a result of a national procurement contract, by a contractor of Bolzano. The estimated time for RoI is 6-8 years of operation. The peaks of production are in summer (110 kW) in relation to the needs of winter heating (90 kW).
4.9.2 Case Study "INPS offices" Genova (Italy)

The refurbishment of the headquarters of the Social Security Offices in Genoa located in Via Cadorna was quite complex. (The project was developed as the previous one by Eng. Enrica Cattaneo).

The building was built before the Second World War by the architect Piacentini and is located in a central area of the urban area of Genoa.

The site, under final completion, concerns the construction of a geothermal plant, the insulation of the building and the creation of a system of radiant heat in the ceiling.

The low enthalpy geothermal plant is constituted by vertical probes closed circuit, is located inside the cavity of the building, occupying a limited space and not invasive, suitable to the existing situation.

The system consists of geothermal probes combined with a transformation system for production of electricity. The system is designed to provide the building (mc 28000) of Via Cadorna with 400 kW thermal heating and cooling by means of the combination of a geothermal system (to heat pump with vertical heat exchangers) and a trigeneration plant.

During the winter, the trigeneration plant is expected to produce 360 kW and the geothermal plant the remaining 40, during the summer, however, the systems should help for half to the achievement of the total power, providing 200 kW each.

The geothermal system, for which from 40 to 50 buried probes with e Double U profile and length of 120 m were designed, takes advantage of the high thermal conductivity of rocks concerned from the wells, with values ranging between 1.6 and 3 W/mK for most of the perforated portion.

These values were determined on cores of rock extracted with a perforation of 150 m. The wells for the introduction of heat pumps, with a diameter of 115 mm, are drilled with the technique of the compressed air (with the addition of water to prevent the formation of powders), while the casings are anchored to the rock walls with cement bentonite with high thermal conductivity (0.9-1.0 W/mK).

The land in the area of via Cadorna is very wet, for the first 80 feet in deep is a alluvial plain, at 100-110 m is rock. There are flaps to 5 - 40 - 80 mt. of depth. The good conductivity of the soil has raised the performance of the probes limiting the perforation to 29 probes compared to the 40 initially planned. The probes in this case have a yield of 40 to 45 W/m.
The project was funded 35% by an invitation to FILSE, the plant has cost a million euro, there is depreciation in 6 years. It is guaranteed by the supplier of Zurich for 75 years. The system is tested and monitored by the CNR to verify the differences between design model and the actual production of electricity, in order to improve the future applications.
4.10 Urban District Renewable Energy Concept: Weimar, Germany

This example (provided by Fraunhofer) focuses at this stage on Energy Supply. Whereas it does not specifically refer to the other issues, these are subsumed within the overall project themes.

Figure 41: Building awaiting refurbishment in the “Old Zöllner District”, located close to the inner city

The “Old Zöllner District” model project intends to demonstrate the economic and technical feasibility of providing a highly efficient, energy-oriented refurbishment of old buildings in inner-city areas with a mixed structure. It is endeavouring to achieve a decentralised, largely self-sufficient energy supply with a large proportion of renewable energies. Another goal of the model project is to develop generally applicable assessment criteria and guidelines for complex inner city mixed structures in order to promote their transferability. A central component is a district energy concept for the Zöllner District that should lead to an energy efficient and low exergy supply for the area based on renewable energies, cogeneration, the development of a local heating network and the deployment of effective control technology. In addition to saving energy, improving the environmental situation should also reduce the operational costs and thus increase the long-term attractiveness of the location as a place to live.

Table 10: Project details

<table>
<thead>
<tr>
<th>Location of local community</th>
<th>99423 Weimar, Thüringen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlement in figures</td>
<td>Area: 84.26 km²; population: 65,230</td>
</tr>
<tr>
<td>Developer, organizer</td>
<td>Max-Zöllner-Stiftung, Weimar</td>
</tr>
<tr>
<td>Settlement</td>
<td>Wilhelminian-era buildings, inner city residential and commercial developments</td>
</tr>
<tr>
<td>Utilisation type</td>
<td>mixed area</td>
</tr>
<tr>
<td>Gross floor area, before (according to DIN 277)</td>
<td>20.460 m²</td>
</tr>
<tr>
<td>Gross floor area, after (according to DIN 277)</td>
<td>25.468 m²</td>
</tr>
<tr>
<td>Residential area, before</td>
<td>8.241 m²</td>
</tr>
<tr>
<td>Residential area, after</td>
<td>10.200 m²</td>
</tr>
<tr>
<td>Schools, kindergartens area, before</td>
<td>10.746 m²</td>
</tr>
<tr>
<td>Schools, kindergartens area, after</td>
<td>10.746 m²</td>
</tr>
<tr>
<td>Total public facilities area, before</td>
<td>1.473 m²</td>
</tr>
<tr>
<td>Total public facilities area, after</td>
<td>4,522 m²</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Age structure</td>
<td>1 listed villa built c. 1900; 7 residential buildings and a school built c. 1925, partly listed; 3 buildings (school, child day care centre) from the 1960s</td>
</tr>
<tr>
<td>State of construction and refurbishment</td>
<td>poor— requires considerable refurbishment (residential buildings), partly refurbished (school, child day care centre)</td>
</tr>
<tr>
<td>Heating system</td>
<td>Before: individual stoves (coal), individual heating systems (natural gas), central heating systems (heating oil, natural gas); after: decentralised energy supply using renewable energy, CHP and local heating</td>
</tr>
<tr>
<td>Ownership structure</td>
<td>Rented by foundation, partly owned by the City of Weimar</td>
</tr>
<tr>
<td>Project themes</td>
<td>New buildings</td>
</tr>
<tr>
<td></td>
<td>Refurbishment</td>
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<td></td>
<td>Conversion</td>
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<tr>
<td></td>
<td>Residential buildings</td>
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<tr>
<td></td>
<td>Listed buildings</td>
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<tr>
<td></td>
<td>Decentralised solutions</td>
</tr>
<tr>
<td></td>
<td>Integrated energy concepts for buildings</td>
</tr>
<tr>
<td></td>
<td>Optimising building envelopes</td>
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<tr>
<td></td>
<td>Optimising building technology</td>
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<tr>
<td></td>
<td>Passive house construction method</td>
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<tr>
<td></td>
<td>Local heating and cooling networks</td>
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<tr>
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<td>Cogeneration</td>
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<td>Renewable energy sources</td>
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<td>Centralised + decentralised energy supply</td>
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<td>Street lightning</td>
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<td>Energy management systems</td>
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<tr>
<td></td>
<td>Project and process management</td>
</tr>
<tr>
<td></td>
<td>Optimisation of operations</td>
</tr>
</tbody>
</table>

