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Instrument: **MED Programme**

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Objective 1.1: Dissemination of innovative technologies and know-how

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Phase 2: "Transnational benchmark analysis of policy instruments and measures to support IRH"

Deliverable:

TRANSNATIONAL INVENTORY OF TECHNOLOGIES

Coordinating partner: CRES (Centre for Renewable Energy Sources and Saving)

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A. OBJECTIVES, APPROACH AND METHODOLOGY

1. OBJECTIVES

This report presents the deliverable “Transnational Inventory of Technologies” (IT), of Component 3 of the IRH-Med project (‘Convergence of strategies to support innovative models for residential housing in the Mediterranean’), Phase 2 (“Transnational Benchmark Analysis of Policy Instruments and Measures to support IRH”).

The general objective of the Transnational Inventory of Technologies (IT) is to briefly present a range of technologies and materials which, if applied, can reduce significantly the environmental impact of new and existing Mediterranean residential buildings. However, the principles for many of these technologies can also be applied to a wide range of building types. The technologies presented are adaptable to the natural resources available in the Med region and can create comfortable and healthy environments for the occupants.

More specifically the objectives are:

- To supplement the IRH Guidelines and grid in the promotion of high quality housing in the Mediterranean
- To serve as a stand-alone database with practical information useful for both building owners and professionals
- To highlight any differences in building practices between the participating countries

2. APPROACH AND METHODOLOGY

The Inventory is structured based on the 7 thematic areas of the IRH-Med rating grid:

- Territory and Site
- Materials
- Energy
- Water
- Health and Comfort
- Social
- Economy and Management

The materials and technologies presented in the IT were selected on the basis of a range of criteria, so as to establish a balance between low impact on the environment and practical / financial viability. These criteria include:

- adaptability to the Mediterranean climate characteristics
- reduction of a building's greenhouse emissions during its life cycle (construction phase, operation phase and end of life)
- origin of components from sustainable sources
- possibility to recycle components
- availability of local know-how on application / installation
- local production of components/ materials
- impact on the health & comfort of occupants
- low need for maintenance

The contents and format of the Inventory were determined through continuous communication between the partners, the Joint Working Group 4, as well as through the needs and conclusions that arose throughout the development of the Preliminary Joint Proposal and the IRH-MED guidelines.

For each technology or material presented, a short technical description is included explaining the basic principles and components. Information is also given on the function and application of each technology, its benefits and potential restrictions (if any), and the environmental indicators of the IRH-MED system which the use of the technology addresses.

The last section of the report provides a brief review and classification of the technologies assessed, in accordance with their applicability to different types of residential projects (new build/extensions/refurbishments) and their main environmental benefits.

B. INVENTORY OF TECHNOLOGIES AND MATERIALS

1. TERRITORY AND SITE

1.1 DROUGHT-RESISTANT PLANTS

Area:	**Indicator:**	**Adequate for:**	
Territory & site	- % Use of Mediterranean vegetation - % Surface dedicated to Mediterranean gardening	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Water demand		

Function

"Drought-resistant" or "drought-tolerant" plants are plants that require minimal watering and can sustain significant periods of drought without suffering undue harm. The fundamental element of drought-resistant plants is water conservation. The most drought-resistant plants are usually the native plants of each area that have been adapted to the climate of the area.

Application

Drought-tolerant plants can be introduced in any green areas of the building and surrounding site, such as courtyards, balconies, terraces, green roofs etc.

Technical description

Drought-tolerant plants are usually characterised by having root systems that grow deeply into the soil to 'mine' for moisture in periods of drought. They often have grey-green or silver leaves that help to reflect the sun and sometimes have fine hairs helping them to trap moisture close to the plant. However, even drought-tolerant plants need watering after planting until their root systems become fully established.

Benefits

- Drought-resistant plants minimise the need for irrigation, thus conserving significant amount of water
- They are aesthetically attractive plants, with less time and cost required for their maintenance
- Using plants native to the area eliminates the need for chemical supplements. Sufficient nutrients are provided by healthy organic soil

Restrictions

- Wind can dry the soil and the plants. Natural windbreaks can be placed such as trees, hedges, shrubs, to protect the plants during the windiest time of the day.

1.2 GREEN ROOF

Area:	Indicator:	Adequate for:	
Territory & site	- Use of green roofs or roofs with a high solar reflection index (SRI) (% of total roof surface) - % Surface of permeable land - Use of wooded or shaded outdoor areas - % Use of Mediterranean vegetation - % Surface dedicated to Mediterranean gardening - Communal outdoors spaces	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand, flood risk, air pollution		

Function

Green roof, also known as *vegetated roof* or *eco-roof* is the roof of a building that is partially or completely covered with vegetation planted over a waterproofing membrane.

Green roof (extensive) on residential building, Athens, Greece

Application

Green roofs are appropriate for many types of buildings, such as residential, commercial, industrial, etc. They are best suited to flat roofs, however they may also apply to pitched roofs. They are mainly applicable to new housing, but can, if the structural design permits so, be retrofitted on existing roofs.

Technical description

There are two main categories of green roofs:

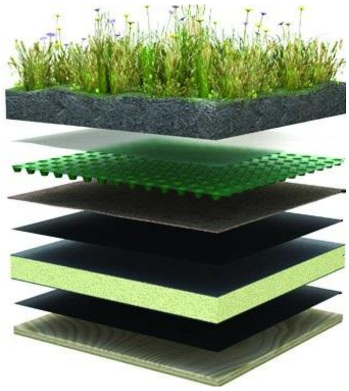
- Extensive

Growth media is less than 150mm in depth and requires minimal maintenance once the vegetation has become well established. The vegetation consists of low-growing plants and ideally native plants, those which are tolerant to drought and temperatures extremes, and have a strong horizontal root system but non-aggressive vertical root system. Extensive green roofs are an economical solution and the most common of the green roof systems.

- Intensive

Growth media is 200mm or more in depth. Intensive green roofs systems require substantial maintenance at regular intervals, including irrigation, mowing, fertilising and weeding.

A green roof typically consists of the following layers (external to internal):



1. Vegetation
2. Growing media
3. Root permeable layer
4. Drainage
5. Membrane protection and root barrier
6. Roofing membrane, insulation, waterproofing
7. Roof structure

Benefits

- Reduction of radiant temperature - moderation of urban heat island effect
- Improvement of microclimate / local air quality around the building
- Increase of the roof thermal mass, moderating peaks in internal temperatures in winter and summer, therefore saving energy for heating and cooling respectively
- Attenuation of storm water runoff, reducing the risk of flooding
- Aesthetic improvement / potential recreational outdoors space for residents
- Noise reduction
- Fire retardation
- Prolongation of the service life of roofing materials

Restrictions

- Higher capital cost than typical roof construction
- Careful selection of plants – emphasis on Mediterranean species
- Mainly applicable to new housing. Refurbishment on existing buildings requires careful consideration from a structural point of view, as the weight load of the substrate and vegetation may exceed the permitted static loading of the existing structure
- In large-scale buildings (e.g. apartment blocks), consideration would be required of the building services equipment which may be roof-mounted (e.g. solar collectors, ventilation units etc). A green roof would limit the space available for such uses, so careful integrated design from early stage would be essential.

1.3 PERMEABLE PAVING

Area:	**Indicator:**	**Adequate for:**	
Territory & site	- % Surface of permeable land	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Flood risk		

Function

Permeable paving includes a range of materials and techniques for paving hard external surfaces (roads, pavements, courtyards etc.) that allow the movement of water and air through the paving material. As an increasingly larger area in the built environment is covered by roads, pavements and buildings, the percentage of open ground is reduced and rainfall that would have been naturally absorbed and retained by the ground is diverted. Permeable paving is an important component in low environmental impact development and offers significant environmental advantages.

Application

Permeable paving can be applied to residential and commercial driveways, public parking lots and pedestrian paths, both in new built areas and existing built up areas, such as old town centres under redevelopment and reconstruction.

Technical description

There are two main types of permeable paving systems:

- Infiltration: surface water is directed via voids within areas of solid paving
    - Concrete block permeable paving

- Porous: water is drained directly through the surface
    - Cellular gravel-filled paving
    - Permeable resin bound surfacing

Benefits

- Permeable paving helps to increase the amount of storm water storage
- Reduction of drainage system cost
- Decrease of downstream flooding
- Control of erosion of riverbanks and streambeds
- Soil reinforcement and stabilisation
- Reduces the risk of pollutants reaching surface waters

Restrictions

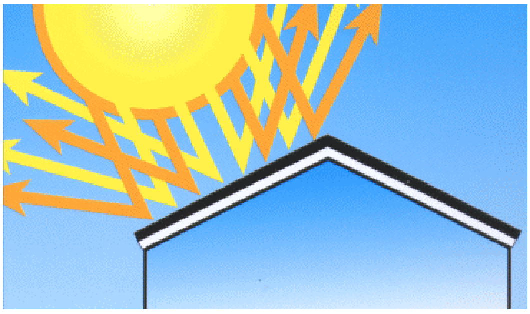
- In large storm events, the water table below the porous pavement can rise to higher levels preventing the precipitation from being absorbed into the ground
- Not applied in areas where pollutant concentrations are exceeded due to potential ground water contamination
- Inappropriate in areas of high traffic volume and weight
- Inappropriate where the surrounding land that drains through the permeable paving exceeds a 20% slope
- Inappropriate for cold climates

1.4 COOL MATERIALS

Area:	**Indicator:**	**Adequate for:**	
Territory & site	- Use of green roofs or roofing materials with a high solar reflection index (SRI) (% of total roof surface) - kWh/m^2/yr cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Cooling demand, urban heat island effect		
Favours:	Comfort		

Function

'Cool materials' are materials designed to reject solar radiation and keep surfaces cooler under the sun. This is due to the properties of the materials, which reflect solar radiation and release the heat they have absorbed. There are different types of cool materials, such as paints, membranes, asphalt shingles, coatings, tiles, etc.



In particular, cool roofing refers to use of highly reflective and emissive roofing materials. Reducing heat absorption and thermal emittance helps lowering peak summer temperatures of roof surfaces and surrounding air temperature. The local climate and site-specific factors (insulation levels, duct positioning, roof configuration) play an important role in the amount of savings achieved.

Application

Cool materials can be applied on the external envelope of buildings (homes, apartment blocks, commercial buildings etc), both new-built and refurbishments. Cool roofing materials consist of coatings and single-ply membranes on flat roofs, and reflecting pigments in materials for steep-roof coverings

Technical description

Increasing the reflectance and/or emittance of a building envelope material lowers the surface temperature, which decreases the heat penetrating into the building, as well as the temperature of the ambient air, as the heat convection intensity from a cooler surface is lower. During summer, this results in lower cooling loads for buildings which are air-conditioned, as well as in more comfortable indoor thermal conditions for non-air- conditioned buildings.

Regarding cool roofing materials, coatings (cementitious, elastomeric or combination) or single-ply membranes are applied on flat (low sloped) roofs on existing asphalt membrane, gravel or metal finishing. Coatings are surface treatments (thick paint) containing additives that improve adhesion, durability, suppression of algae and fungal growth, self-wash, etc. They achieve a solar reflectance of ~65% and a thermal emittance of ~80 to 90%. Elastomeric coatings provide a waterproofing membrane, while cementitious coatings are pervious and rely on the underlying roofing material for waterproofing. Cool single-ply membranes (synthetic rubber, polymer or thermoplastic material) are prefabricated sheets glued, heat-welded or mechanically fastened in place over the entire roof surface.

Steep-sloped roof coverings (asphalt shingles, metal roofing, concrete or clay tiles) can use reflecting pigments. Traditional clay tiles reflect 10-30% of solar radiation, and when containing pigments can reflect 25-70%. Metal roofing products use infrared-reflecting pigments and reach solar reflectances of 20 up to 90%.

Benefits

- Mitigation of the urban heat island effect
- Energy saving by reducing the peak cooling demand, thus reducing CO_2 emissions and air pollution
- Improvement of indoors thermal comfort

Restrictions

- The performance of the materials can diminish over time due to albedo degradation and soiling
- Reflecting solar energy in winter reduces solar gains which can increase heating demand and costs during cold winters. However in South Mediterranean climates, it is estimated that overall as an annual balance, cool materials offer energy savings

2. MATERIALS

Criteria to assess suitability of materials for Med areas

A good Med sustainable material should meet the following conditions:

a. Have the same functional qualities as a standard industrial material: solidity, fire behaviour, acoustics, regulations
b. Favour summer comfort
c. Reduce heating demand
d. Reduce consumption of raw materials
e. Reduce water consumption
f. Have low grey energy
g. Be produced locally

This primary basis led to choosing the 5 following materials which can cover most of the needs of a building: foundations, masonry, structure, insulation to walls and roof, frames.

Criteria	Local earth	Reused on site structural material	Local structural wood	Wood-based insulation	Wood frame (see other chapter for glass)
a. Same characteristics as standard materials	Y	Y	Y	Y	Y
b. Summer comfort	Y	Y	Yes and no	Y	Yes under conditions
b. Heating needs	No if alone	No if alone	No if alone	Y	Y
d. Reduction of raw materials	Y	Y	Y	Y	Y
e. Reduction of water	Y	Y	Y	Y	Y
f. Grey energy	Y	Y	Y	Y	Y
g. Locally produced	Y	Y	Yes under certain conditions	Yes under certain conditions	Yes under certain conditions

The above table is only one example of the kind of analysis that can be carried out. It can also be said that that the core part of the building should be massive and mineral, using, when possible, local ground or structural material found on site (stone, rubble, cob, concrete etc). On the other hand, the building skin should be light and vegetal, using non-agricultural materials such as wood.

2.1 LOCAL GROUND

Area:	**Indicator:**	**Adequate for:**	
Materials	- % Volume of local materials - % Volume of renewable materials - LCA / embodied energy including transport	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Materials LCA impacts (resources, energy, CO_2, water)		
Favours:	Comfort, local labour		

Function

Ground can be used as a load-bearing, filling or ornamental material. It can also be used for vegetated roofs.

Straw/clay walls construction, residence in Archanes (Crete), Greece

Application

Ground can be used in existing buildings, as a coating material or in the form of raw-ground-bricks. It can be used in any form for new buildings.

Technical description

Ground can be used in several states:

Rammed earth walls, EDEN Project, Cornwall, UK

- Pisé (rammed earth): ground and water are mixed and compacted in formwork. This technology is very similar to that of the concrete. Ground concrete is being tested by Craterre (Grenoble, France).
- Adobe / Compressed earth bricks: these bricks can be made in a factory or on site, with mechanical press, adding a small quantity of water and cement. They are then laid the same way as cement of fired bricks.
- Cob and coating: earth can be used as an exterior or interior coating material. It is mixed with lime, water, sand, straw and some adjuvants like liquid soap.
- Vegetated roof: ground is used to accumulate heat and to prevent roofs from being overheated by the sun.

Equivalents: Sand or loose gravel can share some similar uses to ground.

Benefits

- The raw material can be found anywhere underground, and at the end of its life returns to nature
- Ground has good sound and thermal insulation properties (heat barrier in the summer, inertia in the winter) increasing internal comfort
- It naturally regulates humidity

- It has ‘warm’ colour aesthetics
- It is a fireproof material, which is an important consideration for the Med regions
- If it sourced locally, the transport energy and associated CO_2 emissions are minimised
- It offers a simple and low-cost construction method

(Useful link: http://craterre.org/)

Restrictions

- Ground cannot be used alone to meet winter regulatory insulation requirements, but its thermal performance can be improved by the use of natural insulation materials e.g. cork, straw, recycled paper etc.
- The material can be inhomogeneous in appearance and quality
- In many countries (e.g. Greece), there are no specific performance standards developed yet with regards to the use of ground as a building material
- Its structural performance in earthquakes has not been established, and is subject to additional research. Typically ground would be reinforced by other elements such as straw etc. to better withstand seismic forces. Alternatively, ground can be used for non-loadbearing elements, with other materials as the load-bearing structure (wood, stone etc.).

