Black Sea Basin Joint Operational Programme 2007-2013

BSBEEP

Black Sea Buildings Energy Efficiency Plan

Manual for Training on Energy Efficiency in Buildings

Builders

Project funded by the EUROPEAN UNION

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1. Brief presentation of the BSBEEP PROJECT

Black Sea Buildings Energy Efficiency Plan (BSBEEP) Project is carried within the framework of Black Sea Basin Joint Operational Programme 2007-2013. The project aims to strengthen the administrative capacity of local authorities in a very crucial sector (energy efficiency in buildings) having major environmental and economic impacts locally and globally. The project aims to improve energy efficiency systems in buildings, as well as exchange of knowledge and experience in energy sector. In Figure 1 the project logo is presented.

Figure 1 The BSBEEP logo

The general objective of the project is to contribute to stronger regional partnerships and cooperation schemes in Black Sea area through the reinforcement of administrative capacities of local authorities and bodies. The specific objective of the project is to reinforce the administrative capacities of local authorities and bodies in a very crucial sector (energy efficiency in buildings) having major environmental and economic impacts locally and globally.

Moreover, the project focuses on the establishment of a knowledge and experience exchange network aiming at the promotion of energy efficiency in buildings. The network will engage a wide spectrum of organizations such as local and regional authorities, universities and NGOs, which will help in promoting energy efficiency in buildings at local and regional levels. Meanwhile, it will focus on raising awareness and mobilizing the private sector and leveraging funds to support future initiatives.

Ten partners from six different countries are involved in the BSBEEP Project: Municipality of Kavala (GR), Municipality of Galati (RO), Municipality of Cahul (MD), Municipality of Mykolayiv (UA), Municipality of Samsun (TR), Municipality of Tekirdag (TR), Democritus University of Thrace (GR), "Dunarea de Jos" University of Galati (RO), American University of Armenia (AM) and Renewable Resources and Energy Efficiency Fund (AM). More details on BSBEEP are available on its website: **www.bsbeep.com**.

2. Training objectives

2.1. Training overview

Improving energy efficiency is a strategic objective of the national energy policy of any country, due to the major contribution he has to achieve security of energy supply, sustainability and competitiveness, saving primary energy resources and to reduce emissions of greenhouse gases. The national policy for energy efficiency is part of energy policy of the state and follows:

a. Removing barriers to promote energy efficiency;
b. Promote energy efficiency mechanisms and financial instruments for energy savings;

c. Final consumer education and awareness on the importance and benefits of applying measures to improve energy efficiency;
d. Cooperation between end users, manufacturers, suppliers, distributors of energy and public bodies in order to achieve the objectives set national energy efficiency policy;
e. Promotion of fundamental and applied research in the field of efficient use of energy.

This educational manual for training on energy efficiency in buildings is dedicated to the builders and it contains mainly technical aspects.

2.2. The training objectives

The main objective of this educational booklet is to allow a better understanding by the builders of the concept and benefits of energy efficiency in buildings. The booklet briefly presents an overview of the methodology used to determine the energy efficiency of buildings and the different opportunities and measures for reducing energy use in buildings without sacrificing comfort levels. In the same time, other objectives are to describe the different mechanisms for financing energy efficiency measures in buildings, as well as a summary of legislative and policy tools that have been successful in promoting energy efficiency in buildings.

2.3. Training learning outcomes

The booklet is addressed to builders. It can be used and applied by every kind of person or company involved in building construction or remodeling: designers and architects, new home builders and remodelers and their site supervision staff, building industry suppliers and manufacturers' representatives of building products, energy raters. Readers can easily and quickly learn about key issues related to energy performance of buildings and respective technologies. Information included in the following pages can help them adapt their behavior to energy-efficiency demands and understand energy-management solutions. Finally, they can be informed about energy-efficiency programs and policies that are available in the E.U. and BSBEEP participating countries through links provided in the BSBEEP Library (www.bsbeep.com).

2.4. What is building energy efficiency?

About 40 percent of the global energy consumption is used in buildings and this corresponds to one third of the global greenhouse gas emissions in both developed and developing countries. Fortunately, the potential for greenhouse gas emissions reductions from buildings is relatively high. Increasing energy efficiency in buildings is the solution to overcome the unfavorable trend of rising energy consumption., The energy efficient measures such as energy-efficient building are found to be used in greenhouse gas emission reduction.