**Project description**

Because of existing characteristics such as the building and supply structure and the still low use of renewable energies, inner city residential districts offer considerable potential for increasing the efficient and ecological use of energy. They can therefore make a considerable contribution to protecting the climate and conserving resources.

**The community**

With funds from the German Federal Ministry for the Environment, the City of Weimar is currently working on an integrated, community climate protection concept called “Electricity, Heating, Cooling”. The “integrated climate protection concept” is concerned with analysing the energy requirement coverage in Weimar, revealing potential for lowering the energy consumption, increasing energy efficiency and the proportion of renewable energies, examining possibilities for action in the community and, finally, with specifying measures for lowering greenhouse gas emissions as part of a priority list. The intention is to create a “total potential atlas” for Weimar showing the potential for saving energy, for using local heating with cogeneration and for using renewable
energies. This atlas shall provide the basics for defining specific climate protection goals for Weimar. Based on this, a catalogue of measures will be drawn up with district-related and target group-oriented action plans.

The district
The site is situated to the southwest of Weimar’s city centre in the middle of an area whose structure has evolved with the town’s expansion at the beginning of the 20th century. The high-quality residential district with its Wilhelminian villas, the very well developed school and nursery location with the Pestalozzi School and the Kindergarten schools in Shakespearestrasse and Böhlaustrasse, as well as the new-build schemes that are to be integrated, offer an ideal location for developing and implementing an innovative energy supply concept for inner city areas.

The project
With is diverse range of new-build measures, refurbishment schemes and different use concepts, the “Old Zöllner District” project in Weimar offers an excellent opportunity to implement innovative technologies and, by means of integrated planning, to link various trades and project participants, to investigate and implement the objectives as part of a model project in an inner city area with a mixed structure, and to monitor them during the long-term operation.

The project partners are endeavoring to achieve a standard for the model project that accords with German Energy Savings Ordinance EnEV 2009 minus 30 per cent for the modernization, with a passive house standard for the new buildings. It is intended to achieve such an energy standard by simultaneously implementing solar thermal energy, geothermal energy and cogeneration in combination with a local heating network and long-term storage for supplying an urban district with a mixed structure. Because of the given and planned levels of use in the redevelopment area, it is intended to incorporate and implement the knowledge gained from the “Energy efficient schools”, “Energy-optimized new buildings” (EnBau), “Energy-oriented improvement of the building fabric” (EnSan) and “Heating and cooling with low energy” (LowEx) projects.

The following technologies, methods and processes shall be incorporated in the conception and implementation:

- Thermal cooling technology for the summer-time air conditioning, all-year use of solar energy, geothermal energy, combined heat, power and cooling generation with communal energy management based on cutting edge information technologies
- Planning and optimising a local heating network with innovative storage technologies
- Reducing consumption in the buildings with lowered costs through using innovative thermal insulation measures on historical facade
- Recovering heat from waste water systems

Procedure
After recording the current state, different alternatives for a decentralised energy supply concept for the inner city refurbishment area will be developed, simulation calculations will be conducted and the proposed overall systems will be assessed in terms of use, expenditure, economic feasibility, viability and environmental friendliness. The most economic and energy-efficient version will be selected and the preliminary planning conducted to implement the concept.
In the second project phase, the energy concept will be implemented and supported with long-term monitoring that will check the efficiency of the measures. Based on the experience gained, generally applicable assessment criteria and guidelines for action will be derived for inner city mixed structures.

**Concept and heat supply options**

By integrating a diverse range of innovative technologies available on the market, it is intended to construct an innovative, optimum supply system for inner city areas that utilizes wasteland. This is because the Zöllner District in Weimar generally offers diverse possibilities for utilizing renewable energies and for producing electricity using gas-fired combined heat and power generation. The roofs of the buildings also enable, for example, the use of solar collectors or photovoltaic systems on a total surface area of 750 m².