2.2 ON-SITE REUSED STRUCTURAL MATERIALS

Area:	**Indicator:**	**Adequate for:**	
Materials	- % of the area of original envelope and intermediate floors preserved - % Volume of local materials - LCA / embodied energy including transport	New (possibly)	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Materials LCA impacts (resources, energy, CO_2, water)		
Favours:	Local labour		

Function

Planet resources are limited. In Med countries, it can be foreseen that the rate of constructing new buildings will increase by very little, whereas changes of use in buildings will increase. It is therefore very important that either refurbishing be encouraged or that demolished structural materials can be reused. This reuse is even more interesting if it is made on site.

Partly retained structure (steelwork, floors, facade), residential development, UK

Application:

On site reused structural materials are mainly used in refurbishment projects; however they may be used in new-built, if material becomes available from demolition of an existing building on-site.

Technical description:

Reusing on-site material can be achieved through different means:

- Refurbish existing buildings retaining the structure rather than demolish it and send to landfill;
- Retain stones, concrete or raw-ground bricks: cement pointing should be removed which means that it can be done if it is low quality cement or if the retrieved material is very valuable;
- Reuse tiles which are in good condition;
- Crush existing materials for:
  - underlay for paths, sports-ground or platforms
  - aggregate for concrete
- Reuse of sections of the building which are still in good condition: internal walls, floor tiles, flooring etc.

Benefits

Reusing structural existing materials reduces heavy loads of transportation of materials, reduces resources and water demand, and favours local labour.
(Useful link: www.recyhouse.be)

Restrictions

Most of the times, reused structural materials cannot be used alone to meet winter regulatory insulation requirements.

2.3 LOCAL STRUCTURAL WOOD

Area:	**Indicator:**	**Adequate for:**	
Materials	- LCA / GWP: $CO_2eq/m^2/yr$, embodied energy including transport - % Volume of local materials - % Volume of renewable materials - Use of certified wood	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Materials LCA impacts (resources, energy, CO_2, water), heating & cooling demand		
Favours:	Local labour		

Function

Planet resources being limited, it is important to replace fossil-energy-based materials by renewable materials as often as possible. This is the case for structural wood which stores CO_2 whereas steel and concrete produce CO_2 emissions.

Wood should come from local well managed forests (e.g. be FSC, PEFC certified); wood from protected primary forests should be excluded.

Application

Local structural wood can be used in new-built, extensions or refurbishments.

Technical description

Local structural wood can be used as follows:

- structural columns
- partition walls
- wood framing
- roof timber structure
- flooring or roofing: laminated (glued or mail-fixed)
- terraces
- sheathing

Equivalents: Other naturally grown bearing materials, such as bamboo.

Benefits

Apart from storing CO_2, using local woods favours local labour, rejuvenates forests and reduces thermal bridges in buildings. At the end of its life cycle, wood can be reused in other wood-based materials or used as fuel for boilers if it hasn't been treated. Some countries now impose a minimum rate of wood use on each construction project calculated with specific tools.
(Useful link: http://www.boisdesalpes.net/; this association which covers three quarters of the total area of Region PACA supports local wood use).

Restrictions

Wood may need to be used along high-mass materials so as regulate inertia.

2.4 WOOD-BASED INSULATION

Area:	Indicator:	Adequate for:	
Materials	- LCA / GWP: CO_2eq/m^2/yr - % Volume of renewable materials - Use of certified wood	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Materials LCA impacts (resources, energy, CO_2, water), heating & cooling demand		
Favours:	Comfort		

Function

Planet resources being limited, it is important to replace fossil-energy-based materials by renewable materials as often as possible. This is the case for wood-based insulation which stores CO_2 whereas mineral or polystyrene insulation products produce CO_2 emissions.

Wood should come from local well managed forests (e.g. be FSC, PEFC certified); wood from protected primary forests should be excluded.

Application

Local structural wood can be used in new-built, extensions or refurbishments.

Technical description

Wood-based insulation can be found in two forms:

- Cellulose wadding, generally loose: it is blown into mural/roof cases, empty spaces or in attics
- Wood-wool can be used the same way as mineral wool: floors, walls, roof; also it can have an acoustic use in partition walls

Equivalents: Other vegetal non-bearing materials such as hemp, straw, linen.

Benefits

Apart from storing CO_2, using wood-based insulation favours local labour (if the manufacture is close to the building site), rejuvenates forests, and highly improves the thermal and acoustic characteristics of buildings. This material has very interesting features:

- it has the same insulating potential as mineral wool (λ = 0.04W/mK);
- in the summer, it has the best heat-barrier potential;
- it has better acoustic performance than mineral wool;
- it contributes towards compulsory wood use regulations in some countries

Restrictions

Wood-based insulation may need to be used along high-mass materials so as regulate inertia. It is not fit for bearing.

2.5 WOOD CARPENTRY

Area:	Indicator:	Adequate for:	
Materials	- LCA / GWP: CO_2eq/m^2/yr, embodied energy including transport - % Volume of renewable materials - Use of certified wood	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Materials LCA impacts (resources, energy, CO_2, water), heating & cooling demand		
Favours:	Local labour		

Function

Planet resources being limited, it is important to replace fossil-energy-based materials by renewable materials as often as possible. This is the case for wood carpentry which stores CO_2 whereas aluminium or PVC carpentry produce CO_2 emissions.

Wood should come from local well managed forests (e.g. be FSC, PEFC certified); wood from protected primary forests should be excluded.

Application

Wood carpentry can be used in new-built, extensions or refurbishments.

Technical description

Using wood carpentry implies taking some precautions:

- To avoid wood treatment, it is important to use rot-proof wood such as larch, laricio pine, douglas which can all be found in Med forests
- Wood should be protected against rain and sun through architectural design (shutters, sun protections etc. These devices should be adapted to the actual use of the building e.g. manual in homes, motorized in office buildings

Benefits

Apart from storing CO_2, wood carpentry favours local labour (if the manufacture is close to the building site), and rejuvenates forests. It also can contribute towards meeting the requirements of local regulations in some countries, on the use of wood in buildings.

Restrictions

Wood for carpentry might need treatment and requires maintenance.

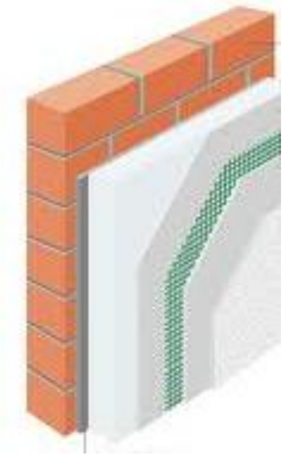
3. ENERGY

PART A - ENERGY DEMAND REDUCTION

3.1 EXTERNAL THERMAL INSULATION COMPOSITE SYSTEMS

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr heating & cooling demand - kgCO_2eq total emissions - Sound insulation of envelope	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function
External Thermal Insulation Composite Systems (ETICS) are a highly efficient technology for the thermal protection of the external envelope of buildings.



Application
ETICS can be installed on both new and existing buildings. In new buildings the system can be adhered directly on the bricks or blocks forming the walls. In refurbishment projects the walls need to be prepared by removing loose materials, such as damaged plaster, and electrical or plumbing installations such as electricity outlets, light fixtures etc.

Technical description
ETICS commonly consist of thermal insulation boards and panels fixed on the outer side of external walls with the use of a special adhesive. In some cases mechanical fixings such plastic bolts are also used. In the case of thicker panels (≥16 cm) and 3 stories or more, mechanical fixings are typically obligatory. Thermal insulation boards/panels are then coated with a layer of specifically designed ready-made plaster and a second finishing layer of coloured rendering. A fiberglass mesh is usually incorporated within layers to further reinforce the system. The last layer of rendering is used as the finished wall surface, and many manufacturers offer a wide selection of finishing materials such as wood, ceramics, metal etc. In addition to the main components, a wide range of detail components is also available as part of the system in order to cover project specific needs for fixing, sealing, edge construction and protection.

Benefits

- Reduction of heat losses through the elimination of thermal bridges
- Reduction of the appearance of condensation and consequently mildew caused by wide temperature differences along thermal bridges
- Preservation of the thermal mass of external walls towards the interior space
- Protection of external walls from the thermal stress caused by wide temperature differences between the interior and exterior side
- Addition of insulation in refurbishment projects can be completed without disruption to the occupants
- Quick installation of the system with very little waste produced on site due to readymade components
- Level and uniform final surfaces
- Indoor thermal and acoustic comfort improvement

Restrictions

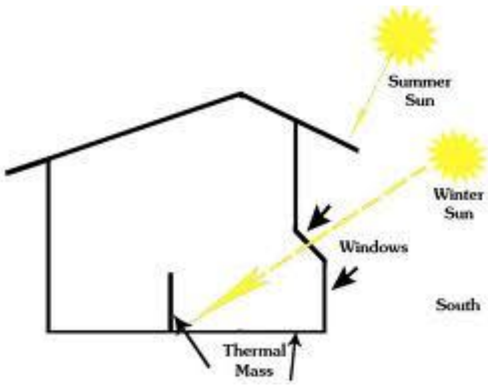
It cannot be applied in existing buildings under conservation or with particular decorative facade elements

3.2 PASSIVE SOLAR SYSTEMS

Area:	**Indicator:**	**Adequate for**	
Energy	- $kWh/m^2/yr$ heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

Passive solar systems allow the building to take advantage of the available solar gains in winter thus minimising the use of mechanical and electrical devices for space heating. Some passive solar systems can be effective in also reducing solar gains in the space in summer, therefore reducing the demand for mechanical cooling.



Application

Passive solar systems should ideally be placed on the south facades of buildings. South facing surfaces receive high levels of solar radiation during winter while in summer they can be effectively shaded with the use of simple overhangs, horizontal louvers or vegetation. West and east oriented systems can also contribute to the passive solar heating of spaces but the received solar radiation during winter is lower while shading them adequately during the summer months can be more challenging and requires a higher degree of involvement by building users.

Passive solar systems can be optimised when designing a new building. However, existing buildings can be adapted or retrofitted, to use passive solar systems.

Technical description

There are a number of passive solar design techniques, and various configurations of systems that can be used. The most common are the following:

- Windows (direct gain): The simplest version of a passive solar system is an adequately sized, sun exposed window, of high solar radiation fraction (g-value 0.7-0.8), allowing high levels of solar energy to be transmitted to the in interior. It should be combined with a high thermal mass building construction. High thermal mass constructions should be provided especially for the interior surfaces reached by the solar beams. In this way heat can be stored within the mass of the construction during the morning hours and then released at night. To improve efficiency it is important to provide shutters or another system that can provide a layer of insulation to the glazing during night hours.

- Sunspaces (isolated gain): A sunspace is a south-facing glazed area located outside the main fabric envelope of the building. It typically includes vertical South facing glazing, and a sloped, glazed or opaque, South facing roof. It can be built as part of a new dwelling or as an addition. The space naturally heats and cools allowing daytime temperatures to rise higher and night time temperatures to fall further than the comfort temperatures of the adjoining living space. In this way it functions as a thermal "buffer" between the inside and the outside of the building. Sunspaces may experience high heat gain and high heat loss through their abundance of glazing. The high temperature fluctuations can be moderated by providing thermal mass in the interior surfaces of the dwelling, and low-e windows on the shared wall. The distribution of heat collected in the sunspace towards the rest of the dwelling can be achieved passively, through correctly placed openings in the separating wall between the sunspace and the dwelling, e.g. doors, vents, or open windows; if passive circulation is not possible or practical, fans with thermostatic controls can be used to circulate the air. Mechanical ventilation can extend the penetration of pre-heated air from the sunspace into areas of the house that are not adjacent to it, via ductwork. Sunspaces are easily overheated in summer, therefore they should be provided with adequate summer shading and ventilation. Shading can be in the form of an overhang, external louvres or fabric roller blinds, as well as deciduous trees. Ventilation can occur by placing openable vents at the top and bottom of the sunspace, to create a "stack effect". These can be controlled either manually or automatically, on a thermostatic control.

- Thermal walls (indirect gain): Thermal walls are a more complex form of a passive solar system, based on the principle of absorption, accumulation and distribution of the received solar energy. There are several variations of thermal walls, the most common being:

    - Trombe-Michel wall / Mass wall: The system consists of a south oriented glass unit placed on a high thermal mass solid wall (concrete, brick), darkened in colour, with an air void in between. This construction allows the wall to act both as a solar collector and a heat storage element. During the day, solar heat is transmitted through the glazing and absorbed by the wall which slowly stores heat. By the evening, this heat is conducted to the inside face of the wall and radiated to the adjacent room. The glazing can be single (high solar transmission) or double (retaining absorbed heat). There are vents at the top and bottom of the wall. This creates a thermosyphon loop, allowing the air that has been heated up during the day in the cavity, to be vented into the interior living space. This system requires involvement for the user as during the winter months the vents should be closed when solar radiation is not available in order to reduce heat loss while during the summer months the glazing should be shaded and the vents closed so as to avoid overheating.

A simpler variation of the system is a mass wall, whereby there are no vents to the interior space, and heat is simply absorbed by the wall construction during the day and conducted to the interior space by the evening.

- Thermosyphon air panel: It consists of absorber surface, covered with one or two glazing panes at the front, adequate insulation behind the absorber, and an inlet and outlet on the insulation panel, venting to the interior space. The air in the cavity between the absorber and the back insulation warms up when radiation is incident on the absorber, rises due to buoyancy, and through the top level opening vents into the room through natural convection. The process is continued as long as the air is collecting heat from the absorber and the outlet air temperature is greater than the inlet air temperature (room temperature).

- Phase-change materials: they have ability to accumulate or release heat while changing phase from solid to liquid. These materials (salt hydrates, paraffin, etc.) are incorporated in plastic tanks and positioned on south orientation or microencapsulated in building materials (plaster, plasterboards or concrete walls) in the interior. Absorbing extensive heat enables peak energy saving and reduces the working hours of the heating/cooling system.

Benefits

- Reduction of space heating and cooling demand minimising the use of mechanical systems
- Improvement of indoor thermal comfort levels
- Sunspaces, even though they are unheated, can provide additional living space when natural conditions make them comfortable

Restrictions

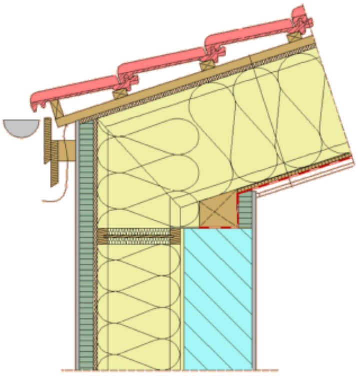
- Thermal walls, as well as sunspaces (depending on their design), can reduce daylight entering the adjoining living space
- A sunspace with an opaque roof provides better insulation and shading, however reduces the daylight entering the adjoining living space (properly designed venting skylights can be considered). A sunspace with a glazed roof optimises solar gain on winter days, however it results in increased heat loss in overcast conditions and on winter nights, in significantly higher risk of summer overheating, and in higher risk of glare and of water leakages.
- Sunspaces are particularly sensitive to user misuse. If used correctly they can make a significant contribution to energy conservation, however with inappropriate use they can have the opposite effect. If automatic ventilation or temperature controls are provided the users should be fully aware of how to operate them.
- Because transmission of stored heat is delayed by a number of hours, depending on the wall design, indirect gain systems are suitable for residential buildings where the main activity starts in the afternoon.
- Trombe-walls can be expensive because of higher cost for the materials and the structural modifications required compared to a conventional wall

3.3 ROOF INSULATION

Area:	Indicator:	Adequate for:	
Energy	- kWh/m²/yr heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

Increasing the levels of roof insulation leads to increased cost-benefit ratio in energy saving and indoor comfort improvement.



