Cash
Cities Action for Sustainable Housing

Technological Development

Mini Guide no.1 / June 2011

- What to do?
- Which technology to use?
- Which energy-efficient renovation approach to adopt?
- Is certification needed?
- Is labelling important?

Cash is a European URBACT II project around a network of 10 cities and 1 region from 9 countries: Bridgend-UK, Brindisi-IT, Rhône Alpes Regional Council-FR, Echirolles-FR, Frankfurt-DE, Les Mureaux-FR, Eordea-EL, Tatabanya-HU, Utrecht-NL, Yambol-BG. Its ambition: to propose new solutions and promote new policies in the European Union for the energy-efficient renovation of social housing.

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CONTENT

INTRODUCTION & PURPOSE

A network of 11 European urban and region partners involved in the European URBACT **“Cities Action for Sustainable Housing – CASH”** project, through the lead of Echirolles city (France), is working on issues of energy efficiency (EE) and sustainable renovation of social housing. In the project, the aspects of technological development, legal framework, financial engineering, citizen involvement, energy production and project engineering are being analysed during thematic seminars. Each leads to the production of a mini-guide presenting the state of the art on the subject, key issues, advice with associated experiences in partner cities and sources of information.
This edition, covering the theme of **technological development** is the 1st in a series of 6 mini-guides.

Which technology to use? Which renovation approach to adopt? Is certification needed? Is labelling important?

This Mini Guide on Technological Development helps pinpoint: the key elements to focus on (heating systems, insulation, glazing, ventilation…) when renovating, as well as the renovation type and the approaches, all issues tackled by the European directive *2010/31 EU* on the energy performance of buildings.
Its purpose is to give practical support to cities interested in identifying effective measures to enhance energy performance of existing housing stock.

OVERVIEW

The central objective of this overview of main **technological development and techniques** is to provide local communities with key elements to consider and choices to make when planning energy renovation.
It will cover:

- the envelope of the building and the envelope air-tightness;
- the technical installations;
- energy production and transformation;
- monitoring.

The envelope of the building

Energy-efficient (EE) material and appliances for walls, roofs, ceilings and windows, are synthesized hereafter:

→ Wall

• The effective insulation or inertia is key. Most common is the **insulation of the outer walls**. Insulation panels are typically made of polystyrene foam, but mineral fibre has much better fire protection values (compulsory for high rise buildings). Natural insulation products, such as cellulose flakes, wood fibre mats, hemp, sheep's wool, etc., do not underperform when compared to man-made ones. Instead they are often far better in terms of performance, durability, in addition to providing health benefits. Furthermore, they present a lower carbon footprint and grey energy and provide characteristics which offer protection from the cold during winter and optimum heat protection during summer. In presence of cavity walls, cavity can be filled with insulation material as perlite. **The new trend** is to fill the insulation material cavities with gas (e.g. CO_2) or vacuum. However this technology has yet to be proofed: uncertainty of maintaining the vacuum over time exists, insulation cannot be punched and vapour migration over the aluminium cover is still an unknown factor. With regard to Silica-aerogel based insulation, it is only available in semi-transparent glazing.

• **Ventilated curtain wall** is an alternative to thermal insulation panels. It consists of a sub-structure (wood or aluminium profiles) attached to the outer wall, with insulation material inserted in between and an air gap remaining for ventilation between insulation. This technique helps prevent moisture and mold.

• **Internal insulation** offers an alternative for houses with facades worth preserving and is less expensive than external insulation. Its disadvantages: it reduces residential area, it often requires occupants to move temporally and it carries an additional risk of moisture problems.

• **The new trend** is the use of **"Ultra-light-weight aerated concrete"**. In addition to having low thermal conductivity, this material is also hygroscopic (moisture buffer) and has low water vapour resistance.

While performing wall insulation, it is fundamental to control moisture balance and condensation in walls. Since the impact of thermal insulation on water vapour dissemination is low, vapour diffusion retarders available as membranes or coating are used. They reduce the rate at which water vapour can move through the building envelope and prevent air leakage through the envelope. Multiple layers of paint in existing housing units already act as vapour diffusion retarders.