Two refurbishment versions result in the following heating requirement forecasts:

- **Current condition and new buildings according to EnEV 2009**: Balanced heating requirement for the existing, non-refurbished buildings in their current condition and construction of new buildings in accordance with the EnEV standard 2009. This combination results in energy consumption values for the building heating amounting to 2.635 GWh p.a.
- **Refurbishment (KfW Efficiency Building 70) and new construction (passive house)**: Refurbishment of existing buildings in accordance with the KfW Efficiency House 70 standard (EnEV 2009) and construction of new buildings to the passive house standard. This results in a heating requirement of 1,375 GWh p.a. This leads to 48% energy savings.

For supplying the “Old Zöllner District” with heating energy, three alternatives were initially considered that differ in terms of the heat generation and local heating network and in terms of the solar feed, heat storage and control systems.

**Version I:**
- Heat generation: central
- Local heating network: separate networks for space/water heating, solar and geothermal energy
- Solar feed system: central
- CHP operation: electricity driven
- Heat storage system: seasonal storage tanks for solar and CHP waste heat, central storage tank for geothermal energy
- Control system: Separate controls for the CHP, solar power system and peak load boiler on the one hand and for the geothermal system on the other, with communication between them and with the loads.

**Version II:**
- Heat generation: decentralized CHP and gas condensing boiler for building groups
- Local heating network: ring main between the loads, all generators feed into the network
- Solar feed system: decentralized
- CHP operation: heat-driven
- Heat storage system: storage of CHP waste heat in the geothermal field (summer) and in the ring main (winter); buffer storage tanks for heating water
- Control system: peak loads and the daily heating requirements are produced and balanced out by the heat distribution systems themselves through retaining heat.
Version III:

- Heat generation: independent supply of individual building groups
- Local heating network: network for building groups
- Solar feed system: decentralized
- CHP operation: heat-driven
- Heat storage system: decentralized storage tanks for solar thermal and geothermal energy
- Control system: intelligent control system to enable surplus energy and peak loads to be balanced out between the individual generators.

Financing

Project phase 1 (recording the current condition, decentralized energy supply concepts, simulation calculations, assessment of the conceived overall systems) is being supported with funds from the German Federal Ministry of Economics and Technology (EnEff:Stadt research initiative).

Table 11: Energy characteristics

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>Potential</th>
<th>After</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total area with energy requirement</strong></td>
<td>25.468,00</td>
<td>25.468,00</td>
<td></td>
<td>m²</td>
</tr>
<tr>
<td><strong>Final energy requirements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(electricity)</td>
<td>21</td>
<td>12</td>
<td></td>
<td>kWh/m²</td>
</tr>
<tr>
<td><strong>Final energy requirements</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(heat)</td>
<td>53</td>
<td>28</td>
<td></td>
<td>kWh/m²</td>
</tr>
<tr>
<td><strong>Primary energy requirement (heat)</strong></td>
<td>131</td>
<td>66</td>
<td></td>
<td>kWh/m²</td>
</tr>
</tbody>
</table>
4.11 Examples from the UK and USA

This set of 12 examples (collated by SCOTLAND) embraces Heritage Significance, Technical Compatibility, Environmental Performance and Energy Supply. The two USA cases are considered relevant as replicable best practice examples for Europe.

Under renewable energy, hydro-electric generation – which has considerable application across the UK – features alongside solar and air-source heat pumps as well as biomass district heating systems. An implemented ground source heat pump system is included from Harvard University, USA.

Under district fabric retrofit, the example of the Chicago Green Roofs Project ‘was intended to demonstrate the benefit of green roofs in moderating summer temperatures within ultra-urban environments. The roof is monitored to demonstrate these benefits. The City Hall green roof is currently, on average year-round, 3.9 °C cooler than the surrounding roofs, and as much as 16.66 °C cooler in summer.’

Under district services retrofit, a proposed combination ground source heating-cooling system for the extensive museum and cultural quarter of South Kensington, London, is cited together with discrete district heating systems for dispersed parts of the University of Edinburgh’s property portfolio.

The building fabric and services retrofit examples include the recently completed building comprehensive retrofit to Passivhaus standard features of 19th century terraced houses in London. An Edinburgh example is cited of flatted properties within the UNESCO World Heritage Site where best practice methods included secondary glazing, slim-profile double glazing, draught-proofing shutter refurbishment, new boilers, floor insulation, top-up loft insulation, low energy lighting, smart monitors and home energy advice visits to the occupants. In this example the average energy consumption of each flat was reduced by an average up to 12,000 kWh; the annual CO$_2$ emissions by an average of over 1 tonne.

4.11.1 Introduction

The 12 examples are sorted into the following categories:

- renewable energy generation
  such as geothermal, hydro-electric and photovoltaic (PV) plants
- district fabric retrofit
  such as sedum green roofs
- district services retrofit
  such as combined heat and power (CHP) plants
- building fabric retrofit
  such as internal wall insulation and secondary glazing retrofits
- building services retrofit
  such as biomass boiler
4.11.2 Renewable energy generation

4.11.2.1 Archimedes-screw hydro-electric turbine

Figure 42: Morden Hall Park Morden, London, United Kingdom© National Trust

Description
Morden Hall Park in southwest London is a park owned by the National Trust, a non-government, non-profit conservation organisation, which has converted a stable block within the park as an education, outreach and visitor facility.