Application

Thermal insulation can be added to pitched or flat roofs or ceilings/attics. It can be used for both new and refurbished buildings. Energy regulations in each country make it compulsory to provide some minimum levels of roof insulation for all new buildings, and going beyond the minimum standards offers additional benefits. Retrofitting roof insulation on existing buildings is usually the simplest energy saving measure which offers good energy savings in relation to the initial capital cost. If installed externally, roof insulation results in no disruption for the occupants.

Technical description

There are various materials which are used as roof insulation materials, which come either in the form of panels, rolls, or loose. Mineral wool (rockwool or glasswool), expanded or extruded polystyrene are added on the basic construction of the roof in thicknesses between ~5 to 30cm. Mineral wool can be placed on the ceiling of the top floor or between roof girders. Polystyrene is often used on flat roofs: expanded polystyrene is placed below the waterproofing membrane and extruded polystyrene can be placed above. The waterproofing membrane is covered with a separator layer and gravel or other waling surface of higher load capacity.

In the selection of roof insulation material, its environmental impact should be considered. Blowing agents which are often used in the manufacturing process of insulation contain substances which have significant Global Warming Potential (GWP). For that reason the use of HCFCs as a blowing agent has been phased out in Europe. However there are many HFCs, which are commonly used as replacements for HCFCs, which still have significant GWPs and should be avoided. Ideally materials with low GWP (<5) should be selected (for example pentane and CO_2 blown insulants, mineral wool, glass fibre and extruded materials).

Benefits

- Energy saving
- Health and comfort improvement

Restrictions

- When retrofitting insulation on an existing building, depending on the roof construction, its load capacity may be unable to take the additional weight
- When retrofitting roof insulation, the additional cost should be considered of potentially having to remove existing components (e.g. roof tiles) and re-installing them

3.4 REFLECTIVE INSULATION

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m²/yr heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function
Significant heat losses arise due to heat radiation. In winter the reflective foils of this material reflect heat back to the interior and in summer they keep the radiated energy outside.

Application
Applicable to thermal insulation of attics (roof and walls).

Technical description
This thermal insulation material consists of an external reflective aluminium foil, an internal reflective film and polyethylene foam as the separating layer.

Reflective thermal insulation is fabricated from metalised polyethylene or aluminium foil with a variety of core materials (low-density polyethylene foam, polyethylene bubbles or fiberglass). Every layer can be multiplied. It has 2 to 10 times lower thermal conductivity coefficient than standard thermal insulation materials. Up to 97% radiant energy can be reflected and depending on the core material used, the thermal, sound, moisture or fire protection can be improved.

Benefits
Significant reduction of material thickness can be achieved as 8 reflective layers of few cm thickness have the equivalent effect of 21cm of standard thermal insulation material.

Restrictions
Reflecting solar energy in winter reduces solar gains which may increase winter heating demand and costs.

3.5 WALL CAVITY INSULATION

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

This type of insulation is used for filling the air void of a 2-layer external wall, where the basic construction is concrete or brickwork and the external layer is brickwork.

Application

For new buildings, it is compulsory to provide minimum levels of insulation in cavity walls to comply with energy regulations. For existing buildings, insulation can be retrospectively inserted within the cavity. The process is performed by forming small holes from outside through which insulation is blown into the cavity. Ideally the entire void must be filled with insulation. The insulation can be mineral wool, beads, granules or foamed insulants for use in existing and new walls.

Technical description

Mineral wool used for wall cavity insulation is loose-shot free (roll) or unbounded (blown), non-combustible glass wool of standard thermal conductivity. The insulation must be water and moisture non-permeable. By applying thermal insulation in a 10cm air void, an overall wall U-value of 0.3W/m^{2}K can be achieved in a cavity wall.

As referred to in section 3.3, insulation materials with low GWP (<5) should be selected (mineral wool and glass wool are such materials).

Benefits

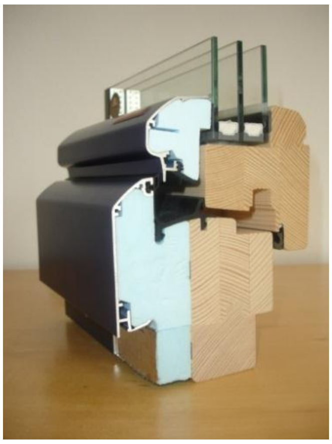
Cavity insulation highly contributes to energy saving and indoor condensation risk prevention.

Restrictions

Only authorised installers can perform the work of blowing insulation into existing cavity walls. Cavity insulation filling is a rather unknown method in the Med area but commonly applied in other countries e.g. in the UK.

3.7 INSULATED WINDOW FRAMES

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement - Sound insulation of envelope	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		



Function

Insulation in the window frames reduces the heat transfer coefficient of the window frame and additionally through the spacer bar.

Application

A typical application would include up to 30mm of thermal foam in a composite material window frame (wood/aluminium-foam-wood) of total thickness of 60 to 90mm. A warm spacer bar is installed between the glass panes.

Technical description

Thermal foam is placed on the outer side of the frame continually across the height and over the start of the glazing level. The frame must be set in line with the thermal insulation of the external envelope to avoid thermal bridges.

By using thermal insulation, the heat transfer coefficient value of window frames (U_f) is close to that of high quality glazing, enabling an overall high quality window with considerable energy savings.

The warm edge spacer bar is produced from hard foam allowing expansion and contraction, is resistible to nitrogen and argon gas absorption and UV radiation.

Benefits

- Energy saving
- Indoor condensation risk prevention
- Improved indoor health and comfort
- Acoustic comfort

Restrictions

Windows must be carefully positioned to overlap with wall thermal insulation, so as to achieve continuity of thermal insulation of the external envelope in order to reduce the effect of thermal bridges.

3.8 SECONDARY GLAZING

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr heating & cooling demand - kgCO_2eq total emissions - Thermal comfort improvement - Sound insulation of envelope	-	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

Secondary glazing can offer additional thermal and sound insulation while keeping the existing character of buildings under conservation.

Application

It is placed on the niche of existing windows from the interior side, usually in heritage buildings and historical city areas, where windows cannot be replaced, so as not to affect the external façade appearance.

Technical description

Secondary aluminium/wood/PVC frame single or double glazing is anchored onto a subframe. A casement between the existing and the new window is formed. For large glass surfaces, toughened glass is used. Various high quality glazing systems can be used, and low-e coatings or gas-filled insulated glass can be added to improve thermal performance. A weighted sound reduction index of up to Rw = 45dB can be achieved. Fixed, sliding or hinged frames can be used. An innovation in secondary glazing includes the use of polarised magnetic strips on frames, holding the transparent panes, acrylic or glass (3-4mm thick. This system has the flexibility to adapt to uneven frame surfaces of old window frames and achieve a perimeter seal.

Benefits

- Energy saving by reducing the heat transfer coefficient of the window
- Acoustic improvement
- Fire protection
- Health and comfort improvement
- Elimination of draughts and ventilation losses
- Prevention of condensation between the panes

Restrictions

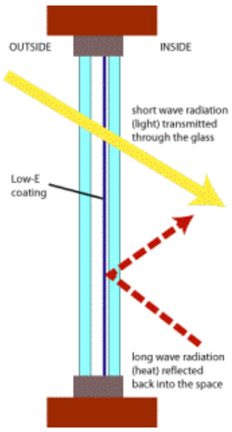
Secondary glazing can typically be applied only to buildings with thick walls (pre-1950s constructions).

3.9 LOW-EMISSIVITY GLAZING

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

A low-emissivity (low-e) coating on the glass pane increases radiant energy reflectance to improve the thermal efficiency of glazing while letting visible light pass. The properties of the coating and glazing materials can be designed to optimise energy balance for heating, cooling and daylighting.



Application

Low-e coatings (thin film metal oxide) are applied during the manufacturing process of double-glazed units, onto the external surface of the inner pane of double glazing. There are low-e coatings on plastic films which can be applied to existing glass as a retrofit measure, however they tend to be less efficient.

Technical description

Standard clear window glass has a high thermal emittance (~84%), having poor thermal insulation properties.

Applying microscopically thin low emissivity coatings reduces radiant thermal energy emission keeping radiant heat on the same side of the glass from which it originated.

As an indication, the following values can be achieved:

- solar heat transmittance g=0,78-0,79, light transmittance LT=0,75-0,78 for single coating reaching heat transfer coefficient for glazing U_g=1,5 W/m^2K;
- solar heat transmittance g=0,66-0,68, light transmittance LT=0,64-0,67 for two coatings reaching heat transfer coefficient for glazing U_g=1,0–0,7 W/m^2K

One coating is applied on a double-glazed pane; one or two coatings are applied on a triple glazed pane.

Coatings are applied by pyrolitic CVD (deposition of fluorinated tin oxide applied while the glass is still hot) or magnetron sputtering (deposition of thin silver layer in one to three layers, with antireflection, enclosed within multiple panes because it cannot be exposed to the air).

The general use of low-e coatings is to reflect radiant heat originating from indoors back inside thus reducing heat loss. The effect on solar gain can vary:

- low solar gain low-e coatings used in hot climates retain good visible light transmittance (for double-glazing, air-filled: 27% solar transmission, 64% light transmission)
- moderate solar gain low-e coatings used in moderate climate, still retain high visible light transmittance (for double-glazing, air-filled: 39% solar transmission, 70% light transmission)
- high solar gain low-e coatings used in cold climate allow high visible light transmittance (for double-glazing, air-filled: 71% solar transmission, 75% light transmission)

Low-e coatings are particularly effective when used in conjunction with gaseous fillings.

Benefits

- Energy saving by reduction of heating & cooling load
- Increase of indoor comfort

Restrictions

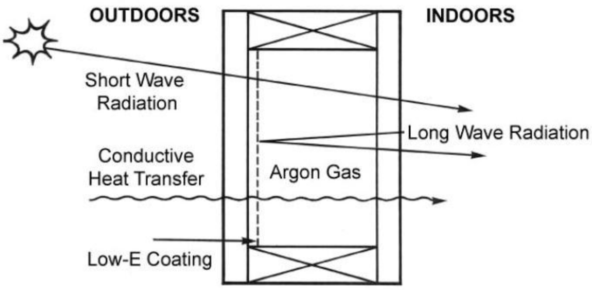
- The use of high solar gain coatings is advised in cold climates to increase passive use of solar energy; the use of moderate solar gain coatings is advised in both hot and cold climates, whilst the use of low solar gain coatings mainly reduces solar heat gain and cooling demand.
- Low-e coatings on films applied to existing windows tend to be less efficient and with a shorter lifespan, thus where possible it is worth to consider replacing a window with a new energy-efficient one with the low-e coating integrated within it.

3.10 GAS FILLING FOR GLAZING

Area:	Indicator:	Adequate for:	
Energy	- kWh/m²/yr heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement - Sound insulation of envelope	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		

Function

The purpose of gas filling is typically to reduce heat transfer and improve the energy efficiency of an insulating glass unit. Gas filling can also be a means of reducing the sound transfer through the glass and improving its acoustic properties.



Application

Gas filling is applied during the manufacturing process of new double-glazed units. In refurbishments, existing windows can be replaced with new double glazed ones, gas-filled instead of air-filled. For the process of gas filling, air is extracted from the space between glass panes which is then filled with heavy gas (colourless, odourless, non-flammable and non-reactive inert gases) of viscosity higher than oxygen and nitrogen to reduce convective heat transfer.

Technical description

Compared to air, argon (33%), krypton (67%), xenon (50%) or sulphur hexafluoride (22%) have lower thermal conductivity (respective % shown in brackets). The effectiveness of using an inert gas depends on the optimum thickness of the inner air space. Argon has the best cost-efficiency whilst krypton is more expensive and works better at smaller pane spacing so it is typically used in triple and quadruple glazing.

The application of krypton results in a substantial increase of the heat transfer resistance, allowing the use of double paned windows in place of the costlier triple paned ones, as well as reducing the thickness, and therefore the total weight of the unit, further reducing the load on the building envelope. Gaseous filling improves protection from solar radiation, e.g. glazing units filled with krypton reduce by up to 60% the conductive heat transfer. Gaseous filling is particularly effective when used in conjunction with a low-e coating, which reduces the radiation heat transfer.

The two current methods for gas filling include the vacuum method and the probe method. In the vacuum method the insulating glass units are initially evacuated in some form of chamber and then backfilled with the inert gas. With the probe method, the insulating glass units are filled with gas via one lance or probe, while evacuating the existing air via a second lance location. When the units contain a high concentration of inert gas (which can be measured), they are assumed to be fully filled.

Benefits

- Energy saving for heating and cooling
- Prevention of condensation in the space between the glass panes
- Reduction of noise levels by 5 dB/m^2 for double-paned and 15 dB/m^2 for triple-paned units
- Light transmission remains constant

Restrictions

A double-glazed unit would typically achieve 90% fill gas concentration, gradually evaporating over time reaching not less than 75% concentration after 20 years.

3.11 DRAUGHTPROOFING

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr heating demand - kgCO$_2$eq total emissions - Thermal comfort improvement - Sound insulation of envelope	-	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating demand		
Favours:	Comfort		

Function

Draught proofing means blocking cold air passing through gaps on door and window frames or other unwanted gaps in construction, installation ducts in walls or ceilings or openings left uncovered. Increasing the air-tightness of the building by draught proofing can significantly reduce heat losses in winter resulting in heating energy savings.

Application

- On construction gaps: weather strips/draught excluders e.g. self-adhesive foam strip, self-adhesive rubber strip, brush strip, silicone rubber sealant, sprung strip, flexible rubber tube, flexible fillers, mastic-type products
- On doors and windows: secondary glazing installed in existing windows, low profile threshold, door seals
- On pipework/installation ducts: silicone fillers, expanding polyurethane foam

Technical description

There are various techniques for draught proofing that can be used:

- Strips of the appropriate thickness and type should be installed between gaps, for them to be effective.
- On openings left uncovered, a cap can be put over the chimney pot or an inflatable cushion that blocks the chimney; unused extractor fans can be filled with bricks and sealed from inside and outside.
- An automatic door bottom seal can be spring loaded to lift clear of the floor as soon as the door leaf is opened by a few millimetres.
- Low profile threshold plates facilitate the free movement of wheels while reducing draught.
- External doors in-line seals are composed of a fixed and a flexible part, mounted on the bottom door line: the flexible part returns to original shape after compression.

Benefits

- Energy saving
- Comfort improvement

Restrictions

Controllable ventilation (mechanical ventilation or window opening) must be provided in airtight spaces, to prevent condensation that causes harmful moulds, especially in bathroom and kitchen areas.

3.12 EXTERNAL SHADING DEVICES

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr cooling demand - kgCO_2eq total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Cooling demand		
Favours:	Comfort		

Function

External shading devices provide solar radiation control and optimisation.

Application

They are applied on windows and large glazed surfaces of South, East and West orientation.

Technical description

External shading devices can be in the form of overhangs, movable or fixed brise-soleil or louvers. These devices minimise solar radiation transmittance to the interior. In general they can be fixed or movable. Usually part of the window surface is shaded by the device and for large glass surfaces complete shading is recommended. For a Southern orientation, horizontal shading elements are typically used, usually fixed. For Eastern and Western orientations, vertical shading elements are more effective, ideally moveable. Large glazed surfaces on roofs also require shading.

Shading devices can integrate elements generating energy from solar radiation (e.g. photovoltaic cells) thus contributing to the total energy balance of a building. Additional shading elements such as screens can be used internally in the building. Vegetation from local plants used for natural shading contributes in creating natural ambient. In bioclimatic design, a whole façade surface can be shaded by the use of plants.