→ Roof

The roof is the most exposed to environmental influences. For individual houses it is the first criterion to be considered. High insulation thicknesses are highly recommended. In addition, special importance has to be given to high air-tightness
otherwise this can lead to moisture damage, especially in wood construction.

→ Top floor ceiling

For the insulation of the top ceiling, insulation boards (mineral wool, foam...) or beds (perlite, cellulose) are possible. The insulation is placed on the ceiling and/or between existing beams. To prevent cold air flow around the insulating material, joints must be avoided and insulation boards should be laid with staggered joints. For uneven surfaces with many penetrations, perlite or cellulose-flake bedding may be used.
Green roof installation can reduce cooling loads on a building by 50% or more, but it needs to be correctly built in order to avoid water leakage and material degradation and their maintenance cost has to be integrated.

→ Basement ceiling

To reduce the heat loss from the basement, insulating plates can be attached to the basement ceiling. For uneven or vaulted basement ceilings, airtight cloths can be attached acting as air chambers to form a natural insulation layer.

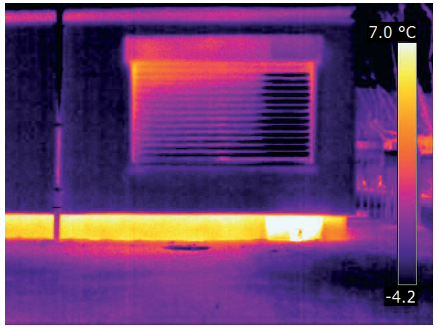
→ Windows

Modern windows with heat-resistant glazing offer a significant reduction in heat loss (about 40 to 70%). This is achieved by an invisible metallic layer (keeping heat inside) and an inert gas filling between the panes.
Three-pane insulating glazing (Ug = 0,5 to 0,6 W/m²K) is available on the market, offering additional heat loss reduction of 30% compared to the **two-pane windows** and is becoming widely used. Its prices varies and can increase considerably the budget of a renovation operation.
Not only should the U-value of the glazing be known, but also that of the entire window influenced by the **quality of the frame.** Highly insulated frame exist, such as the passive house window. If the window frame is covered with insulation up to 2 to 4 cm, an installation nearly free of thermal bridges is guaranteed.

The new trend is **double vacuum glazing** (Ug = 1,4 W/m²K), but it is still very expensive.

Envelope air-tightness

Attention should be paid to achieving a good balance between energy efficiency (air-tightness and air renewal) and sanitary conditions.
Air-tightness (air permeability or leakage rate) of the envelope is an essential issue to keep in mind. Controlling infiltrations from: joinery-wall, joinery-floor and roof-wall junctions, as well as from expansion joints, sheaths, evacuations, electrical conduit, traps, rolling shutter, etc., must be ensured, knowing that they can generate up to 50% overconsumption of heating in well-insulated housing units. It is critical that any tape and sealant used should remain a high flexibility over time to ensure it copes with differential movement and resists high and low temperatures over the lifetime of the building. It should, as well, perform under high humidity conditions.



Top left in orange indicating infiltration from rolling shutter after insulation, Echirolles, France.

Technical installations

→ Ventilation

Central mechanical ventilation uses a ventilator, moving the air from the most burdened rooms (kitchen, bathroom and toilet) via a pipe system to the exhaust. The result is a slight negative pressure in the building, which causes filtered outside air to stream, via supply valves in the outer wall, to living areas. Energy savings can be gained by the choice of ventilator, the exhaust grill and by demand controlled or CO_2 controlled exhaust.
Hygro-adjustable ventilation and **double flux** ventilation are the most commonly used ventilation systems and are widely available. The first allows energy savings through the reduction of airflow (0,3 vol/h) but without control on indoor air quality (its reduced flow requires the use of indoor materials free of volatile organic compounds and formaldehyde). The second allows energy savings without reducing airflow (0,54 vol/h) through heat recovery from extracted air.
New solutions are oriented toward **small decentralized devices**, with simultaneous or alternated blowing and air extraction providing ventilation for a single room. They can be integrated in windows without requiring any ventilation network hard to be installed in existing housing units. These are not yet

widely available.