To power the park’s visitor centre, the National Trust has installed here London’s first Archimedes-screw hydro-electric turbine, which, acting like a water wheel to generate electricity from the river Wandle, produces around 59,000 kW/a.

The installation of the Archimedes screw by Mackley Construction and Hallidays Hydropower is one of the last stages of the £ 990,000 - restoration of the park, funded by the Heritage Lottery Fund. The City Bridge Trust (of the City of London Corporation) and Thames Water helped support the costs of the turbine.

The installation of the hydro-electric turbine is part of the National Trust’s on-going bid to use ‘greener’ energy on its portfolio of properties around the country, cutting its fossil fuel use in half by 2020. The visitor centre at Morden Hall Park, which also features three different types of photovoltaic (PV) panels, an air-source heat-pump and a wood-burning stove, will be the most energy-efficient historic building in the country when it is completed, says the National Trust.

References
National Trust, 2013. The heart of the park project at Morden Hall Park. [online] Available at: http://nationaltrust-mordenhallpark.blogspot.co.uk/

4.11.2.2 Water-source heat-pump and hydro-electric turbine

**Figure 43:** Lanark Mills New Lanark, South Lanarkshire, United Kingdom

New Lanark Trust; right image: Jim and Liz Denham (Source: http://www.geograph.org.uk/photo/1319590)

**Description**

New Lanark in west Scotland on the river Clyde is a textile mills with an attached model village, both founded in 1786 and therefore examples from the early industrial era. New Lanark’s mills and village are now a World Heritage Site and are managed by the New Lanark Trust, formerly the New Lanark Conservation Trust. Water power has a long history at the New Lanark Mills. At Mill no. 3, a new hydro-electric turbine was installed recently to provide electricity for some of the visitor attractions.

The New Lanark Conservation Trust has now also installed two 44kW water-source heat-pumps at the Mills building, costing £144,000. The fast flowing water of the Mill Lade drives a turbine. Because of the risk that a heat-pump system using conventional polyethylene pipe loops could be drawn into the turbine, shredded and released into the river, three stainless steel heat exchangers (’Slim Jim’s’) with a size of 3.6 m x 1.2 m were submerged into the water instead of the looped pipes, conventionally used. The chosen system is considered a visually suitable solution in this heritage context, as most of the system is not visible, being submerged in water. The 90 kW heat-pump provides the heating for the building housing the so-called ’The Institute for Correction of Character’ and for levels 1, 2 and 3 of the Mills buildings. The pump has reduced the heating costs by 40%. Another heat-pump system, installed in the tail race, provides heating for a new leisure facility nearby.

**References:**


4.11.2.3 Biomass boiler and district heating system

![Image of Garnethill Campus, Glasgow School of Art, Glasgow, United Kingdom](https://via.placeholder.com/150)

**Figure 44: Garnethill Campus, Glasgow School of Art, Glasgow, United Kingdom ©John Robson**

**Description**

The Glasgow School of Art (GSA) has installed a new biomass boiler and associated plant to serve the existing district heating system within its Garnethill Campus. This city-centre campus includes the Mackintosh Building, which is heritage-designated at category A and has recently undergone a £9 million conservation project. Upgrading the historic building fabric of the Mackintosh Building thermally, to achieve reduction in CO\(_2\) emissions, was considered not appropriate for conservation reasons. Instead a 500 kW biomass boiler was installed.

The annual reduction in CO\(_2\) emissions has been calculated to be in excess of 300 t CO\(_2\) per year. A biomass boiler of this size can satisfy around 60% to 80% of the annual energy demand, depending on the load profile. Although providing significant reductions in CO\(_2\) emissions, it is not intended that biomass boilers should provide 100% of the heat load for the site. Slow response times and relatively poor performance at low load make biomass boilers most suited to running constantly at high output. It is therefore proposed that the biomass boilers provide around 25% of the peak load, using gas-fired boilers to ‘top-up’ the heating system, when required. During peak load there will be a delivery of pellets required every 7 to 10 days due to storage limitation in the city-centre location.

**References:**

Description
Anne Thorne Architects about their project at Hawthorne Road: “An eco-renovation of two purpose-built flats and conversion into a 3-bedroom family house designed for the ‘Retrofit for the Future Competition’. The house is owned by Metropolitan Housing Partnership. The competition required an 80% reduction [of in-use CO\textsubscript{2} emissions] on UK average housing, which is the 2050 [UK] government target and this is achieved by designing the conversions to passivehouse standard, using PHPP (passivehouse, planning package). The total primary energy use for all appliances, domestic hot water and space heating and cooling is predicted as less than 115 kWh/m\textsuperscript{2}/a

“Main features are:
- solid wall insulation of 225 mm, internal at front, and external at rear
- a combined gas condensing boiler and solar thermal system supplies small radiators and hot water
- high performance triple-glazed windows
- air tightness as tested on completion: 2 air changes per hour
- new heat recovery ventilation system
- use of natural insulation materials and lime plaster to provide good hydroscopic qualities to the building fabric

Anne Thorne Architects about their project at St. Luke Street: “The refurbishment works to 23 St Luke Street for Sanctuary Housing, completed March 2011, are to a very high energy standard, part of the ‘Retrofit for the Future’ programme, funded by the Technology Strategy Board to show how we can retrofit existing houses to achieve over 80% reductions in CO\textsubscript{2} emissions.