Benefits

- Energy saving by reduction of cooling load
- Increase of indoor thermal comfort
- If properly designed to control and diffuse natural illumination, shading can improve the quality of daylighting and prevent glare

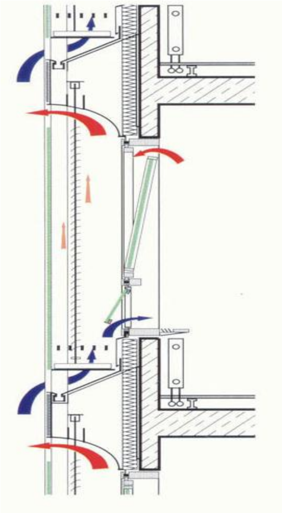
Restrictions

- External shading may reduce daylight transmission to the interior space, thus affecting visual comfort
- Good façade design depending on the building use and location, is essential in order to achieve the optimum balance between low solar transmission and high daylight transmission. The appropriate combination of good performance glazing and effective external shading is required for each orientation in order to satisfy, often conflicting, design, cost, comfort and aesthetic requirements.

- The visual appearance of a shading device must be integrated to the overall design and location of the building.
- The material selection for shading devices (e.g. shiny metallic surface or non-reflective wooden surface) and their tilt can affect the solar radiation reflected back to the interior of the space, therefore it is a parameter to consider in the overall design.
- The durability of the device is very important to assure its proper function and reduce maintenance costs.

3.13 VENTILATED FACADES

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m²/yr heating & cooling demand - $kgCO_2eq$ total emissions - Thermal comfort improvement - Sound insulation of envelope	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating & cooling demand		
Favours:	Comfort		



Function
Ventilated facades reduce the solar heat transfer to the building.

Application
Double-glazed ventilated facades can be used in new buildings, and in existing buildings where the façade is replaced. They are mostly applicable to high-rise buildings (e.g. apartment blocks) rather than individual dwellings, and they operate more efficiently on a southern orientation.

Technical description
There are various types of ventilated facades, briefly summarised below, which operate in different ways. Selecting the most suitable system should be based on a detailed assessment by the design team and façade specialists, of the project specific requirements (thermal, daylight, acoustic requirements) in conjunction with the local climatic conditions.

- ‘Breathable wall’: this system comprises of a solid wall (concrete or brick), thermal insulation boards or panels with a waterproof, vapour-permeable layer, an air void of minimum 40mm with small ventilation openings ensuring minimum air circulation, aluminium bearing sub-structure and ceramic/wood laminate/wood panel cladding. This system achieves best performance during summer when the outer shell heated by the solar radiation is ventilated in the air void enabling time shift of the heat load on the solid wall and to interior.

- Double-glazed ventilated façade: it consists of 2 layers of glazing and a ventilated air void. The openings are at the top and bottom of the external pane of glass and the cavity is ventilated by outdoors air circulation. This reduces the transmission of heat in the space in summer, reducing cooling demand.

- Active façade: it consists of a double-glazed / low-e / gas-filled outer layer, an air void via which indoor air additionally heated by solar radiation is extracted, and a single glazed inner layer.

- Interactive façade: it consists of a single glazed outer layer, an air void in which indoor air is introduced and preheated, and a double glazed / low-e /gas-filled inner layer.

Benefits

- Energy saving and CO_2 emissions reduction
- Indoor thermal and acoustic comfort improvement

Restrictions

- These systems cannot be applied to existing buildings under conservation or with decorative façade elements
- Retrofitting a ventilated façade to an existing building may be subject to limitations, e.g. the structural implications of mounting the second (outer) skin of façade on the existing building facade needs to be considered, as well as other issues related to the integration of such a system into the existing ventilation strategy.
- Higher installation costs then ETICS
- The systems are more efficient on high-rise buildings rather than individual dwellings
- Careful design of the system by the design team and specialists is required, to ensure the façade’s optimal operation

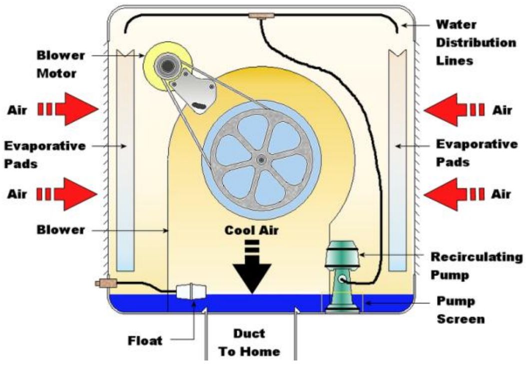
PART B - ENERGY CONSUMPTION REDUCTION

3.14 EVAPORATIVE COOLING

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ cooling consumption - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Cooling consumption		

Function

Evaporative cooling relies on the principle of cooling outdoor air by passing it over water saturated pads and causing water to evaporate into it. The cooler air is then directed into the building and pushes warmer air out through windows.



Application

Evaporative cooling is used in machinery and buildings. It can be applied in locations where cooling loads are not high, in order to maintain a comfortable indoor environment.

Technical description

There are two main forms of evaporative cooling, as well as systems which use combinations of these:

<u>Direct evaporative cooling:</u> it is used to lower the temperature of air by using latent heat of evaporation, changing liquid water to water vapour. In this process, the energy in the air does not change. Warm dry air is changed to cool moist air. The heat of the outside air is used to evaporate water.

<u>Indirect evaporative cooling:</u> it is similar to direct evaporative cooling, but uses some type of heat exchanger. The cooled moist air never comes in direct contact with the conditioned environment.

Benefits

- Simple technology, relatively cheap and resulting in a lower energy consumption than other forms of cooling
- More effective during the hottest time of the day, when the air is drier
- Doors and windows can be left open
- Environmentally friendly without the use of chlorofluorocarbons (CFCs)
- Freshening air with the constant air circulation in a room

Restrictions

- Evaporative cooling requires significant consumption of water
- It is efficient when the relative humidity is low
- Evaporative cooling raises the internal humidity level, which can cause problems such as swelling of wood furniture, panels, doors and trim

3.15 CEILING FANS

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ cooling consumption - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Cooling consumption		

Function

Ceiling fans increase comfort by blowing air downward on room occupants during summer.

Application

Ceiling fans are an efficient cooling method for some climates and conditions, especially when the use of a ceiling fan allows to reduce the use of air-conditioning.

In temperate climates or during moderately hot weather at mid-season periods, the consumption of air conditioning may be avoided with the use natural ventilation combined with ceiling fans.

Technical description

Ceiling fans can improve occupant comfort at a given room temperature by creating a wind chill effect, when they blow relatively cool air across the skin.

Ceiling fans are considered the most effective of other types of fans, since they effectively circulate the air in a room to create a draught throughout the room.

Ceiling fans are not ventilation devices; they are circulation devices. They don't bring cooler air into a home or vent warm, humid air from it.

Benefits

- Ceiling fans can save a significant amount of energy in summer allowing users to raise the air conditioning thermostats by up to 3^{o}C
- Doors and windows can be left open
- Ceilings fans can potentially also be used during the heating period blowing air upwards. This helps disperse the warm air that tends to gather near ceilings, distributing it more evenly throughout the room, especially around the perimeter and near the floor.

Restrictions

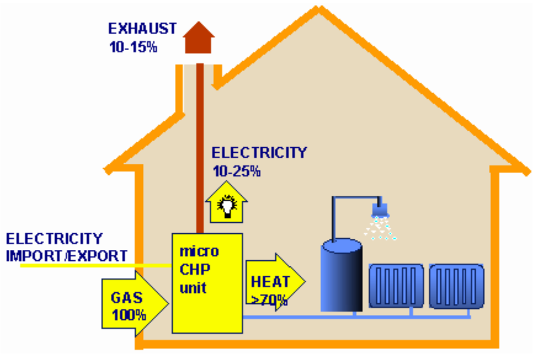
- Ceiling fans are not appropriate in rooms with high ceilings

3.16 MICRO–COGENERATION

Area:	Indicator:	Adequate for:	
Energy	- kWh/m^2/yr heating consumption - kgCO$_2$eq total emissions - Conversion factors to primary energy - Peak electrical demand reduction	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Electricity consumption		

Function

Micro–Cogeneration or micro-CHP (Combined Heat & Power) units combine Heat and Power provision conversing primary energy to useful heat and power at the point of consumption. According to an EU directive, micro-cogeneration units are defined as those having an electrical output of less than 50kWe.



Essentially the micro-cogeneration unit replaces the conventional boiler in a central heating system or the individual boilers and comprises a small engine which drives an electrical generator. The waste heat from the engine is used in the primary circuit of the heating system and the electricity generated is either used in the house or exported to the grid.

Application

Micro-Cogeneration is suitable for buildings where there is both electricity and heat demand for long periods. Apartment blocks are such buildings, other suitable building types include: care homes, student residences, hotels etc.

Technical description

Micro-Cogeneration systems can be based on different technologies regarding the engines:

- Internal Combustion Engine: The combustion engine is powered by the expansion of the hot combustion products or fuel, directly acting within the engine. To function it requires air, fuel, compression and, for spark ignition, a combustion source.

- Free Piston Steam Engine: The engine uses an external heat source, which can be a fossil fuel based product, solar energy or biomass, to create motion from temperature difference.

- Fuel Cells: They are electromechanical devices which generate electricity through a chemical reaction. Usually the reactant gases used are hydrogen and oxygen which are extracted from natural gas (hydrogen) or air (oxygen).

Benefits

- Micro-Cogeneration systems offer a higher overall efficiency compared to typical conventional electrical power generation
- Reduced building carbon footprint (lower CO_2 emissions)
- Reduced energy costs
- Peak energy demand reduction
- Lower distribution losses
- Easy to use by automatic operation
- With a micro-CHP, the house can become to a large extent independent from the electricity network

Restrictions

- Fossil-fuelled CHP systems maintain the dependency on fossil fuels; ideally renewable energy should be used as the source of heat
- Carbon savings are insignificant in very small houses
- High installation costs

3.17 LOW TEMPERATURE HEATING SYSTEMS

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ heating consumption - $kgCO_2eq$ total emissions - Thermal comfort improvement	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating consumption		
Favours:	Comfort		

Function

Low temperature heating systems operate at lower supply and return water flow temperatures (approx. 45^{o}C and 25-35^{o}C) when compared to conventional high temperature heating systems (90^{o}C and 70^{o}C respectively). Progress in heating technology and improvements in the building insulation standards allows systems with lower water temperatures to be sufficient nowadays to heat a house thoroughly, even at low outside temperatures.

The lower the temperature that the heating system operates at, the lower the energy consumption becomes for heat generation, making these systems more environmentally friendly. The potential also increases of using low temperature heating sources (sun, ground, waste heat etc.) in combination with such systems.

Application

The most well-known application of a low temperature heating system is underfloor heating, but there are also other applications such as walls and ceiling heating, as well as low-temperature radiators. The system can be applied to both new buildings and retrofits, however retrofitting it involves removing floor or wall coverings and underlays to install the pipework, and if the system is water based, reconfiguring the dwellings hydraulic network.

Technical description

Heat sources for low temperature heating systems may include conventional fossil fuel boilers and electricity. However they are well combined with the heat pump technology, which can be used to extract energy freely available in the air or ground. The heat pump extracts low temperature heat from the surrounding air or ground, and increases its temperature. The upgraded heat is then transmitted to low temperature radiators or underfloor heating systems. The system can be configured in a number of ways: the system can be sized to provide the entire heating demand throughout the winter, or to provide the majority of the heating demand, with peaks covered by a conventional boiler or a back-up electric heater. The configuration of the system depends on the climatic location, but also on the design of the building i.e. the extent by which heating demand has been minimised through good design of the building envelope.

Benefits

- When combined with air or ground source heat pumps, low temperature heating systems can result in significant savings in energy and CO_2 emissions compared to conventional heating systems
- High levels of comfort, due to the smaller temperature differential between the heat emitter and the room temperature
- If configured appropriately, the system can be reversed in summer months to provide cooling in an energy-efficient way

Restrictions

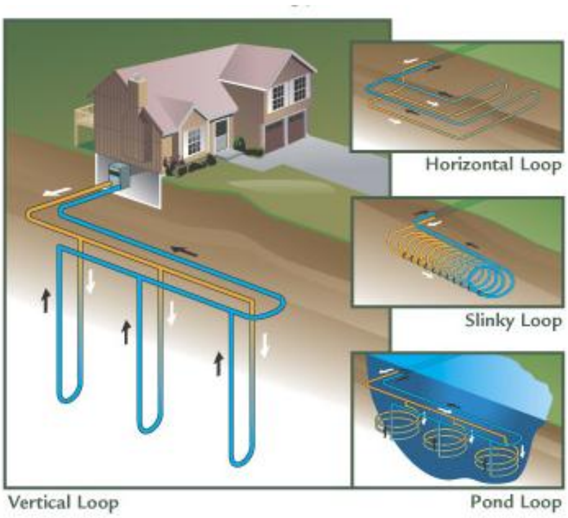
- Due to the limited load capacity of low temperature systems, they operate best when combined with a well-designed building envelope, whereby the heat losses through the fabric and through infiltration have been minimised.
- Significant re-configuration of the heating pipework and disruption to occupants may be required to retrofit the system to existing buildings

3.18 GEOTHERMAL HEAT PUMP SYSTEMS

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kWh/m^2/yr$ heating, cooling, DHW consumption - $kgCO_2eq$ total emissions - Conversion factors to primary energy - Thermal comfort improvement - kWh/y or % of renewable thermal energy of total	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating, cooling and DHW consumption		
Favours:	Comfort, Use of renewable energy		

Function

Geothermal energy is the heating and cooling energy that can be generated taking advantage of the near-constant temperature of the ground. Heat pumps are used to 'extract' this freely available energy and make it useable for the building.



Application

Geothermal energy can be used to cover some or all of a building's space heating, space cooling and domestic hot water demand.

It is a technology mostly applicable for new buildings (or extensions) because the installation is underground. Hence, integration at an early stage with the structural and mechanical design of the building is vital. Applying the technology to an existing building would only be possible if there was an area of land available adjacent to the building which could be used for installing the underground pipework.

For the technology to be more cost-efficient it should be used in buildings which have a balanced heat and coolth demand over the year so as to optimise the energy-efficiency of the heat pump, achieving higher energy savings.

Technical description

A few meters from the surface (2-3m), the ground provides a steady energy source by maintaining a nearly constant temperature throughout the year (~14-17^oC, depending on location). Heat pumps pump water to the surface while it circulates in the ground via pipework: the water in the pipework coming to contact with the ground, obtains a near constant temperature and can then be used to circulate in the building's heating/cooling systems. This technology reduces energy use compared to conventional systems, as water is 'pre-heated' in the winter and 'pre-cooled' in the summer.

There are two main types of geothermal systems:

- Closed-loop systems: vertical loop (boreholes 50-150m deep depending on the requirements) or horizontal loop (in trenches 2-3m deep). The heat transfer occurs from the contact of the ground with the underground pipework in which the water circulates, which then is pumped and distributed into the building's heating & cooling systems. Horizontal loop systems require a large site area in order to have the equivalent kW output of a vertical loop system
- Open-loop systems: heating/cooling is achieved by extracting water from a surface or underground source (e.g. lake or water aquifer) and re-inserting it after it has circulated through the building systems. Open-loop systems are more complex to design as there are typically restrictions by local environment or water agencies as to the volume and temperature of water that can be extracted and re-inserted, and obtaining a special permit for these works is typically required.

Benefits

- Due to the temperature differences achieved between the temperature of the ground and the supply/return temperatures for the heating/cooling system, geothermal heat pumps achieve higher efficiencies than air source heat pumps or conventional heating/cooling systems. Therefore they achieve energy savings, making them a low-carbon form of energy generation.
- Geothermal systems are well combined with low-energy systems such as underfloor heating, which can use the low temperature heat coming off the ground, which would only need a small additional increase before it can be used in the building.
- If the geothermal heat pump is sized to provide the majority of the building's annual heating/cooling demand, with back-up provided by conventional systems at peak times, then smaller size conventional systems would be required, saving costs and space, offsetting some of the capital cost of the geothermal installation.
- The predicted energy demand profile of the building should be assessed before selecting the most appropriate system, or else the system may not operate efficiently.