Energy production and transformation

Several independent energy supply units exist that can be installed at building and house scales for heating and for domestic hot water (DHW).

→ Heating

Biomass heating

Biomass is a renewable low carbon fuel, producing a fraction of the carbon emissions of fossil fuels if correctly managed. A wide range of **biomass fuels** can be used: virgin wood, energy crops, agricultural, food and industrial residues. Most widespread for small scale heating systems are wood pellets and chips from round wood. Several types of **biomass heating systems** exist, the most common being **stoves**, available from room heaters of 1.5 kW up to around 12kW, and **boilers** > 25kW. Biomass-fired boilers can be integrated into existing heating systems, and are therefore a real alternative in renovation projects if adequately selected (high performance and low particle emission).

Condensing boilers

Condensing boilers are a further development of the low-temperature boilers. They are the most energy-efficient boilers since they use two heat exchangers: one taking the water vapour (hot gasses) produced from burning the hydrogen content of the fuel to heat the water flowing back from radiators into the condensing boiler, one capturing the heat from the condensation process during the cooling of the water vapour which condenses into liquid water. The effectiveness of this condensing process depends on the temperature of the water flowing back to the boiler. System design and installation are key (longer chain of distribution resulting in cooler water). Since the condensation boiler is a low temperature device, it is recommended by Decrees in many European countries in case of renovation / reconstruction.

Passive and active solar space heating systems

These solar heating systems with air heat collectors (glazed or unglazed) or with liquid collectors, can be > 25 times more cost-effective than solar electric systems. Evacuated tube solar collectors mounted on the roof or on another structure should have a high performance so that high temperatures can be achieved even with cold outdoor conditions.

Electric heat pumps

A heat pump can provide heating or cooling, moving heat from ‘a natural source’ - at the highest temperature (outside air, soil, groundwater, water body, with constant temperature from 5-10°C), to a ‘heat sink’ - at the lowest temperature. To maintain this thermodynamic cycle, the heat pump needs electricity from an electric or gas engine, or from renewable resources. Most cost-effective are air / water heat pumps, but these bivalent systems are less efficient. Air source heat pumps are the least efficient but can still be used in low energy consumption dwellings. They have the disadvantage of high outside temperature differential which leads to lower efficiency. Geothermal heat pumps, since they draw heat from the ground or groundwater which is at a relatively constant temperature all year round, have typically higher efficiency but are more expensive since they require excavation. A performance coefficient of COP > 4 should be selected (for 1kWh of electricity consumed, 4 kWh of heat is produced). The most efficient systems have a COP of 7. Their capacity has to match heating and cooling demand without being undersized (risk of inadequate cooling) or oversized (risk of inappropriate dehumidification). Most heat pumps need an additional heat source to cover peak consumption (cold days, etc.). Intelligent heat pumps (such as Syd Energi units installed in Sonderborg, Denmark) with a control unit collecting weather data, household consumption and electricity prices, produce heat when prices are low and provide heat through their heat-storage device, at peak consumption.

Co-generation units - Combined Heat and Power (CHP)

Cogeneration units (Combined Heat Power - CHP) generate heat and electricity simultaneously, the heat resulting from the production of electricity or the reverse. This decentralised energy production system avoids transportation and reduces the carbon footprint. CHP saves more than 30% primary energy and CO_2 compared to a separate production of heat and power. Different solutions exist from micro CHP (<36 electrical kW, 1-5 electrical kW) for single family houses, 50 electrical kW for housing blocks and up to

Micro CHP, source CASH – Utrecht, Netherlands.

Cogen motor 5 electrical kW SENERTEC ‘Dachs’ machine, Frankfurt, Germany.

50 electrical kW motor managed by social home owners association Rödelheim, Frankfurt, Germany.

CHP motor 611 electrical kW, 800 thermal kW power gas engine for district heating network, Sossenheim, Frankfurt, Germany.

several 100-1000 electrical kW district heating nets for social housing districts. CHP units work mostly on natural gas but a wide range of biomass fuels can be used (biogas, wood, sewage sludge…), their system being designed to accept high moisture content material. It is to be noted that CHP is most suitable when there is year round demand for heat to balance the demand for electricity.