“Existing House - A small single Victorian terrace house in Hanley, Stoke on Trent, it receives very little passive solar radiation, and was a cold and hard-to-heat house. ATA undertook a detailed energy analysis and tailored insulation, airtightness and thermal bridge details to dramatically reduce the heat demand.
“Passivhaus’ Principles Retrofit - Using Passivhaus design principles and components, concentrating on a ‘Fabric First’ approach with high levels of insulation and air-tightness, the retrofitted house has been designed to consume over 80% less energy than the existing house, Passivhaus Planning Package (PHPP) was used to model the existing and potential heating needs and energy use of the house.

“A Natural Approach - This retrofit uses insulation materials from renewable sources, including sheepswool and woodfibre insulation. These materials are used for their hygroscopic qualities to help deal with moisture within the existing building fabric, and also to reduce embodied energy used.

“Post occupancy monitoring is ongoing.”

Anne Thorne Architects, http://annethornearchitects.co.uk/?p=326

References:
Anne Thorne Architects, 2011. stluke’s. [online] Available at: http://annethornearchitects.co.uk/?p=326
Anne Thorne Architects, 2011. hawthorne rd. [online] Available at: http://annethornearchitects.co.uk/?p=324
4.11.2.4 Geothermal heat-pumps

Figure 46: Byerly Hall, Harvard University & Trinity Church, Boston Massachusetts, United States of America © Association of Preservation Technology

Description

A ground-source heat-pump was installed at Byerly Hall, Harvard University, in 2006-2007. The pump system has a design load of 150 tons. The annual cost savings due to the new system were estimated at 77,000 $ (approx. £ 50,000); the annual reduction in CO$_2$ emissions was calculated as 432 tons.

The project also incorporated other sustainable approaches to the works, including 85.8% diversion of construction waste away from landfills, 90% of the building being reused, keeping down costs and reducing environmental impact. There was also a 40% reduction in water use with new dual-flush toilets, waterless urinals and low flow showers and sinks. A real-time utility display-monitor, installed in the lobby, shows tenants how much energy and water is being used in the building.

The Trinity Church in Boston's Copley Square has a ground-source heat-pump with a 130-ton design-load, met by four standing column wells that were installed in 2005. Estimated annual savings for this facility is $67,000 (approx. £ 44,000) with an annual reduction in CO$_2$ emissions of 375 tons.

References:

4.11.2.5 Solar water-heating panels

**Figure 47: Lauriston Place Old Town, Edinburgh, United Kingdom © HChangeworks**

**Description**

This project was completed in 2008-2009 by Changeworks, a sustainable-development organisation, in collaboration with a number of key partners, including EAGA Charitable Trust, Edinburgh World Heritage, Lister Housing Co-operative and the City of Edinburgh Council.

Under stage 1 of the project solar water-heating systems were installed to serve forty-nine flats in seven stairs of Georgian tenement buildings, all heritage-designated at category B. The properties are located in Edinburgh’s Old Town Conservation Area and are also part of the city’s World Heritage Site. Often roof-mounted solar panels are considered inappropriate within a heritage context, as they change the exterior appearance of a building. However, in this case the roof consisted of double pitches and the panels were mounted on the pitches forming the roof valley. The panels where thereby hidden from the view, certainly from street level but also from significantly higher altitudes.

**References**


4.11.2.6 Combined heat and power networks

**Figure 48: University of Edinburgh, United Kingdom © University of Edinburgh & The Guardian**

**Description**

The University of Edinburgh has installed three combined heat and power (CHP) systems on three of its five campuses over the last decade. Aging steam boiler systems have been replaced with high-efficiency boilers and three spark-ignition gas-engines with 85% overall efficiency. These currently serve more than half of the university's 5.5 million sqft estate; however the new systems are not interconnected.

Edinburgh's first CHP project was the installation of a 526 kW gas-reciprocating engine in 2003 to operate as the lead boiler serving the Pollock Halls of Residence, which student accommodation, associated administration and function rooms.

The university's properties that are connected to the CHP systems range from new sustainable designed buildings to significant historic buildings within Edinburgh's World Heritage Site.

**References**


Available at: [http://www.ec.estates.ed.ac.uk/docs/open/District_Energy_Article_Dec06_.pdf](http://www.ec.estates.ed.ac.uk/docs/open/District_Energy_Article_Dec06_.pdf)

CIBSE, 2012?. *Decentralised Energy innovation at the University of Edinburgh.* [PDF]

Available at: [http://www.cibse.org/pdfs/Edinburgh_Case_Study.pdf](http://www.cibse.org/pdfs/Edinburgh_Case_Study.pdf)


Available at: [http://www.chpa.co.uk/vital-energi-wins-university-of-edinburgh-district-heating-contract- _1106.html](http://www.chpa.co.uk/vital-energi-wins-university-of-edinburgh-district-heating-contract-_1106.html)


District fabric retrofit

4.11.2.7 Sedum green roofs

![Figure 49: Chicago Green Roofs Project Chicago, Illinois, United States of America © Inhabitat, http://inhabitat.com/images/greenroofs1.jpg](http://inhabitat.com/images/greenroofs1.jpg)

**Description**

“The Chicago Green Roofs Project was intended to demonstrate the benefit of green roofs in moderating summer temperatures within ultra-urban environments. The roof is monitored to demonstrate these benefits. The City Hall green roof is currently, on average year-round, 7 degrees [Fahrenheit, i.e. 3.9 °C] cooler than the surrounding roofs, and as much as 30 degrees [Fahrenheit, i.e. 16.66 °C] cooler in summer.”