Restrictions

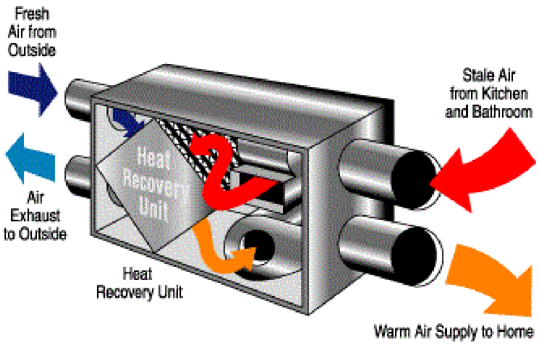
- Geothermal energy is not 100% 'renewable': even if the ground is a renewable source freely available, some electrical energy is required in order to run the heat pump, thus producing some CO_2 emissions (albeit small in relation to the overall CO_2 savings). This restriction can be bypassed if the heat pump is powered by renewable sources (e.g. PVs).
- Local site issues (e.g. local ground composition, hydrological and temperature conditions etc.) should be taken into consideration when designing such systems.
- Initial capital costs are higher than conventional systems, but are offset by lower operational costs and reduction in size of conventional systems.
- Retrofitting to an existing building is only possible where there is an area of land available adjacent to it, which could be used for installing the underground pipework. Also, re-configuration of the existing heating/cooling distribution systems may be required.

3.19 HEAT RECOVERY UNITS

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m²/yr heating, cooling, DHW consumption - $kgCO_2eq$ total emissions	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating, cooling and DHW consumption		
Favours:	Air quality		

Function

Heat Recovery Units (HRU) recover some of the unused heat energy discharged by ventilation or air-conditioning systems to heat incoming air or water for space heating or for producing domestic hot water. These units provide fresh air and improved climate control, whilst also saving energy by reducing heating (and cooling) requirements.



Application

HRU can be incorporated on the HVAC systems of both new and existing buildings.

Technical description

The heat recovery units are heat exchangers that allow the transfer of heat and/or humidity between exhaust air flow and supply air flow, through temperature difference (or humidity).

There are several types of ventilation heat recovery systems available, with varying efficiencies:

- Plate heat exchanger: typically ~55%-65%, max. 80%
- Thermal wheel: typically ~65%-75%, max. 80%
- Run around coil: typically ~45%-50%, max. 55%
- Heat pump: typically ~35%-50%, max. 60%
- Heat pipes: typically ~50%-65%, max. 75%

One configuration of the system is to install an HRU on the hot stream of an air conditioner or heat pump refrigerant circuit. The hot vapour flows through a heat exchanger. The heat from the vapour is then absorbed by the water, which is circulated through the heat exchanger by a small pump. This gives an inexpensive method for generating hot water. Appropriate controls are required for effective operation. In the summer, the heat recovery unit captures some of the heat discharged by the air conditioner, essentially giving free hot water. It may be even possible to turn the regular water heater off – it should just be turned back on when the air-conditioner is not used. If the heat recovery unit is installed on a heat pump, low-cost heating for water during the winter months is also possible. HRU are generally fitted with temperature and modulation controls.

Benefits

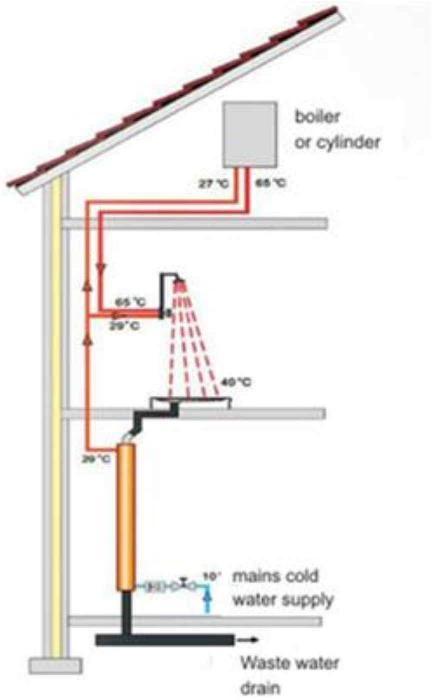
- Due to the filters incorporated within them, the HRU units control contaminants introduced to the internal environment and pre-heat or pre-cool the air.
- HRU permit energy savings by recovering energy from the extracted air that would otherwise be lost. Taking benefit from heat recovery, conventional heating or cooling generation units (boilers, chillers, air conditioning units etc.) can reduce in size therefore resulting in capital cost benefits.
- HRU also reduce wear of the heating and cooling equipment.

Restrictions

In its standard configuration the HRU is not a heat generator or an air cooler, therefore it needs to be integrated into a heating / air conditioning unit.

3.20 WASTEWATER HEAT RECOVERY SYSTEMS

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m^2/yr DHW consumption - kgCO_2eq total emissions	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	DHW consumption		



Function

There are simple wastewater heat recovery systems that take advantage of the wasted heat in the hot water coming off shower drains, and re-use it to pre-heat the incoming cold water from the mains, thus reducing the energy consumed to provide hot water to showers.

Application

The system is best suited to new build dwellings as the plumbing arrangement can be designed to provide for it. Also, it is mostly suitable to maisonette / duplex dwellings, where there is space underneath the first floor shower to install such a system. It could potentially be retrofitted to an existing dwelling, however this depends on the drainage pipework configuration and the available space; reconfiguring the drainage may involve high costs and disruption to the occupants.

Technical description

The system consists of a copper pipe, which is “wrapped” around the drainage pipe coming off the shower. Copper has a very high thermal conductivity.

The copper pipe has twin-layered skin, consisting of an inner and an outer pipe. The wasted hot water which runs off the shower during its use, flows through the inner copper pipe, transferring its heat to the copper material. Simultaneously, the mains cold water supply enters the outer section of the same copper pipe, absorbing the wasted heat, therefore being pre-heated before it reaches the boiler.

A section of copper pipe of a vertical length ~2m is required as a minimum underneath the shower, for the system to be effective. There are systems using a horizontal heat exchanger within the shower tray which overcome this restriction; however they tend to be less efficient.

Benefits

- Energy saving for Domestic Hot Water, as the cold water is pre-heated, therefore it is required to additionally heat it by a smaller temperature difference before supplying it to showers.
- Such a system could be a useful alternative solution, in cases where, for planning or other restrictions, the use of solar hot water collectors is prohibited.

Restrictions

- A section of copper pipe of a vertical length ~2m is required, as a minimum, underneath the shower, for the system to be effective. Therefore it is ideally suitable for first floor showers in maisonettes or duplex apartments, where there is space in the floor below to locate the vertical pipework. There are variations of the system using a horizontal heat exchanger within the shower tray which overcome this restriction; however they tend to be less efficient.
- Retrofitting to an existing dwelling may be possible, however it depends on the drainage pipework configuration and the available space; reconfiguring the drainage may involve high costs and disruption to the occupants.

3.21 HEATING SYSTEM CONTROLS

Area:	**Indicator:**	**Adequate for:**	
Energy	- kWh/m²/yr heating consumption - $kgCO_2eq$ total emissions	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating consumption		
Favours:	Comfort, user participation		

Function

Heating system controls (HSC) have the function of maintaining the indoor temperature to pre-defined limits when outside external climatic conditions vary and taking into account the presence of internal heat sources (people, appliances, etc.).

Application

HSC can be installed on both new and existing buildings. In new buildings the controls are component parts of the new heating systems. In refurbishment projects, HSC can be retrofitted on existing systems (e.g. radiators thermostats, programmable thermostats etc.).

Technical description

HSC commonly consist of two different types of thermoregulatory systems: thermostats and climate control units with external sensors. From technological point of view there are analog and digital systems.

- Thermostats: these are particularly suitable for apartments; they are installed centrally in the dwelling or in each room, and measure the air temperature. The measured temperature regulates the functions of the boiler (/heating system) and the water or air flow temperature through which space heating is provided. The more thermostats are provided the better control there will be of the thermal conditions in individual rooms, which will vary according to their orientation, the amount of glazing, their internal equipment etc.

- Climate control units with external sensor:
  These are particularly suitable for single-family and multi-family houses; they can be incorporated within the boiler (/heating system) or installed in a room. The outside temperature is measured by an external sensor. The sensor manages the operation of the boiler (/heating system) and the water or air flow temperature through which space heating is provided.

- Analog HSC: analog temperature control systems are connected to the boiler in one direction: the thermostat measures the temperature and communicates this information to the boiler, with no communication in reverse.

- Digital HSC: digital systems are the most modern; they can exchange information in both directions; it is possible to connect heating programs to boiler data and vice-versa. The boiler operation and heating temperatures are managed according to the temperatures measured indoors and outdoors. This type of heating control is the most effective in terms of thermal comfort.

Benefits

- Optimisation of comfort conditions
- Covering differing heating demands in different zones/rooms
- Management of inactivity periods
- Control of minimum temperatures
- Optimisation of the energy generation
- Fast response to external climate variation
- Optimisation of the combustion process (particularly with condensing boilers)
- Reduction in energy consumption
- Longer life of the boiler

Restrictions

- Control systems should be user friendly and not complex, in order to encourage their use by the occupants

3.22 SMART METERS

Area:	**Indicator:**	**Adequate for:**	
Energy	- Installation of lighting meter; electrical appliances meter; heat meter; hot water meter; meter for heavy electricity consuming equipment - kWh/m^2/yr total consumption - kgCO_2eq total emissions - kW of peak power consumption (delivered from the grid)	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Energy consumption & operational cost		
Favours:	Better interaction between Customer and Energy Supplier, good management		

Function

Smart metering is a control system for real-time remote monitoring of electricity, gas and water, by the relevant Energy (or Water) Supplier.

Application

Smart Meters (SM) can be installed on both new and existing buildings.

Technical description

Smart metering is a control system, based on sensor networks (wireless, PLC, etc) for real-time monitoring of energy and water consumption. SM manages energy and information flows, optimising the performance of the plant. SM also permits remote interventions in cases of faults. Smart metering enables an innovative remote management of meters and therefore a new approach with customers.

The most common are electrical SM. The system is a smart infrastructure where the electronic meters installed at the customer's premises provide access to the actual parameters and contractual data of the supply through a display; a module for communicating with the Energy Supplier central systems and a switching device enabling, remotely, the consensus to connection and supply disconnection are also featured. Meters are therefore able to transmit data regarding consumptions, receive updates of the contractual parameters and remotely manage the supply connectivity.

Smart metering is one of the fundamental building blocks for the evolution of traditional electricity grids into Smart Grids, to adapt the grids to the new electrical market scenario. The employed technologies for building up the SM are well-known, and are typically cost-effective.

Benefits

Smart metering allows the introduction of a flexible tariff system (e.g. hourly-based), adaptable to the various needs, allowing customers to select a supply contract tailored to their needs and consenting to energy saving. The system represents also a step forward for the electrical system at large, improving the services to the customers, supporting the demand side management and providing a ground to Energy Companies for the improvement of their internal processes.

The remote management of the large majority of their main activities on meters can also help an Energy Company to reduce environmental impact, since on-site interventions are no-longer needed.

Restrictions

SM can only installed where the distribution grid of the Energy Supplier company so permits. In many countries (e.g. Greece), smart metering is currently still tested at pilot stage, before its application can be rolled-out on national basis in future. The Energy Supplier is in the process of adapting the relevant infrastructure to be able to accommodate such networks.

3.23 LOW ENERGY LIGHTBULBS

Area:	Indicator:	Adequate for:	
Energy	- kWh/m^2/yr lighting consumption - kgCO_2eq total emissions	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Lighting consumption		

Function

A Low Energy Lightbulb (LEL), or an energy saving lightbulb, is one that produces more light for less power, which results in electricity energy savings.

Application

LEL can be installed on both new and existing buildings and they are installed in exactly the same way as any other light fitting without the need for any additional wiring or equipment.

Technical description

There are many types of LEL available. The two most common are Light-Emitting Diode (LED) and Compact Fluorescent Lights (CFL).

- LED lamps are an emerging technology. LEDs are small, solid bulbs which are extremely energy-efficient. When first developed, LEDs were limited to single-bulb use in applications such as instrument panels, electronics, pen lights or Christmas lights. New LED bulbs are grouped in clusters with diffuser lenses which have broadened the applications for LED use in interior lighting applications such as in homes and commercial buildings.

  Today, LED bulbs are made using as many as 180 bulbs per cluster, and encased in diffuser lenses which spread the light in wider beams. Now available with standard bases which fit common household light fixtures, LEDs are the next generation in home lighting. The common styles of LED bulbs include the following:
  - Diffused LED Bulbs
  - Dimmable Globe LED bulbs
  - Track Lighting, pin base
  - Flood Reflector LEDs for Recessed Cans and Track lights, screw-in base
  - Flame Tip, Candelabra Base LEDs
  - LED Tube Lights

- Compact Fluorescent bulbs have been used for a long time, and the technology is constantly improving. CFLs can be screwed into standard lamp sockets, and give off light that looks similar to the common incandescent bulbs. CFLs are available in a variety of styles or shapes. Some have two, four, or six tubes. Older models, and specialty models, have separate tubes and ballasts. Some CFLs have the tubes and ballasts permanently connected. This allows changing the tubes without changing the ballast. Others have circular or spiral-shaped tubes. In general, the size or total surface area of the tube determines how much light the bulb produces. CFL bulb models come with standard sockets for easy installation in most common household applications and typically include the following:

- Spiral Lamps
- Triple Tube Lamps
- Standard Lamps
- Globe Lamps
- Flood Lamps
- Candelabra

Benefits

LEL consume up to 80% less electric energy than an incandescent lamp, for providing the same levels of visual comfort.

In particular, benefits from LED lighting are the following:

- Long-lasting: LED bulbs last up to 10 times as long as compact fluorescents, and more than 20 times than typical incandescent;
- Durable;
- Cool (these bulbs do not cause heat build-up);
- Mercury-free
- Very energy-efficient

CFL benefits are the following:

- Energy-efficient;
- Less expensive;
- High-quality light;
- Versatile (can be applied nearly anywhere where incandescent lights are used)

Restrictions

There are some current disadvantages to LED lighting which however are expected to be overcome as the technology becomes more widely adopted and technology improves:

- Current initial costs are higher than conventional lighting (however this is balanced by significant reduction in operational costs and a longer lifespan)
- LED lamps are heat sensitive. Excessive heat or inappropriate applications may reduce both light output and lifespan
- Colour appearance of the various low-energy lighting options should be taken into account, as this may affect visual quality and comfort

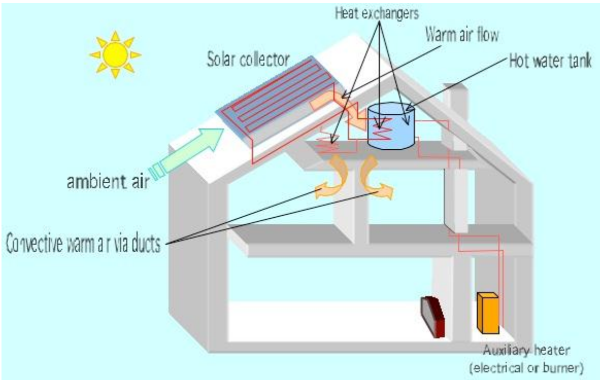
PART C – USE OF RENEWABLE ENERGY SOURCES

3.24 ACTIVE SOLAR SPACE HEATING

Area:	**Indicator:**	**Adequate for:**	
Energy	- $kgCO_2eq$ total emissions - Conversion factors to CO_2 emissions - kWh/y or % of renewable solar thermal energy of total	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating CO_2 emissions		
Favours:	Use of renewable energy		

Function

Active solar space heating uses solar thermal energy to heat the space inside a building, leading to energy and cost savings. This is achieved by using mechanical equipment such as pumps, fans and blowers to help with the collection, storage and distribution of heat throughout the space.