District heating

More and more social landlords and owners adopt district heating. In the city of Echirolles (France), it heats more than 75% of social housing units. This system distributes hot water (or steam) to connected buildings and individual houses, through highly insulated flow and return pipes and a heat exchanger (substation) within each building. The heat is often obtained from a cogeneration plant burning fossil fuels (oil / natural gas) or biomass, although single boiler installation, or geothermal heating or central solar heating can also be used. District heating avoids costs of energy when based on biomass or renewable energy sources and reduces investments in household or building heating equipment. However, it requires important initial investments, thus being less attractive for areas with low population. With **CHP, district heating has the lowest carbon footprint of any heating system.** In itself, district heating is approximately 30% more efficient. However, ownership monopoly issues should be taken into account.

District heating Cie., Grenoble, France.

District heating substation, Grenoble, France.

→ Domestic hot water (DHW)

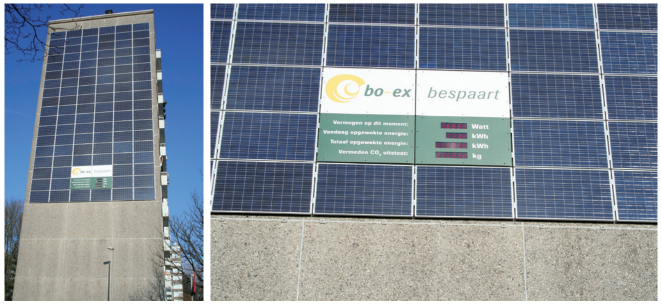
Solar Water Heating systems (SWH)

They can cover up to 2/3 of the hot domestic water heating. Simple devices with a storage tank mounted above solar collectors on the roof ('closed-coupled' SWH) exist. Others have ground or floor assembled storage tanks. In winter there may sometimes not be sufficient solar heat gain in order to deliver enough hot water. The performance of an SWH system may be defined by its solar fraction (corresponding to the fraction of a building's water heating energy demand to be met) which depends on the solar characteristic of the system, but also on the water-use pattern and on the solar resource.

Heat pump using exhaust air

An integrated hot water heat pump which actively uses up to 70% of the energy from exhaust air (from ventilation systems) to ensure central domestic hot water preparation all year round, independent of the existing heating system.

Solar water heating system, Echirolles, France.



Solar water heating system, Utrecht, The Netherlands.

Monitoring

Monitoring devices (i.e. individual meters, check meters, master meters and digital smart meters) are necessary to measure the impact of renovation on energy consumption, to evaluate the effect of each new technological and technical implementation, to identify possible malfunctions and to get knowledge on the behaviour of the occupants in order to promote energy conservation measures and to maintain the energy performance of the housing unit. However, instrumentation should be easy to use, an energy baseline should be available, data must be reliably recorded and stored, measurement duration should be adapted to the monitoring objective and sample size and structure should be representative,
Feedback of metering results should be fast, clear and understandable, enabling action and directly translate into costs related to the energy bill. Clear communication is needed.

Some tips for choosing energy systems and technological aspects

- Carry out a survey on the heat energy demand (heating and domestic hot water DHW).
- Look for potentials of reducing demand (through insulation, water saving devices…).
- Make a comparison calculation of different heating systems (only boiler, boiler and CHP, heat pump, biomass heating systems -stoves, boilers…-, district heating), comparing not only acquisition, installation and maintenance costs, but fuel dependency and emissions (CO_2 and others) - keeping in mind that prices for different fuels may develop differently in the future.
- Make a long term 15-20 year calculation.

To avoid ad-hoc decision making, Social landlords and house owners should make a structural renovation plan, where technical, social and economic aspects as well as environmental aspects play a role. The grey (hidden) energy, including the energy required in transporting and in recycling the different materials / technology at the end of their life cycle, should be taken into account in their selection.