**References**

The City of Chicago & The School of Art, Institute of Chicago, 2006. *Chicago Green Roofs: Guide for building green roofs in Chicago*. [website] Available at:

http://www.roofmeadow.com/case-studies/selected-case-studies/chicago-city-hall/

http://www.artic.edu/webspaces/greeninitiatives/greenroofs/main.htm


Secondary glazing and slim-profile double-glazing

Figure 50: Lauriston Place and Archibald Place Old Town, Edinburgh, United Kingdom © HChangeworks

Description
This project was carried out between 2007-2008 by Changeworks, a sustainable-development organisation, in collaboration with a number of partners, including EAGA Charitable Trust, Edinburgh World Heritage Trust, Lister Housing Co-operative and the City of Edinburgh Council.
The project aimed at tackling the on-going issue of fuel poverty and energy inefficiency in the setting of a historic building within Edinburgh’s World Heritage Site. The improvement measure used in this project included secondary glazing, draught-proofing, shutter refurbishment, boiler replacements, floor insulation, additional loft insulation, low-energy lighting, smart monitors and visits by consultants to advise building occupants on how to reduce their energy use.
The annual energy bills were reduced by an average £ 175 and up to £ 400 in some instances, and the annual CO² emissions for each property were reduced by an average of more than 1 tonne. The average energy consumption of each flat was reduced by an average up to 12,000 kWh.

References
Available at: http://www.historic-scotland.gov.uk/slim-profile_double_glazing_2010.pdf
Building fabric retrofit

4.11.2.8 Secondary internal windows

**Figure 51: Victorian tenement flats Old Town, Edinburgh, United Kingdom® Adam Dudley Architects**

**Description**

An energy-efficiency improvement project carried out in five tenement flats, owned and managed by Castle Rock Edinvar Housing Association. The concerned buildings are all heritage-designated at category B and some are within Edinburgh’s World Heritage Site. Although all flat are very different in size and layout, the walls of all these buildings are traditional stone wall constructions, which have been retrofitted with internal wall insulation and window upgrades.

This project trialled a way of integrating secondary glazing with insulation behind the wall linings and around the window openings in tenement buildings, to improve the thermal performance of the entire building envelope. External doors were also upgraded. The secondary glazed units were designed so that the existing window features, such as the shutters and the easy-clean function of the sashes, remained fully operational.

Due to the bespoke components used in this pilot study, and the small scale of works, the cost per property was substantial.

**References**


Available at: [http://www.thermalshield.co.uk/](http://www.thermalshield.co.uk/)


Available at: [http://www.historic-scotland.gov.uk/refurb-case-study-1.pdf](http://www.historic-scotland.gov.uk/refurb-case-study-1.pdf)
District services retrofit

4.11.2.9 Heating and cooling network (proposed)

Figure 52: Victorian museums & concert hall in South Kensington London, United Kingdom © Mott MacDonald

Description
A partnership has been formed by Science Museum, Victoria And Albert Museum, Royal Albert Hall, Imperial College London and Natural History Museum, all located in close proximity in South Kensington, an urban district in London, to develop a masterplan for the implementation of an energy system model five major public buildings, in order to reduce the CO2 emissions from their estates.

In the 1950s a large-scale 42 MW district heating-system was installed in the five institutions to replace their smaller district heating-systems and operated until 2000, when two of the institutions withdrew.

Recently a new 1.8 MW combined-heat-and-power plant was installed at the Natural History Museum. It is placed next to two 9 MW gas-fired boilers for daily heating. Currently the museum uses 3 MW of electricity during the day and 1.5 MW at night. The plant covers the museum’s needs in the summertime, and the surplus heat from producing electricity is used for the cooling system.

Under the new masterplan, boreholes drilled into the chalk aquifer 70 m below London would allow heat to be collected from the buildings during summer, stored and recycled to provide winter heating. During winter, an underground cold store would be built up to provide summertime cooling.

References
Mott MacDonald, 2013. 30% carbon saving for London museums. [online] Available at: http://www.mottmac.com/carbonsavingforlondonmuseums/
Danfodd District Heating: Agenda #5. [online] Available at: heating.danfoss.com/PCMPDF/agenda_3_eng_low.pdf
4.11.3 Building services retrofit

4.11.3.1 Biomass Heating Boiler

Figure 53: Rosslyn Chapel Midlothian, United Kingdom © John Robson

Description
Rosslyn Chapel is a medieval building, located in a village outside Edinburgh. The building is heritage-protected at category A and is managed by the Rosslyn Chapel Trust. The chapel has recently undergone an extensive conservation work to help prevent further deterioration of its building fabric. Furthermore a new visitor centre was built near the chapel to provide better access to the site and new interpretation facilities. To help prevent fabric deterioration, it was decided to install low-level heating (12 to 14 °C) for the chapel, to achieve a more controlled and stable indoor environment. Therefore a new heating system was required, which was also to have low CO₂ emissions. Following an energy appraisal, Rosslyn Chapel Trust decided that an 85 kW woodchip biomass boiler would be the best system to meet the heating and hot-water requirements for both the chapel and the extended visitor centre. Annually it is predicted to save 15.9 tonnes of CO₂ and 170,000 kWh of energy. A meter display has been installed in the visitor centre to illustrate the impact the new system is making to visitors. It is predicted that the new system will save 397 t CO₂ over the next 25 years.