Application

Solar collectors are placed on flat or sloped roofs, ideally oriented South (optimum tilt varies per location, typically 30+/-10^o). The technology is mostly applicable to new buildings. They may be retrofitted to existing dwellings, however this is subject to potential limitations (structural load on the roof, space availability for equipment) and re-configuration of the existing heating system would be required.

Technical description

Active solar space heating systems use solar collectors to capture solar energy. There are two basic types of active systems based on the type of fluid heated inside the solar collector:

- <u>Liquid systems</u>: these are the same as those used for domestic solar water heating. The solar heat captured in the hot water is then stored in water tanks or the thermal mass of a radiant slab system. In water tank storage systems a heat-exchanger is used to transfer the heat to the water in the tank. There are various ways in which the solar thermal energy can then be distributed throughout the dwelling:
  - Radiant slab systems
  - Hot-water baseboards
  - Central forced air systems (using a water-to-air heat exchanger)

- <u>Air systems</u>: they use air as the fluid for capturing the solar thermal energy and transferring the heat to the living space. In the most common configuration, the collector draws cool air from the dwelling, heats it, and returns the heated air to the living space (closed-loop system). Another set-up is the open-loop system which draws in cold outside air, heats it and then transfers it to the living space. Distribution of the heated air is carried out by fans or blowers**.**

In both systems adequate controls should be installed which monitor temperatures within the collector and inside the space, in order to control the provision of heat.

A construction with high thermal mass helps store the solar thermal energy provided in the dwelling by the solar air heating system, absorbing the heat during the day and slowly radiating it at night into the living space.

Benefits

- Significant heating energy savings, CO_2 emissions and heating costs

Restrictions

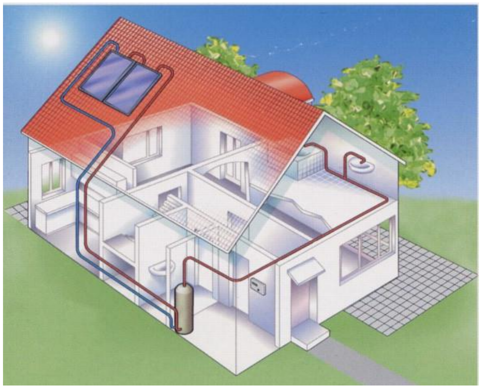
Large collector areas are required to produce adequate amounts of heat in the winter when heating is predominantly required, and when solar radiation levels are low. In the remaining period of the year the system effectively remains inactive, as passive solar gains (from windows etc.) are sufficient to provide adequate space heating.

3.25 DOMESTIC SOLAR HOT WATER HEATING

Area:	Indicator:	Adequate for:	
Energy	- kgCO_2eq total emissions - Conversion factors to CO_2 emissions - kWh/y or % of renewable solar thermal energy of total	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Domestic Hot Water CO_2 emissions		
Favours:	Use of renewable energy		

Function

Solar hot water heating uses solar thermal energy to heat water for domestic purposes (washbasins, kitchen taps, showers, washing machine), using solar collectors located on the building roof, through which water circulates.



Application

Solar collectors are placed on flat or sloped roofs, ideally oriented South (optimum tilt varies per location, typically 30±10^{o}). The technology can be applied to new buildings or retrofitted to existing ones within minimal implications, subject to the required space being available.

Technical description

Solar hot water systems use collector panels to capture solar energy. There are three basic types of collector panels:

- flat-plate collectors
- selective-coating collectors
- evacuated (or vacuum) tube collectors

The solar heat captured in the hot water is then stored in a hot water tank and pumped into the dwelling for domestic use. There are typically two configurations of the system:

- Split system: the collector panel is placed on the roof and the tank inside the dwelling. A pump is required to pump the hot water down from the panels into the tank. However, the energy for the pump is offset by reduced heat losses, as the tank is more protected. If the location where collector panels can be placed is far away from the location where hot water will be used, a split system results in better usage, as the hot water is stored closer to where it is used. An added benefit is the in-built frost support. In near-freezing temperatures the pump automatically starts circulating water to reduce the risk of freezing of the panels and pipework.
- Thermosyphonic system: a collector and tank system is mounted on the roof, with the tank placed directly above the collector panel. The "thermosyphon" principle is based on the naturally occurring phenomenon that hot water rises. Water going through the pipes in the

solar panel is heated up by the sun, becomes lighter than cold water so naturally flows up into the tank (being pushed up by cold water which follows in and gets heated up in the panel). The system avoids the use of a pump, thus is more reliable and cheaper to run. These systems are very popular in Southern Mediterranean countries. However they have a strong aesthetic impact on the exterior of the building, which often is undesirable. There are also situations where the hot water would need to travel a long distance from the tank to where it needs to be used in which case the split system would be more efficient.

Benefits

- Solar hot water heating is a very cost-effective non-polluting method of generating hot water for domestic applications, particularly in the Mediterranean climate where there are high solar radiation levels for significant periods over the year. In most cases the system can fully cover the residential hot water demand throughout the summer period and for significant periods at mid-season. This can lead to more than 60% annual energy savings which translate into CO_2 savings and cost savings.
- The system has low maintenance requirements.

Restrictions

- A solar hot water system alone is not sufficient to cover the entire annual hot water demand of a dwelling as in the winter it only produces limited amounts of hot water due to the low levels of solar radiation available. Therefore it needs to be supplemented by a conventional hot water generation system, gas or electric-fuelled.
- At periods of very low external temperatures in the winter, there is the risk of frost damage of the panels and pipework. To avoid that, water should circulate through the system to prevent its components from freezing.
- In certain areas, e.g. heritage areas etc, there may be planning restrictions in locating solar hot water systems on the roof (particularly those of the thermosyphonic type) so as to preserve the architectural character of the area. As an example, in a lot of the Greek islands such restrictions are imposed.
- Careful siting of the collectors is required so that they are not overshadowed by other structures / buildings, as this significantly lowers their performance.

3.26 PHOTOVOLTAIC PANELS

Area:	Indicator:	Adequate for:	
Energy	- $kgCO_2eq$ total emissions - Conversion factors to CO_2 emissions - kWh/y or % of renewable electric production of total	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Electricity CO_2 emissions		
Favours:	Renewable energy use		

Function

Photovoltaic panels (PVs) convert sunlight into electricity, which can be connected into a building's power network and supply some of its electrical demand. At times when there is surplus of electricity generated by the panels which cannot be used in the building, this can be fed back into the national grid.

PV panels on the roof of private residence in Rhodes, Greece

Application

PV panels are placed on flat or sloped roofs, ideally oriented South (optimum tilt varies per location, typically 30±10^o). The technology can be applied to new buildings or retrofitted to existing ones within minimal implications, subject to the required space being available.

PVs can also be "integrated" into the building's structure, replacing traditional roofs or walls materials, or used on shading elements like external louvres. Semi-transparent PVs (integrated within glazing) allow some transmission of daylight through them and can be used in cases such as atria roofs, becoming an architectural element which at the same time generates power.

Technical description

PV panels consist of a number of PV cells. Each cell consists of two thin layers of semi-conducting materials ('p'-positive and 'n'-negative), usually silicon, with specific chemicals added. Sunlight shining on the solar cells releases electrons from the orbits of the semi-conductor in sufficient numbers to generate a direct current (DC). The DC power generated passes through an inverter to create alternating current (AC) which can then be used in domestic appliances (topped up if necessary by the grid).

The performance of solar panels is measured in terms of their efficiency at converting solar radiation into electricity.

There are various types of solar panels available, with varying efficiencies:

- Hybrid: ~20%
  Hybrid panels combine the benefits of monocrystalline and amorphous, leading to maximum power output per square meter of panel
- Monocrystalline: ~13-15%
- Polycrystalline: ~10-13%
  Monocrystalline and polycrystalline are the most commonly used type of panels, as they offer good efficiency at reasonable cost
- Thin-film (amorphous): ~5-7%
  This type of panel is made from a flexible material having the form of a membrane, so it can be used on curved building roofs. It has better efficiency in diffuse light, so it better performs in locations with high levels of diffuse radiation. However, due to its low efficiency, it requires a large surface area in order to produce a reasonable output.

Benefits

- Power generation using PVs uses the sun which is a renewable source of energy, reducing traditional power generation therefore saving on CO_2 emissions and other harmful pollutants.
- Conventional electricity use reduces therefore saving on energy costs. Furthermore, most countries operate a “feed-in tariff” scheme, whereby the government pays people a certain tariff for each kWh of electricity they generate using PVs. If surplus of energy is generated it can be sold back to the grid.
- PVs are a technology with no moveable parts, therefore it is noise-free
- They have low maintenance requirements.

Restrictions

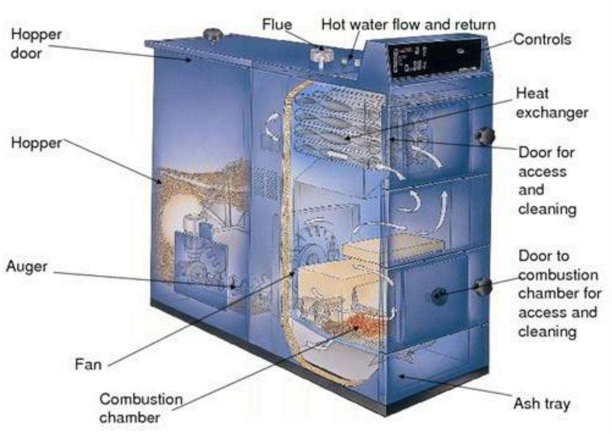
- Capital costs have fallen significantly in with the rapid expansion of the technology in recent years, however they still remain considerably high in relation to the running cost savings.
- Panels integrated into building elements are more expensive than those which are mounted on a stand-alone structure on the roof.
- In certain areas there may be planning restrictions in locating PV panels on building roofs due to aesthetics reasons.
- The performance of PV panels reduces when dirt gradually covers the surface of the panel, therefore occasional maintenance is required cleaning the panels surface, in order to maintain their optimum efficiency.
- The performance of PV panels reduces when excessive heat accumulates at the rear side of the panel, therefore their mounting should ensure that the space behind the panels is properly ventilated.
- Careful siting of the panels is required so that they are not overshadowed by other structures / buildings, as this significantly lowers their performance.
- The panels should be installed by accredited electrical installers.

3.27 ENERGY FROM BIOMASS

Area:	Indicator:	Adequate for:	
Energy	- $kgCO_2eq$ total emissions - Conversion factors to CO_2 emissions - kWh/y or % of renewable thermal energy (/electricity) of total	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Heating and Domestic Hot Water CO_2 emissions / Electricity CO_2 emissions (if used in biomass CHP)		
Favours:	Renewable energy use		

Function

Biomass is the term used for substances deriving from organic (animal or vegetable) matter. Biomass is a renewable source, and can be used as a fuel to generate energy for buildings.



Application

In domestic applications, biomass can be used to generate space heating and hot water. The most typical application is the use of biomass boilers that burn wood pellets or chips to produce heating energy. In larger scale developments, biomass can be used as a fuel in CHP units, producing both heat and electricity for domestic uses (e.g. lighting and appliances, cooling).

Technical description

Biomass is considered as a "carbon-neutral" technology. Through the process of photosynthesis, chlorophyll in plants captures the sun's energy by converting CO_2 from the air and water from the ground into carbohydrates (compounds composed of carbon, hydrogen and oxygen). When these carbohydrates are burned, they turn back into CO_2 and water and release the energy they initially captured from the sun. In this way biomass functions as a "natural storage" of solar energy. Biomass is a renewable energy source not only because the energy comes from the sun but also because it can re-grow over a relatively short period of time. As long as it is produced sustainably – meeting current needs without diminishing resources or the land's capacity to regrow biomass and recapture carbon – then it can continually provide a source of low-carbon energy.

There are various forms of biomass that can be used in building applications. The most effective and sustainable one will vary from region to region and will depend on the availability of resources in the region, and the efficiency of converting biomass into its final application.

The most common biomass forms are:

- Wood: including logs, woodchip or pellets. The source can be directly from forestry, residues from processing or discarded materials from sectors such as construction
- Energy crops: crops grown specifically for the purpose of use in renewable energy technologies (e.g. short-rotation coppice, miscanthus)
- Wastes and residues: the biomass in household or commercial/industrial waste can be used for generating energy
- Sewage gas: biogas produced by the anaerobic digestion and incineration of sewage sludge from waste water plants. The gas contains a mixture of methane, carbon dioxide, hydrogen, nitrogen and hydrogen sulphide. It is compressed and purified before it can be transformed into mechanical and thermal energy, or power a generator to produce electricity
- Biomethane: it is the gas produced by the purification of biogas through the removal of any residual carbon dioxide to create pure biomethane

Biomass has been used for space heating for years, in the form of wood-burning stoves and open fires. Recent advances in technology have led to the development of biomass boilers which provide an efficient solution to heat water for both space heating and domestic hot water use. Biomass boilers burning wood (chip or pellets) are the most common form used in small scale residential applications. Other forms of biomass mentioned above are typically used at larger scale developments, e.g. in district heating schemes, industrial buildings, power stations etc.

Biomass boilers range in size from a few kilowatts (kW) for houses or small commercial buildings to megawatt (MW) size units for district heating systems.

The operation of a biomass boiler is summarised as follows:

Wood fuel, stored within a hopper, is (manually or automatically) fed it into a combustion chamber by an auger, which is ignited by an electronic probe. The rise in temperature due to combustion heats water which can then be circulated around the building’s heating/DHW system. Ash is a residue of the process, which is collected in an ash tray and needs regular emptying.

Benefits

- When compared with traditional fossil fuels, biomass is a sustainable “carbon neutral” fuel, as it emits on average the same amount of carbon dioxide as is absorbed by the plants before they are converted to fuel, therefore giving an overall net balance.
- Use of biomass reduces conventional fuel consumption and related energy costs
- High efficiency (>90%), comparable to high efficiency conventional boilers
- Many countries operate incentive schemes paying back households with a biomass heating system for each kWh of heat they generate.

Restrictions

- Biomass combustion produces air pollution in the form of NOx (nitrogen oxides), VOCs (Volatile Organic Compounds), particulates etc, in some cases at levels above those from traditional fuel sources, so air quality issues need to be addressed by careful design and location of the boiler flue. In many countries there are stringent air quality regulations in urban environments posing limitations for the emissions from biomass boilers.
- Like all energy sources, energy from biomass has some environmental risks which need to be mitigated. If not managed carefully, biomass can be harvested at unsustainable rates, damage ecosystems, produce harmful air pollution, consume large amounts of water and produce net greenhouse emissions. However, there is a wide range of biomass resources that can be produced sustainably and with minimal harm, whilst reducing the impact from using fossil fuels. Implementing proper policies at national and international level is essential to securing the benefits of biomass and avoiding its risks.
- Biomass boilers should not be oversized, as they operate best when they work at their maximum output, with the fuel burning fast and at high temperature. When low levels of output are required it may not be the optimum solution. In such cases it is more efficient to provide a small size biomass boiler supplemented by a conventional boiler. In the winter the biomass boiler would be working at its maximum, using the supplementary boiler where required to meet peak demand for just the coldest days of the year, whilst in the summer and mid-season it can work generating hot water, which is a constant demand throughout the year for residential buildings.
- With rapid progress of the technology in recent years, a high degree of automation has been incorporated within the boiler minimising maintenance requirements. However, some maintenance is still required in re-filling the fuel store and emptying the ash with remains as a residue from the combustion process (the required frequency for emptying the ash depends on the use, but typically it could be every 6-8 weeks).
- Dedicated space is required in the building, for locating the biomass boiler and the fuel store. Good design of the biomass fuel store, considering the frequency and mode of delivery of the fuel, as well as access for maintenance, is very important for an efficient, smooth operation of a biomass installation.
- Biomass boilers need to be installed by accredited installers.