KEY ISSUES DISCUSSED BETWEEN CASH PARTNERS

Certification of materials and of buildings, aspects of **energy performance labels**, as well as **renovation approaches,** were the key issues discussed during the CASH thematic seminar on technological developments held in Utrecht in January 2011. Here are the main factors identified:

Certification

→ Certification of materials

Even though the environmental aspects of products do not yet play a key role in the certification process of the European Organisation for Technical Approval, specialized databases of validated and **labelled building materials** based on Life Cycle Analyses (carbon emission and energy used during material production, transportation, recycling...) exist. Not all national validations return to the same results, depending on the assumptions made in the calculations and on differences made on how the materials are being used or applied. In the Netherlands a national calculation system is being developed, bringing at least seven other systems together.

→ Certification of buildings

Certification of the building demonstrates its commitment to energy efficiency, site sustainability and indoor environmental quality. It is **not mandatory but provides an opportunity to ensure that specific energy efficiency (EE) targets are met.** There is not one standard European certification tool but several national **certification tools**. Some propose integrated calculation methodology including all the EE aspects, such as heating, technological cooling and lighting installations, position and orientation of the building, heat recovery, etc., and not just the degree of the building's technical insulation. Some used in the countries of the CASH network are presented hereafter:

GPR Building
"GPR Building" is a performance based tool developed by the municipality of Tilburg and W/E Consultants in the **Netherlands**. The aim of this quick and easy-to-use software is to raise building quality and reduce the environmental load of buildings, using five indicators: Energy, Environment, Health, User Quality, and Long Term Value. It permits to visualize the effect of each measure on the sustainability and gives achieved CO_2 reduction. At the moment "GPR Building" is being extended so that it can be used internationally.

ITACA Protocol
The ITACA Institute (Federal Association of Italian Regions) in **Italy**, developed the ITACA Protocol as a tool for the certification of the **residential public building.** Indicators used are: Site, Consumption of resources, Environmental loads, Environmental indoor quality, Quality of the service and Socio - economic aspects. It helps provide a common baseline for all stakeholders (property owners, builders, designers and operators of the sector). While the ITACA Protocol defines the strategic guidelines and supervises the certification system, regions and provinces should define their own procedures of certification and accreditation systems and issue the certificates.

Passive House Planning Package PHPP
Calculating the energy balance of **buildings with very low energy consumption** is a demanding task - existing regulations, standards and pre-standards lack the required precision. The method developed by Passivhaus Institut in Darmstadt **Germany** is the most widely accepted method in Europe for calculating the design process for passive house renovation.

Energy performance labels

Under the European Directive on Energy performance of Buildings (2002/91/EC) to achieve energy performance in buildings, *Member States* are responsible for: setting the **minimum standards as regards the energy performance** of new and existing buildings.
To meet their *commitment* and promote the achievement of high energy performance levels, countries have developed a series of **energy performance labels (EPL).** In the absence of European standards, they have developed their own national standards which are not directly comparable. This is because countries aggregate different components in the building's total allowed energy budget (i.e. some countries ignore domestic hot water, equipment, lighting, or fans), they control different stages of the energy chain (e.g. net energy demand, delivered energy or primary energy) and have divergent assumptions on system efficiencies (e.g. boilers) and primary energy factors. Moreover, areas and volumes are calculated in different ways in different countries, which complicates simple comparison of requirements that are normalized in relation to floor area or facade areas, such as energy use [kWh/m².year] or air-tightness. Also, the climate conditions in different countries and regions are different.
Some European examples of EPL, based on reducing the long term consumption of the buildings, are:

• **Passivhaus**, in **Germany**, with less than 15 kWh/m².year of energy consumption for heating and the same for cooling,

• Low Energy Consumption Building **(BBC)**, in **France**, for buildings with primary energy consumption of 50 kWh/m².year (level A) for new building and of 80 kWh/m².year for renovated buildings or **Effinergie** integrating the concept of airtightness.

Initiatives such as the European EPLabel project proposes to harmonize this framework in public buildings across Europe. Whereas the level of Passivhaus is achievable in renovation, the question of impacts on the way of living due to building air-tightness constraint should be raised.