Dealing with energy efficiently means:

1. Using less energy to achieve the same result.
2. Using the same amount of energy to produce a better result.

Or, to put it in mathematical terms: Energy efficiency = energy used/energy supplied

There is no specific definition for an energy-efficient building whether in academic studies or national level, each country in Europe has a different definition and scope for energy-efficient building.

The energy efficiency of a building is the extent to which the energy consumption per square meter of floor area of the building measures up to established energy consumption benchmarks for that particular type of building under defined climatic conditions. Building energy consumption benchmarks are representative values for common building types against which a building's actual performance can be compared.

Energy efficiency promotes energy savings and rational use of energy, as a prerequisite for achieving sustainable development. The energy consumption of a building depends on the climate conditions where it is located, its architectural and construction characteristics (e.g. types and adequacy of insulation), the type and the condition of its electro-mechanical equipment, the desired internal temperature, humidity, ventilation, etc., the hours and duration of its operation, and the purpose of its use (e.g. educational, medical, office, etc.).

The energy efficiency of a building is affected by two important components:

1. Energy efficiency of building envelope;
2. Energy efficiency of electro-mechanical systems serving the building.

By electro-mechanical systems must understand all the equipment from a building which are used in distribution and conversion of the energy in building area.

Both components must have good energy efficiency to have an efficient building.

A significant factor affecting a building's energy performance is occupant behavior. Occupants (tenants, residents, workers, etc.), who lack information about the rational use and management of energy, often tend to waste energy, e.g. by utilizing air conditioning or heating systems with open windows, using low efficiency equipment and appliances, neglecting maintenance of heating systems, using domestic hot water combined with cold water, etc.

2.5.Why is energy efficiency in buildings important?

Making buildings more energy efficient has been identified for many years as a largely untapped solution to address climate change, energy security and fossil fuel depletion. In the late 1970s, the concept of negawatts was created- the idea of that energy needs could be met by increasing efficiency instead of increasing production.

Actually the negawatt it is a theoretical unit of power representing an amount of energy (measured in watts) which it is saved.

Energy has emerged as a critical economic issue and top priority for policymakers. Unsustainable energy supply and demand have serious implications for everything from household budgets to international relations. Buildings are on the front line of this issue because of their high consumption of energy. Studies have repeatedly shown that efficient buildings and appropriate land use offer opportunities to save money while reducing greenhouse gas emissions depending on the resources which it is offered by the land.

The current worldwide mix of energy resources is weighted heavily toward oil, coal, and natural gas. In addition to emitting greenhouse gases, these resources are nonrenewable: their quantities are limited. Though estimates regarding the remaining quantity of these resources vary, it is clear that the current reliance on nonrenewable energy sources is not sustainable and involves increasingly destructive extraction processes, uncertain supplies, escalating market prices, and national security vulnerability. Accounting for approximately 40% of the total energy used today, buildings are significant contributors to these problems.

Reducing buildings energy consumption has benefits both to building operators and users locally, regional governments and globally.

The local benefits are:

- Reduce operating costs – The obvious incentive to building operators/owners is that of cost saving related to reduced energy consumption. Once initial capital outlays have been reimbursed these savings can directly reduce operational costs;
- Reduce impact of energy price increases – with growing demand worldwide for energy due to population and economic growth, energy costs are increasing. Reduction in energy consumption helps to minimize the impact of these increases;
- Increased comfort for building users – modern energy efficient technologies often also have the benefit of improving occupant comfort. This is particularly the case with HVAC systems where optimization of systems' energy consumption often leads

to improved comfort, less fluctuation in temperatures and improved ventilation. Energy efficient lighting strategies can often include more natural lighting which is generally considered more 'comfortable' to building users;

- Reduce maintenance costs – Energy efficiency measures quite often emphasize routine maintenance and monitoring in order to optimise system operation. With more careful and rigorous attention paid to maintenance, major faults can be avoided and system lifetimes lengthened. Newer equipment installed during energy efficiency schemes can also have reduced maintenance requirements.