4. WATER

PART A – WATER DEMAND AND CONSUMPTION REDUCTION

4.1 WATER-EFFICIENT DEVICES

Area:	Indicator:	Adequate for:	
Water	- Use mechanisms to reduce water consumption (% reduction of potable water from local baseline)	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Water demand		

Function
Water-efficient devices can be used or applied to water fittings, in order to reduce the demand for potable water in dwellings.

Application
Water-efficient devices in dwellings include: low and dual flush WCs, delayed inlet valves in WCs, flow restrictors for taps and showers, water saving baths.

Technical description
The following devices can be used to reduce water demand, and can either be installed in new dwellings or retrofitted into existing ones:

Low & dual-flush WCs
These are designed to reduce the volume of water consumed during flushing. Systems include:

- single flush cisterns of low flow (e.g. 4.5ls, 4ls)
- dual flush cisterns providing a 'part' flush and a 'full' flush using different levels of water (e.g. 6/4ls, 6/3ls or 4/2.6ls)
- delayed action inlet valves: these are fitted to WCs, to prevent water immediately re-entering the WC cistern whilst the toilet flushes.

Flow restrictors
These are devices which contain holes or filters to restrict water flow and reduce the outlet flow and pressure. They are typically fitted within the console of taps or shower heads, but can also be fitted in the pipework or at the water mains inlet to the dwelling.

- Flow restrictors in washbasin taps can limit the flow to <6ls/min, compared to a conventional tap of 10-12ls/min. The can be screwed onto or fitted onto the tap outlet, or onto the base of the fitting.
- Flow restrictors in showers can limit the flow to <9ls/min, compared to a conventional shower of 12-15ls/min. They can be fitted between the shower valve and the shower hose and head.

Water-saving baths

Baths can be used that prevent the use of excessive amounts of water, either by having a reduced capacity to the overflow, or by their shape which is altered to reduce the bath's capacity but maintaining the water depth.

- A water-saving bath can have a capacity of <120ls, as opposed to a conventional average bath capacity of 190ls.

Benefits

Using low water fittings in a dwelling can result in water savings of up to 60% compared to using conventional fittings, having environmental as well as cost benefits.

Restrictions

- Although low water WCs may be retrofitted to existing properties, attention should be given to connecting them to old existing pipework in bad condition, which may result in blockages if low volumes of water are used.
- In all cases, when selecting water-efficient fittings, compliance with the water regulations applicable to each country should be ensured.

4.2 PLANT WATERING SYSTEMS

Area:	**Indicator:**	**Adequate for:**	
Water	- Use efficient systems for irrigation or use non-potable water (% reduction from local baseline)	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Water consumption		

Function

Sustainable plant watering systems include automatic systems which control the amount of water supplied based on a pre-determined schedule and/or depending on the plant requirements. Reclaimed rainwater or greywater can be used, combined with an automatic irrigation system.

Application

In residential applications, areas which may contain plants requiring irrigation can be private or communal, and include gardens, patios, terraces and balconies.

Technical description

<u>Drip feed irrigation</u>

Automatic drip feed or micro irrigation systems disperse water to the plants in a method that is programmable, so it can be set depending on the specific environment and plant requirements, or on a timer. The water flows out of small devices which can either be placed close to the soil surface near the plant or below the soil surface directly in the plant root zone. The most advanced systems incorporate soil moisture sensors, so that only the amount of water required is provided without excess water being wasted. The irrigation control can be zoned to permit variable irrigation to different planting assemblages which have different water requirements.

<u>Rainwater/Grey water recycling</u>

Reclaimed water either from rainwater harvesting or from a grey water recycling system can be used for the irrigation of planting and landscaping. The collected water in both cases would pass through appropriate filters, removing debris etc, before being supplied to plants through a drip irrigation system. A storage tank would be required, the size of which can vary depending on the location/ amount of rainfall and the use of the recycled water, i.e. whether it is used purely for irrigation or for other purposes too). More information on rainwater and greywater collection systems can be found in sections 4.3 and 4.4 of this report.

Benefits

- The benefit of micro-irrigation systems is that water transfer loss, as well as loss from evaporation and run-off are minimised. Providing plants only with the amount of water they require without excess water being wasted, results in both environmental and cost savings.
- Using reclaimed water (rainwater/greywater) for irrigation offers significant savings as it offsets potable water from the mains that would otherwise be required.
- Water savings which can be achieved through sustainable irrigation systems, become increasingly important especially in the Med areas which tend to have hot and dry summers with water shortages.

Restrictions

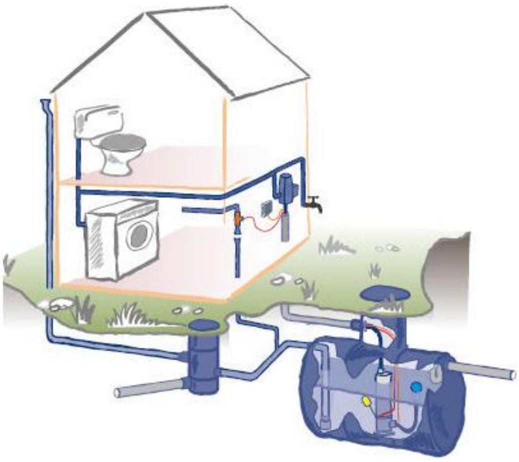
- An automatic irrigation system can be easily installed by a homeowner or landscape contractor; however if combined with a rainwater or greywater recycling system the installation becomes more complex and needs to be carried out by an experienced plumber.
- Design restrictions apply when storing greywater or rainwater in tanks, so as to avoid health & safety issues.
- In the Mediterranean areas where rainfall levels are limited, storing rainwater would only be able to partly cover the annual irrigation demand, being effective in winter and mid-season. For the summer months an alternative solution would be required.

PART B - WATER RECYCLING

4.3 RAINWATER RECYCLING

Area:	Indicator:	Adequate for:	
Water	- Use rainwater or groundwater (% reduction of potable water from local baseline)	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Water consumption		
Favours:	Water cycle optimisation		

Function



Fresh water is an increasingly scarce and expensive resource. Using collected rainwater instead of fresh potable mains water for some domestic uses, such as toilet flushing and irrigation of planting, can offer significant environmental and cost savings.

Application

Rainwater collection can be applied on an individual dwelling or as a communal system for a number of dwellings. It is a widely used technology throughout Europe and there are numerous configurations of systems that can be applied, depending on the site-specific and building-specific conditions. The technology is best suited to new-build properties, due to significant practical issues that would arise if it was to be retrofitted into an existing building.

Technical description

A typical residential rainwater collection system includes a rainwater pipe through which the collected water is channelled through a filter unit, to exclude leafs, debris and other large particles. The filtered water is then diverted into a storage tank, typically placed underground (but can also be placed above-ground). Further cleaning takes place by settlement in the tank, with heavy particles remaining at the bottom. Using a pump located within the storage tank, pressurised water can be supplied on demand, to WCs, washing machines or external irrigation points. An alternative configuration, particularly used when rainwater is only intended to supply WCs, includes an additional internal header tank. If the system runs low on rainwater, a solenoid valve is used to provide top-up water from the mains supply, to guarantee continuous supply of water to the fittings, compliant with the water regulations. Excess water from the tank discharges through an overflow.

To calculate the size of system required, the volume of water that can be collected (rainwater yield) in the particular location based on the annual rainfall and the available collection area must be identified, and compared to the amount of water needed, based on the consumption of the fittings to be supplied by rainwater.

Benefits

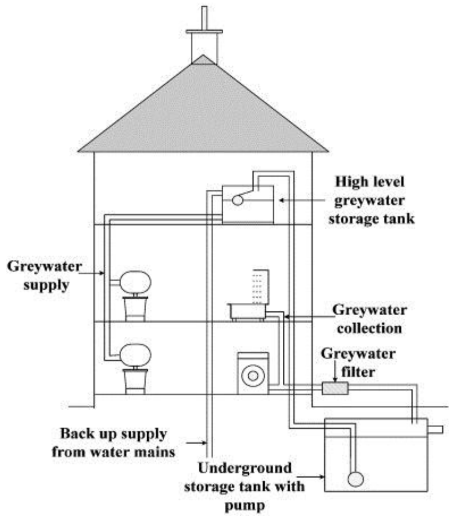
- Reduction of consumption of mains water for non-potable uses, thus reduced impact on the environment
- Reduction of water costs
- Attenuation of storm water runoff
- Well-established technology with many applications in European countries

Restrictions

- Rainwater in its raw state is not suitable for drinking or bathing and is not recommended for use in hot water systems. In addition, in Mediterranean locations where rainfall levels are limited, the rainwater yield is unlikely to be sufficient to meet all household needs, therefore rainwater re-use would typically be limited to toilet flushing, laundry, irrigation, car washing.
- Regular maintenance is required of the filter unit (every few months), to ensure that the stored water will not deteriorate in quality. Good quality filters, pumps and controls and careful design can minimise the maintenance requirements
- The technology is best suited for new-build properties. To incorporate it into an existing building would have significant implications such as disruption and high costs associated with re-routing the existing internal plumbing and drainage pipework, in order to connect to the rainwater pipework and storage tank.

4.4 GREYWATER RECYCLING

Area:	**Indicator:**	**Adequate for:**	
Water	- Use of recycled water (% reduction of potable water from local baseline)	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Water consumption		
Favours:	Water cycle optimisation		



Function

Greywater is the wastewater from showers, baths, hand basins, excluding the more contaminated water from washing machines, kitchen sinks and dishwashers. The water can be collected from these sources and, after treatment, be used for domestic uses that do not require drinking water quality, such as toilet flushing or irrigation of planting/landscaping.

Application

Greywater collection can be applied on an individual dwelling or as a communal system for a number of dwellings. It is ideally suitable for communal systems, as potential problems of uneven supply and demand can be avoided, with people's different consumption patterns. The technology is best suited to new-build properties, due to significant practical issues that would arise if it was to be retrofitted into an existing building.

Technical description

Greywater reuse systems can vary in complexity and size, from small systems with very simple treatment to larger systems with complex treatment processes. However, systems would typically include the following common features:

- A tank for storing the treated water
- A pump
- A distribution system for transporting the treated water to where it is needed
- A level of treatment

All greywater systems have to incorporate some level of treatment as untreated greywater deteriorates rapidly in storage. This is mainly because it is often warm and rich in organic matter, providing ideal conditions for bacteria growth, resulting in odour problems, poor water quality and potential health risks.

There are different types of greywater systems depending on the type of treatment they use:

- Direct reuse systems (no treatment)

Greywater is reused without any treatment provided e.g. once bath water has cooled, it can be used directly to water a garden. This is an inexpensive way of saving water and avoiding storage issues, however the water must not be stored for long before use, because its quality will deteriorate rapidly.

- Short retention systems

These systems apply a very basic treatment to greywater, such as skimming debris off the surface and allowing particles to settle to the bottom of the tank. The principle is that the greywater is not stored for too long, otherwise, if it is not used within a certain time the stored water is released and the system is topped up with mains water. These systems have relatively low capital and maintenance costs.

- Physical and chemical systems

These systems use a filter to remove debris from greywater before storing it, and use chemical disinfectants (e.g. chlorine or bromine) to stop bacterial growth during storage.

- Biological systems

These systems use bacteria to remove organic material from wastewater. Oxygen is introduced to wastewater to allow the bacteria to ‘digest’ the organic contamination. There are different ways of supplying the oxygen: some systems use pumps to draw air through the water in storage tanks while others use plants to aerate the water. Reed beds can also be used, whereby wastewater is passed through the soil/gravel in which the reeds are growing and the bacteria fed by the oxygen from the reeds and nutrients from the wastewater decompose the waste.

- Biomechanical systems

These are the most advanced systems, which use a combination of biological and physical treatment. The units typically include both a filter and organic matter removal by bacteria, as well as UV disinfection. The size of units is larger than in other systems and would require installation in a basement or garage; it would also be more suited for communal systems.

The type of system that is suitable for each particular application needs to be assessed on a project specific basis, after establishing the water requirements and water usage patterns in relation to the quantity of greywater that is available.

Benefits

- Reduction of consumption of mains water for non-potable uses, thus reduced impact on the environment
- Reduction of water costs
- Attenuation of storm water runoff
- More reliable and consistent supply of non-potable water compared to rainwater, reducing the amount of mains back-up required

Restrictions

- Greywater systems are relatively expensive to purchase, maintain and run, while the cost of water still remains relatively low, so there is currently limited financial incentive to install such systems. However as water charges increase, the systems will become more cost-effective.
- In Med countries there is often lack of national standards relating to quality of non-potable reused water, thus increasing people's perception of potential health risks associated with it.
- National regulations may apply in relation to preventing non-potable water entering the mains water supply.
- Reusing greywater at a domestic scale is generally energy and carbon intensive, especially when intensive treatment is used. The priority should be to focus on water efficiency first. Reusing greywater for irrigation saves energy and water, but the water must not be stored for long.
- For systems with filters, these require regular cleaning to avoid blockages.
- Environmental impact and cost implications of the use of disinfectants should be considered when assessing the overall costs and benefits.
- Bio-mechanical systems produce high quality of water however they are expensive to purchase and operate, and have higher space requirements.
- Greywater systems are best suited for new-build properties. To incorporate them into an existing building would have significant implications such as disruption and high costs associated with re-routing the existing internal plumbing and drainage pipework.
- Best suited for communal systems as opposed to individual installations, as they can offer improved supply/demand balance, higher water quality, higher reliability (through better maintenance) and more reliable cost savings

5. HEALTH AND COMFORT

5.1 REDUCE SOURCES OF RADIATION

Area:	Indicator:	Adequate for:	
Health & Comfort	- Use of measures for the reduction of natural radiation - Level of materials and equipment with radioactivity emissions	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Radiation levels, health risks		
Favours:	Indoor health & comfort		

Function
Human exposure to radiation can occur due to exposure to a number of natural or man-made sources. Good building design and careful selection of materials and equipment can minimise the sources of potentially harmful radiation.

Application
The majority of the radiation received by occupants in a residential building comes from naturally occurring sources – radon and other radionuclides people eat, drink or breath, and by human-made sources i.e. household products.

Technical description
There are two main types of radiation sources that can pose a risk to residential buildings:

- Natural sources of radiation

Naturally occurring radiation can be found in soils, air and water, and people encounter it every day through the food they eat, the water they drink and the air they breathe. In proportion, the majority of natural radiation received is from radon. Radon (222), is a colourless, odourless gas which is produced by the decay of radium-226, both being part of the uranium decay chain. Uranium can naturally occur in the soil and water, in varying concentrations depending on location. Therefore radon can be found in the soil and rocks beneath homes and in underground waters. However, as its concentration in domestic water supplies is highly regulated, the greatest risk for radon entering homes is from the soil through any cracks and holes in the foundations, concrete walls and floors, joints, basement drains and other openings. Unsafe levels of radon could accumulate in poorly ventilated homes and buildings. Exposure to high levels of radon increases the risk of developing lung cancer.

To minimise the potential for radon concentration, good building design and operation is essential, by two means: 1) ensuring continuity of the building envelope especially where it comes in contact with the ground, avoiding cracks, and sealing gaps around construction elements joints or building services penetrations and 2) designing doors and windows so that efficient natural ventilation can be achieved, and opening them frequently, to prevent radon from building up in the indoor air.