Renovation approach

Which EE renovation targets should be achieved by social landlords or co-properties or private owners and **what should the approach be**: global or step-by-step? While **minimum performances are advocated by the European Directive, specific targets to be achieved through renovation vary from country to country** and are defined by their legal frameworks which will be presented in the **second CASH mini-guide.**
Regarding the approach, the answers from CASH partners vary:

• **Tatabanya (Hungary)**, favours achieving the best available and most complete building energy refurbishment rather than proceeding to a renovation reaching minimum requirements, since these energy operations are long-term interventions and most often the unexecuted works are never achieved later on.

• **Rhône-Alpes Regional Council (France),** has developed (with key stakeholders) a 'step-by-step' approach for Rhône-Alpes region which concentrates on the means (work package) more than on the goals. This progressive approach, not focusing on reaching 'BBC renovation level' immediately but remaining compatible with it, allows social landlords to invest in renovation operations even if they do not have the financial means to reach high targets.

• **Echirolles (France),** until now has favoured the global approach with renovation integrating all the elements of the envelope, the energy production and the technical installations (e.g.: recent 'Village 2' district rehabilitation program with new and renovated buildings at BBC levels). However, given the present difficult financial context, the assets of a step-by-step approach are being discussed in the frame of Echirolles – URBACT CASH Local Action Plan.

'La Bruyère' BBC level, renovation OPATB program, Echirolles, France.

EXAMPLES FROM PARTNERS

Renovation approach: Rhône-Alpes regional council energy renovation plan for social housing

Starting with the challenge of national EE targets set in the new French Environment bill ‘Grenelle 2’, of 80 000 renovations by 2020 in the Rhône-Alpes region with an energy consumption performance level <150kWh/m²/year), CASH partner Rhône-Alpes Regional Council (RARC) has adopted an ambitious **regional energy renovation plan in favour of social housing,** both public and private, for the 2011-2013 period. This plan, built around the regional partnership between RARC, the French Agency for Energy and Environment Management (ADEME) and the regional association of social housing organizations (ARRA-HLM), will provide technical assistance and financial support to public social landlords and co-properties.

Objectives of this plan are to generalize the target of high energy performance and to develop a project management integrating a multi-criteria approach (architecture, ventilation, comfort, eco-materials, etc.). Energy requirements have been set up so that **flexibility and capacity of adaptation are guaranteed to operators.** There are thus 2 approaches sharing the common goal of a minimum energy saving of 35%:

1. a “step-by-step” approach reaching at least a level <150kWH/m²/year, based on technical solutions or “work packages” compatible with low-energy buildings standard (BBC level <80kWh/m²/year), which will not kill future energy saving potential. Priority is given to the envelope/shell (a minimum of two actions), with safeguards to satisfy (e.g. minimum thermal resistance) and some technical consistency to respect (e.g. mandatory intervention on ventilation if the works programme implies replacement of windows);

2. a global approach reaching the BBC low-energy consumption level (<80 kWh/m²/year) and obtaining the French label BBC Effinergie Renovation.
It is a **progressive plan,** with a pilot operation during the first year (2011), on which basis the activities for the next two years will be revised and optimised.
The Rhône-Alpes example shows that high goals can lead to **new ways of working** and the development and **implementation of new technologies.**
For more information on technical requirements, see www.logementsocialdurable.fr

Decision-making tool: renovation in a portfolio strategy - Mitros

The Dutch housing corporation Mitros uses a **decision model** for its housing stock, **based on return on investment** from EE renovation. The principal goal is not to minimize the costs, but to try to raise the value of the housing stock. Next to the market value of the houses, it is also the value for renting them out and the value for the quality of living (‘social return’). Return on investment gained through increased life span and value of the house, is a management criterion too. The returns from renovation can be summarized as follow:

Returns for tenant:
lower ‘cost of accommodation’
better climate (health)
more comfort/safety (well-being)
Returns for the house owner:
extension of exploitation (direct + indirect)
increase in rent (direct)
lower risk of future utilization (direct)
value increase (indirect)

Making such future-oriented calculations **urges house owners, tenants and landlords, to search for the latest techniques and technologies** for energy renovation. With such a model, a rational decision can be made between “Continuation of Utilization”, “Disposition”, “Renovation” or “Demolition / rebuilding”.