References
Community Energy Scotland, 2009. Rosslyn Chapel Trust project. (Report: P40334) [PDF]
Available at: http://www.communityenergyscotland.org.uk/assets/0000/3945/P40334_Rosslyn_Chapel.pdf
An Ideal Retrofit Process

This example focuses on **Technical Compatibility** and **Environmental Performance** and incorporates **Energy Supply**. Whereas it does not specifically refer to **Heritage Significance**, references to components such as windows are highly relevant.

DWE has drafted a generic ‘Ideal Retrofit Process in 15 Stages’ applicable to all situations. It is focused on technical issues associated with understanding and improving a building’s constructional performance and indoor environmental quality together with the installation of appropriate renewable energy systems and reductions in energy demand. It is directed at building professionals as well as building owners and users.

Being generic, this draft does not incorporate Heritage Significance into its parameters. Nevertheless, its reads: “Windows and glazing systems are very expensive and usually one of the least cost–effective retrofit measures, so a careful analysis of the condition and performance of the windows should be undertaken before deciding to replace them.”

This Process underscores the need to fully understand a building’s technical and environmental performance before embarking on retrofit measures which may have additionally have damaging heritage impacts.

Introduction

DWEcoCo have distilled the ideal retrofitting process into the 15 stages outlined below based on our experience of retrofitting buildings and on our research into how others have organised the retrofit process. We offer this as a useful summary for any building type on the basis that these stages should be considered for any building even if some of them will end up not being applicable to every building.

1. Baseline Assessment

People are the most intelligent ‘sensors’ in a building and occupants have the detailed knowledge and day to day experience of a building’s indoor environment. Occupants should be the primary source of information for identifying problems and issues of any indoor environment and building. If occupants and the management of a building are engaged at the beginning of a retrofit program to identify the problems and baseline situation a more effective retrofit with higher occupant satisfaction is likely to result. Establishing this Baseline Assessment and performance of a building is the first step in a retrofitting programme and we have included it as the first retrofit measure that should be undertaken in a retrofit process.

2. Management Procedures

‘No cost’ changes in the management of a building can usually achieve between 5% and 20% energy savings due to the conventional default to ‘on’ of most building systems. The facilities management and energy auditing industry has demonstrated this through many case studies and experience with many building types. Occupant behaviour has a significant impact on energy use and with feedback, information, awareness campaigns and incentives it is possible to reduce energy use significantly. ‘Monitoring and Targetting’ programmes are well established successful procedures for reducing energy use. These management and occupant behaviour changes should be high priority retrofit measures in any retrofit programme or project because they are the most cost effective.
3. **Internal Building Cleaning**
The common proprietary products used to clean the interior of buildings contain volatile chemicals which significantly pollute the indoor air. A change to the cleaning products used in the building will improve the indoor air quality by reducing the VOC’s and reactive chemicals which can create air pollutants. This is a ‘no cost measure’ with significant immediate benefits to health and IAQ which can reduce the amount of ventilation.

4. **Airtightness**
Usually the most cost effective physical measure to reduce energy use in a building is the airtightness of the building envelope. Infiltration and energy losses due to leaks in the building envelope can account for up to 30% of energy losses in temperate and northern climates. Each building should ideally undergo a blower door test as part of the Baseline Assessment to establish the degree of airtightness and to identify the leaks in the envelope which need to be sealed. Airtightness should never be considered separately from ventilation as the two concepts are inextricably linked.

5. **Ventilation**
A building that is retrofitted is usually made more airtight in the process and therefore needs its ventilation to be carefully reconsidered as part of the retrofit process. An airtight building has less air leaking in and out of the building and this reduces the air change or ventilation rate to the point where the indoor air quality can be negatively affected. Many buildings do not have designed ventilation systems and rely on a natural ventilation strategy using permanent vents, trickle vents and openable windows deployed according to common practice in the industry, minimum standards and ‘rules of thumb’. While these may have been adequate when the buildings were originally built, changes in the way we use buildings has increased the ventilation ‘load’ over time.

The successful operation of a building’s ventilation system is very important in achieving a high standard of IAQ and energy efficiency. ‘Retro-commissioning’ (RCx)\(^2\) is the application of the commissioning process to the HVAC services and controls in an existing building. Retro-commissioning is a cost-effective retrofit measure which addresses the importance of the HVAC systems in a building in creating and maintaining the IAQ while optimizing the energy efficiency of the systems.

7. **Exposed Thermal Mass**
Exposing the thermal mass of a building allows heat to be absorbed by the thermal mass which releases it slowly when internal temperatures are lowered. Thermal mass can balance minimise temperature changes as its ‘thermal flywheel’ effect stores energy while internal conditions change. Internal heat gains during the day can be absorbed and the heat dissipated during the night when the heating is off. In summer ‘night time cooling ventilation’ can remove the heat absorbed during the day and significantly reduce the cooling load and energy use. It can also reduce the peak daytime temperatures and improve comfort levels. This can sometimes be

achieved in existing buildings during retrofitting / refurbishment by removing ceilings and other interventions which may have been installed during the life of the building.