Furthermore, some building materials (like some ceramics) are known to have slightly higher natural background radiation than others, however these are normally within accepted limits and not known to cause any adverse health effects.

- Human-made sources of radiation

Some of the products people own and use regularly might contain radioactivity or emit radiation. When they are used according to their instructions for use, they do not pose any health risk. Examples of such products which may contain small amounts of radioactive materials are smoke detectors, some foods, fertilizers, some antique items (e.g. old watches and clocks with dials visible in the dark; old glassware, tiles and pottery; old camera lenses). Electronic equipment such as TVs, computer screens etc may emit some levels of radiation however there are stringent standards regulating these so manufacturers are required to demonstrate that their products meet radiation emissions levels which are considered safe, before any product can be commercially available.

Benefits

Minimising the exposure to sources of radiation, natural or man-made, reduces the risk of health problems developing and improves occupant’s health and comfort.

Restrictions

There is often lack of awareness of building occupants as to the potential sources of harmful radiation. Added to that, there is often insufficient information given by manufacturers on their products’ properties on the product labels.

5.2 LOW VOC MATERIALS

Area:	Indicator:	Adequate for:	
Health & Comfort	- Indoor materials with VOC emissions (Y/N)	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	VOC levels, health risks		
Favours:	Indoor air quality		

Function

Volatile Organic Compounds (VOCs) are emitted by a wide range of interior building products. Using no or low-VOC building products minimises the negative impacts on indoor air quality.

Application

Low VOC building products can be used when specifying: paints and varnishes, glues, wood panels (e.g. particleboard, fibreboard, wood flooring, wall panelling), textile and laminated floor coverings (e.g. vinyl/linoleum, carpet etc), flooring adhesives, wallpapers. Such products may be used in both new builds and refurbishment projects.

Technical description

Volatile Organic Compounds (VOCs) are organic chemicals, of which large number of molecules enter the surrounding air and when at high concentrations, can be dangerous to human health. Exposure to VOCs can trigger asthma attacks, create throat and eye irritation, nausea and headaches, amongst other health problems.

Some of the more common VOCs used in paints as solvents and preservatives include formaldehyde and benzene. Pigment chemicals can include lead, cadmium and chromium.

The risk of human exposure to the release of chemicals from manufactured products and their possible impact on indoor air quality and health, is an important consideration in European regulations and there are a number of European Directives regulating the use of such products.

The emissions of VOCs from paints and varnishes are regulated by the European Directive 2004/42/CE. Products containing high organic solvent content should also be avoided, according to the EU VOC Solvent Directive 1999/13/EC. The possible impact of building products on indoor air quality is included in the European Construction Products Directive, 89/106/EEC. The amended Directive, 93/68/EEC provides the criteria for CE Marking of products.
Products to be fitted in buildings should not contain any substances regulated by the Dangerous Substances Directive 2004/42/CE, which could cause harm to people by inhalation or contact. Materials containing heavy metals (e.g. antimony, barium, cadmium, lead and mercury) and other toxic elements (e.g. arsenic, chromium and selenium) or regulated biocides (e.g. pentachlorophenol)

should be avoided. The UK's BRE Digest 46437 also includes products which have been tested and shown to be low-emitting.

Low- or no-VOC paints are available from most standard mainstream paint manufacturers. These 'eco-friendly' paints are typically water-based paints rather than solvent-based, and they may use other organic materials such as plant oils and resins, plant dyes; natural minerals such as clay and chalk; milk casein, bees' wax etc.

Benefits

- Reduced toxins, improving indoor air quality
- Reduced landfill, groundwater and ozone depleting contaminants from disposal
- Low- or no-VOC paints have lower odour than standard paints

Restrictions

There is often lack of awareness of building occupants as to the potential health risks by VOC emitting products. Added to that, there is often insufficient information given by manufacturers on their products' properties on the product labels.

6. SOCIAL

6.1 BUILDING USERS GUIDE

Area:	Indicator:	Adequate for:	
Social	- Future users will receive the necessary information for an accurate use and maintenance of the building and its components	New	Refurbishment
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Impacts from faulty operation, environmental impact and costs		
Favours:	Information and participation of users, good management, optimum equipment operation, comfort		

Function

Providing to future occupants, a 'users' guide' enables them to understand and operate their home efficiently and make best use of the available services and facilities.

Application

A building users' guide can be produced and be provided to future residents and facilities managers of residential buildings, by the developers or owners of the properties. It is mainly applicable to new build properties, but also to those that have undergone major refurbishment.

Technical description

A building users' guide is a simple guide that can be provided to future users of a dwelling that contains necessary details about the everyday use of their home. For residential buildings with a number of dwellings including communal areas, a variation of the users' guide can be provided to the building facilities manager, including more technical details and information on the operation of the communal equipment and facilities.

Indicative information that can be contained within a building users' guide includes:

- Details on the environmental strategy or any specific sustainable design features of the dwelling and how they should be best operated
- Details on installed energy-saving appliances and controls, information on how to operate them, and tips on reducing energy use; information on the heating, cooling, lighting, domestic hot water systems installed, as well as any renewable energy technologies
- Details of any water-saving fittings/systems and controls, information on how to operate them, and tips on reducing water use
- Details of the waste and recycling facilities available, and of the Local Authority collection scheme (if available)

- Details of local public transport facilities, and of cycle and car parking provisions
- Information on the location of local amenities (cash machine, pharmacies etc) and of places of interest
- Information on purchasing sustainable products, e.g. low-energy light fittings and bulbs, low energy/low water white goods etc.
- Emergency information (medical, police, fire service)
- Contact information, of the company responsible for the construction and for the management of the property

Benefits

- Giving the users simple information on the features of their home and on how to make best use of them can lead to reducing the environmental impact from the building's operation, i.e. to energy and water savings, increased recycling etc.
- Better awareness of how to operate the home can increase the occupants' comfort
- Better management and operation of the building's installed services and equipment can lead to reduced running costs
- Being informed increases the sense of participation and social integration/well-being within the residence and the surrounding environment

Restrictions

A building users' guide should act as a simple informative tool, to assist occupants in making best use of the available facilities within their home. This should act in a supplementary way, to equipment and controls selected in the first place to be user-friendly and self-explanatory where possible, so as to promote its correct use on an everyday basis.

7. ECONOMY AND MANAGEMENT

7.1 BUILDING ENERGY MANAGEMENT SYSTEM (BEMS)

Area:	Indicator:	Adequate for:	
Economy & Management	- Installation of lighting meter; electrical appliances meter; heat meter; hot water meter; meter for heavy electricity consuming equipment - Meter screens are easily accessible for users	New	Refurbishment (with restrictions)
Applicable in:	Spain, France, Italy, Croatia, Greece		
Reduces:	Energy consumption & operational cost, impacts from faulty equipment operation		
Favours:	Information and participation of users, good management, optimum equipment operation, comfort		

Function

A Building Energy Management System (BEMS) monitors and controls the operating systems within a building, using specially designed software, and giving feedback on systems operations and energy consumption.

Application

Building Energy Management Systems are ideally installed on new buildings, so that the controls network can be designed early and integrated appropriately into the design and installation of the building services equipment. BEMS can be retrospectively fitted on existing buildings however there may be restrictions on controlling some of the systems, due to their existing configuration or potentially out-dated type.

Typically the application of BEMS is more essential on large buildings where a variety of parameters would need to be monitored and controlled, e.g. on a high-rise apartment building. The system can then be operated by building management or maintenance personnel, and changes to control settings made where required.

However, there are also smaller scale energy management systems developed specifically for dwellings, often referred to as “smart home systems”. These rely on operation by the building users, and give them the possibility to control all appliances and systems within their home, optimising their operation, as well as leading to energy savings and improved occupant comfort.

Technical description

A network of sensors and meters are connected to all installed equipment and give digital outputs of energy consumption on a central system. The smart control systems record in real-time, all sources of energy consumption (from lighting, electrical appliances, heating etc) and with the appropriate control devices/routines they can coordinate the optimum operation of the dwelling.

“Smart home” systems can incorporate automated controls for a number of additional operations e.g. operation of shading devices, irrigation, intruder’s alarm etc. There are options for remote operation of the system and adjustment of control settings by the user (either via a mobile phone or via the internet).

Benefits

- Management of energy and water consumption within the dwelling, savings through the optimum control of systems
- Resulting cost savings
- Improvement of occupant comfort: optimum management of internal conditions/setpoints regarding heating, cooling, lighting, DHW etc, and possibility of remote control
- Safety for equipment and residents: possibilities for the system to detect faults and remotely alert the occupants (e.g. in case of power cut, fire, sound of intruder alarm etc).
- Flexibility to future expansion or adjustment of control settings

Restrictions

- Systems should be selected to be user-friendly in terms of settings adjustment and faults detection, without the need for frequent servicing by specialists
- Automations do not replace good building design (architectural, M&E), which is the key factor in achieving low environmental impact and comfortable internal conditions. However, automations assist in optimising the way of using the building.
- The most efficient systems apply to new buildings, as there needs to be early provision for the necessary cabling and telecommunications network, consulting an electrical engineer/contactor. Nevertherless there are simpler systems which can be retrofitted to existing buildings.

C. CLASSIFICATION OF TECHNOLOGIES AND MATERIALS

Following the assessment of the individual materials and technologies as presented in section B of this report, an overview was undertaken of their applicability to different types of residential projects (new build / extensions / refurbishments) and of their main environmental benefits. The following two tables present a summarised classification of the main attributes related to each material/technology:

1. APPLICABILITY

Thematic area	Building element / technology	Applicability		
		New build	*Extension*	*Refurbishment*
TERRITORY AND SITE	Drought-resistant plants	●	●	●
	Green roof	●	●	▲
	Permeable paving	●	●	●
	Cool materials	●	●	●
MATERIALS	Local ground	●	●	●
	On-site reused structural materials	○	○	●
	Local structural wood	●	●	●
	Wood-based insulation	●	●	●
	Wood carpentry	●	●	●
ENERGY	External thermal insulation composite systems	●	●	●
	Passive solar systems	●	●	●
	Roof insulation	●	●	●
	Reflective insulation	●	●	●
	Wall cavity insulation	●	●	●
	Insulated window frames	●	●	●
	Secondary glazing	X	X	●
	Low-emissivity glazing	●	●	●
	Gas filling for glazing	●	●	●
	Draughtproofing	X	X	●
	External shading devices	●	●	●
	Ventilated facades	●	●	▲
	Evaporative cooling	●	●	●
	Ceiling fans	●	●	●
	Micro-cogeneration	●	●	●
	Low temperature heating systems	●	●	▲
	Geothermal heat pump systems	●	●	▲
	Heat recovery units	●	●	●
	Wastewater heat recovery systems	●	▲	▲
	Heating system controls	●	●	●
	Smart meters	●	●	●
	Low-energy lightbulbs	●	●	●
	Active solar space heating	●	●	●
	Domestic solar hot water heating	●	●	●
	Photovoltaic panels	●	●	●
	Energy from biomass	●	●	●
WATER	Water-efficient devices	●	●	●
	Plant watering systems	●	●	●
	Rainwater recycling	●	▲	▲
	Greywater recycling	●	▲	▲
HEALTH & COMFORT	Reduce sources of radiation	●	●	●
	Low-VOC materials	●	●	●
SOCIAL	Building users' guide	●	●	●
ECONOMY & MANAGEMENT	Building Energy Management System (BEMS)	●	●	▲

Notes

- ● Applicable
- ○ Possibly applicable
- ▲ Applicable with restrictions
- X Not applicable

2. ENVIRONMENTAL BENEFITS

Thematic area	Building element / technology	Environmental benefits																
		particularly suitable to Med climate	reduction of materials/building lifecycle impacts (energy, CO_2, water etc)	reduction of operational heating energy / CO_2 emissions	reduction of operational cooling energy / CO_2 emissions	reduction of operational DHW energy / CO_2 emissions	reduction of operational electrical consumption / CO_2 emissions	reduction of operational water demand or consumption	reduction of water run-off and flood risk	benefit to local labour	sustainable origin	recyclability	local production of components /materials	occupants' health & comfort	reduction of air or water pollution	low maintenance	user participation	good management / efficient operation
TERRITORY AND SITE	Drought-resistant plants	√							√							√		
	Green roof	√	√	√	√										√			
	Permeable paving								√						√			
	Cool materials	√	√		√									√				
MATERIALS	Local ground		√							√	√	√	√	√	√			
	On-site reused structural materials		√							√		√	√		√			
	Local structural wood		√	√	√					√	√	√	√		√			
	Wood-based insulation		√	√	√						√			√				
	Wood carpentry		√							√	√	√	√					
ENERGY	External thermal insulation composite systems			√	√									√				
	Passive solar systems	√		√	√									√				
	Roof insulation	√		√	√									√				
	Reflective insulation	√		√	√									√				
	Wall cavity insulation	√		√	√									√				
	Insulated window frames			√	√									√				
	Secondary glazing			√	√									√				
	Low-emissivity glazing			√	√									√				
	Gas filling for glazing			√	√									√				
	Draughtproofing			√										√				
	External shading devices	√			√									√				
	Ventilated facades			√	√									√				
	Evaporative cooling	√			√													
	Ceiling fans	√			√									√				
	Micro-cogeneration			√			√											
	Low temperature heating systems			√										√				
	Geothermal heat pump systems			√	√	√								√				
	Heat recovery units			√	√									√				
	Wastewater heat recovery systems					√												
	Heating system controls			√										√			√	√
	Smart meters																	√
	Low-energy lightbulbs						√											
	Active solar space heating	√		√														
	Domestic solar hot water heating	√				√												
	Photovoltaic panels	√					√											
	Energy from biomass			√		√												
WATER	Water-efficient devices							√										
	Plant watering systems	√						√										
	Rainwater recycling							√										
	Greywater recycling							√										
HEALTH & COMFORT	Reduce sources of radiation													√				
	Low-VOC materials													√	√			
SOCIAL	Building users' guide													√			√	√
ECONOMY & MANAGEMENT	Building Energy Management System (BEMS)			√	√	√	√	√									√	√

D. CONCLUSIONS

A number of materials and technologies have been presented within this report, as potential solutions which could be considered for sustainable design, construction and operation, with emphasis on residential buildings.

Through the presented overview, it is apparent that there is available knowledge, expertise, and ‘know-how’ within European countries on building technologies/techniques/materials which can have significant environmental benefits. There are numerous already installed applications of such systems/technologies and significant cumulative experience gained. Adopting many of these technologies is simply a case of ‘good practice’ and careful design choices at the outset of a project; others are more innovative.

Some of the technologies already used extensively in Northern European countries are independent of the climatic location and can apply in the same way to Mediterranean buildings, e.g. low-water consumption sanitary fittings, paints with low VOCs etc. Others, are particularly suited to the specific characteristics of the Mediterranean climate, e.g. drought-resistant plants, cool roofing materials etc.

The materials and technologies presented within this Inventory of Technologies, are by no means an exhaustive list of the available options; simply a brief informative overview of potentially available solutions. They are by no means a substitute for the consultancy services by experts (architects, engineers etc). Especially in the case of existing buildings, it is necessary to get specialist qualified support for planning and implementing different refurbishment / retrofit measures, as a combination of parameters need to be taken into consideration.

To summarise, in order to effectively adopt a sustainable approach in residential buildings’ design, construction and operation, it is essential to adhere by the following three principles:

- **Good and timely design**: consideration to the design principles at the earliest possible stage; this applies to both new buildings as well as to refurbishments of existing ones. Retrospective retrofit of technologies in most cases results in higher costs and reduced environmental benefit.

- **Holistic approach** in creating sustainable housing: the concept of sustainability incorporates environmental, economic and social dimensions.

- **Collaboration** between building industry professionals of different specialities and active involvement of the future users, so as to achieve an integrated approach and optimise the design, application and promotion of sustainable technologies and practices.

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