Shared energy skill center - Les Mureaux

The city of Les Mureaux plans to set up a special energy training facility for craftsmen.
The city has identified a shared interest with several training / research organizations in the sector for a **common technical platform.** The project partners wish to realize a new building with the newest energy-efficiency technologies so that the **technical solutions of the building or equipment can be used for educational purposes and training**. The building is planned for realisation in 2014.

2nd conference on Energy efficiency, Les Mureaux, France, May 2011.

CONCLUSION

Technological possibilities for energy-efficient renovation are developing fast. Availability of techniques is not a guarantee that they will always be used in the best and most effective way. To cope with this rapidly evolving environment and with this constraint, it is recommended to pay special attention to the labels and types of equipment and materials, as well as to the installation techniques, in particular for heritage buildings. Certification can be a guide to make the appropriate choices. The renovation approach, whether global or step-by-step, is also a major issue. Many stakeholders, in particular communities and social landlords, often ask themselves if they should act on a limited number of buildings to achieve expected EE renovation targets (80 kWh/m².year) or if they should intervene on only a few components (i.e. insulation and glazing or energy supply and equipment, etc.) over a large number of buildings. Careful decision should be taken to keep in line with the municipal energy reduction goals, available financial resources, other obligations to fulfil, as well as the time lag between major renovation operations (average of 20 to 30 years). Moreover, a renovation plan, aside from including the choice of approach, target, energy sources, technical installations, devices and their adequate sizing, requires the implication of stakeholders throughout the process, in particular the tenants, in order to optimize usages and energy efficiency (integrated participative design process). This subject will be covered in one of the following five CASH mini-guides, as well as legal framework, financial engineering, energy production and EE project management.

1-3 Market Street, Bridgend Townscape Heritage Initiative Scheme (BTHIS), Bridgend, UK.

8-10 and 12 Durnaven Place, BTHIS with historical architectural details reinstated (Sash windows, slate roofs, stone detailing...), Bridgend, UK.

LEARN MORE

GENERAL

The CASH website with all presentations of the Thematic seminar in Utrecht: http://urbact.eu/cash

STATE OF THE ART

Main reference used for the overview of technologies for housing renovation:

• Energieeffizienz im Wohngebäudebestand; Techniken, Potenziale, Kosten und Wirtschaftlichkeit; Institut Wohnen und Umwelt.

http://www.iwu.de/fileadmin/user_upload/dateien/energie/klima_altbau/IWU_QBer_EnEff_Wohngeb_Nov2007.pdf

• W/E Advisers' presentation: "Energy saving technology, state of the art" on CASH Website.

• La rénovation à très basse consommation d'énergie des bâtiments existants. Olivier Sidler, France, 120 p., 2010.

FURTHER WEBSITE SOURCES

www.institut-negawatt.com

www.lowenergyhouse.com (England)

www.kliba-heidelberg.de/publikationen_oekobaufibel.html (Germany)

www.pro.baubook.at; www.sev.nl

http://ec.europa.eu/environment/ecolabel/ (all about eco-labels)

www.ecologicalbuildingsystems.com

www.gprgebouw.nl

www.passiv.de

www.asiepi.eu or www.buildup.eu (ASIEPI EP: Comparing Energy Performance Requirements over Europe: Tool and Method, 2010)

www.norme-bbc.fr (French norms and Grenelle bill)

www.frankfurt.de/sixcms/detail.php?id=3076&_ffmpar[_id_inhalt]=102231

Leitfaden: „Energetische Sanierung von Gründerzeitgebäuden in Frankfurt“; Herausgeber: Stadt Frankfurt am Main, Energiereferat.

http://ecocitoyens.ademe.fr/

www.logementsocialdurable.fr

www.energiaklub.hu (Hungarian climate policy institute. Energiaklub concentrates on energy efficiency, renewable resources, climate protection, energy policy.)

www.lakcimke.hu (A Hungarian on-line and downloadable publication for owners about energy performance certificate of buildings, energy efficiency interventions and renewable energy sources.)

Social housing renovation, Robijnhof, Utrecht, Netherlands.

Social housing renovation with small scale CHP, Tuinwijk, Utrecht, Netherlands.

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