8. **Insulation**
Insulating a building seems the most obvious thing to do when retrofitting a building to increase energy efficiency. However a successful and effective retrofit project will have identified priorities for the most cost effective measures and insulating the external envelope is sometimes not the most cost effective measure. It is more cost effective to insulate the roof and floor before the walls.

9. **Thermal Bridging**
Thermal bridging or ‘cold bridging’ has a significant impact on overall heat loss as the general level of insulation in the external envelope increases. Linear thermal bridging analysis is required by the Passivhaus Institute and recently by the Irish and UK Building Regulations to demonstrate compliance with minimum standards. Reducing thermal bridging reduces heat losses, increases the internal surface temperatures and minimises the risks of internal condensation which can lead to mould growth.

10. **Windows and Glazing**
Windows and glazing systems are very expensive and usually one of the least cost–effective retrofit measures so a careful analysis of the condition and performance of the windows should be undertaken before deciding to replace them.
If they are being retrofitted then either new high performance windows or a retrofit glazing systems should be used. The windows frames should be made airtight to the adjacent construction by sealing with tapes and mastic with a proprietary airtightness sealing system.

11. **Lighting**
Reduce the energy used by lighting in the building. In non-residential buildings lighting typically accounts for about 30% of energy use and significant reductions can usually be achieved. Install energy efficient lighting in the building by replacing luminaries with the latest high efficiency type suitable for the rooms and spaces. In complex buildings install lighting control and management systems with a default to ‘off’.

12. **Fans and Pumps**
Reduce energy use in the electric motors of all appliances, the HVAC and pumped water systems of the building. The VSD will vary the motor speed to meet demand so the motors will not be generating as much sound for most of the time. The reduction of fan speeds in ventilation systems can reduce the noise they produce.
All electric motors for fans and pumps can be replaced with high efficiency ECM (brushless DC electronically commutated motors) motors fitted with solid state variable speed drives (VSD’s) to minimise energy use. The VSD’s need to be properly commissioned and integrated with the BMS system to achieve optimal performance.

13. **Electrical Equipment**
Install a system for automatically switching off electrical equipment and appliances with a management ‘champion’, presence detection, a timing programmer or a wireless automation and control system to prevent the common practice of leaving equipment on, or in ‘sleep mode’, all the time. Implement a policy to only buy the most energy efficient equipment on the market. Instal a voltage optimization system for the building to make the most efficient use of the local grid’s voltage variability.

14. Renewable Energy
Install renewable energy systems appropriate to the building, its location and local environment. Renewable energy systems can often be most cost effectively added to a building during a retrofit process as the installation costs can be integrated with other works.

15. Soft Landings Handover Process
The ‘Soft Landings Framework’\(^3\) has been developed in the UK to bridge the gap between building construction and building operations. The building industry is organised to deliver completed buildings but is not involved in the operations of the building. Occupants of buildings have no contact with the design team who never have the opportunity to explain to the occupants how they intended the building should be used and how the design works. The commissioning of the services at the end of the construction process is completed with an empty building still drying out from wet concrete, plaster and paint. There are often many problems during the handover process when the occupants move in to a new or newly retrofitted or refurbished building.

The Soft Landings Framework was developed by BSRIA\(^4\) (The Building Services Research and Information Association), the Usable Buildings Trust\(^5\) and architect Mark Wray. The framework provides guidance and a methodology for bridging the gap between the construction stages of a building and the occupancy and operations stages of a buildings life. A retrofit of a building can create the same problems as new construction and the Soft Landings strategies can be as useful and effective in a retrofit. The Soft Landings Framework is a necessary retrofit measure for a successful retrofit project or programme.

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\(^3\) [www.softlandings.org.uk](http://www.softlandings.org.uk)

\(^4\) [www.bsria.co.uk](http://www.bsria.co.uk)

\(^5\) [www.usablebuildings.co.uk](http://www.usablebuildings.co.uk)
5 Ongoing Actions

As noted at 3.1 above, ‘It is foreseen – in the essential interests of the ongoing 2012 to 2016 programme of EFFESUS – that the ‘work in progress’ nature of this present exercise will serve as the basis for a progressive accumulation of ‘best practices’ in the repository that will provide a point of continuous reference for the project. Simultaneously, this should inform our “… expectations and standards within the compass of EFFESUS’.”
6 Conclusion and Recommendations

6.1 Conclusion

‘Best practice’ is a targeted outcome of EFFESUS rather than pre-existing.

At this time there is no established European framework against which good practices in the energy efficiency and renewable energy fields may be assessed and recognised against compatibility with heritage values and conservation principles. ‘Recognised as good practices’ is therefore a problematic area to extrapolate and critique at this stage in the EFFESUS project.

Notwithstanding, Work Task 2.3 has succeeded in the objective of collecting a range of examples with which to inform the ongoing EFFESUS research project.

6.2 Recommendations

During the course of the project EFFESUS should formulate and articulate a coherent set of expectations and standards for ‘best practice’ to coincide energy efficiency and renewable energy retrofit measures with heritage values and conservation principles.

Deliverable 2.3 should be regarded as ‘work in progress’ that will serve as the basis for a progressive and continuous accumulation of ‘best practices’ in the EFFESUS repository. This cumulative repository may provide the data base for identifying cost-benefit indicators at a later stage in the EFFESUS project.
7 Other References

Here below a list of references used for the development of the whole document.