The regional (provincial/national) benefits are:

- Decrease peak demand – Building energy consumption is a major contributor to peak electricity loads. Heating and cooling loads in commercial buildings typically peak during the daylight hours when buildings are occupied and at times that overlap with the overall electricity peaks (typically in the morning and evening depending on the climate and season). Reducing the contribution to peak loads reduces the demand for infrastructure that is needed to support these peaks, infrastructure that is typically expensive due to its utilization for only short periods of time.
- Reduce need for growth in energy supply infrastructure – energy efficiency strategies have the flow on effect of reducing the energy demand on energy supply infrastructure as a whole. By concentrating on energy efficiency, expansion of expensive electrical supply and distribution infrastructure can be reduced.

The global benefits is:

- Reduction in GHG emissions – As the majority of the energy services in buildings are supplied through the consumption of fossil fuels, one of the clear benefits and drivers for energy efficiency in buildings is in reducing associated GHG emissions. The link between GHG emissions and climate change is now well established as are the corresponding consequences of rising temperatures, increasing frequency of weather extremes and flow on environmental, economic and social effects.

In conclusion, improving energy efficiency is one of the most constructive and cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. The main benefits of energy efficiency include:

- Environmental: Increased efficiency can lower greenhouse gas (GHG) emissions and other pollutants, as well as decrease water use;
- Economic: Improving energy efficiency costs significantly less than investing in new generation and transmission. Energy efficiency can also boost the local economy and create downward pressure on natural gas prices and volatility;
- Utility System Benefits: When integrated into energy resource plans, energy efficiency can provide long-term benefits by lowering baseload and peak demand and reducing the need for additional generation and transmission assets;
- Risk Management: Energy efficiency also diversifies utility resource portfolios and can be a hedge against uncertainty associated with fluctuating fuel prices and other risk factors.

Conclusion:

1. Energy efficiency in buildings - a must, both economically and ecologically;
2. The cheapest and cleanest energy is the saved energy.
3. The term energy efficiency should not be confused with energy conservation. Although we can (and should) conserve energy by adjusting thermostats and turning off lights, energy efficiency saves energy by enabling a system to do the same amount of work with less energy. As a

consequence, energy efficiency is usually achieved through more efficient technologies or processes rather than by changes in individual behavior.

3. Brief presentation of EU policies related to energy efficiency

The European Union's energy policies are driven by three main objectives:

- To secure energy supplies to ensure the reliable provision of energy whenever and wherever needed;
- To ensure that that energy providers operate in a competitive environment that ensures affordable prices for homes, businesses, and industries
- EU energy consumption is desired to be sustainable, through the lowering of greenhouse gas emissions, pollution, and fossil fuel dependence.

Key policy areas that will help us achieve our goals include:

- A European Energy Security Strategy which presents short and long-term measures to shore up the EU's security of supply
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- Boosting the EU's domestic production of energy, including the development of renewable energy sources
- Promoting energy efficiency
- Safety across the EU's energy sectors with strict rules on issues such as the disposal of nuclear waste and the operation of offshore oil and gas platforms

By using energy more efficiently, Europeans can lower their energy bills, reduce their reliance on external suppliers of oil and gas and help protect the environment.

Energy efficiency has to be increased at all stages of the energy chain from generation to final consumption. At the same time, the benefits of energy efficiency must outweigh the costs, for instance those involved in renovations. EU measures therefore focus on sectors where the potential for savings is greatest such as buildings.

The 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive are the EU's main legislation when it comes to reducing the energy consumption of buildings.

Under the Energy Performance of Buildings Directive:

- energy performance certificates are to be included in all advertisements for the sale or rental of buildings
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect
- all new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018)
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.)
- EU countries have to draw up lists of national financial measures to improve the energy efficiency of buildings

Under the Energy Efficiency Directive:

- EU countries make energy efficient renovations to at least 3% of buildings owned and occupied by central government
- EU governments should only purchase buildings which are highly energy efficient
- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans

The Energy Efficiency Directive places energy savings requirements on EU countries' buildings. This includes making central government buildings more energy efficient and requiring EU countries to establish national plans for renovating overall building stock.

EU countries have drawn up strategies to show how they plan to foster investment into the renovation of residential and commercial buildings.

These strategies are part of their National Energy Efficiency Action Plans. They:

- ✓ provide an overview of the country's national building stock;
- ✓ identify key policies that the country intends to use to stimulate renovations;
- ✓ provide an estimate of the expected energy savings that will result from renovations.

For further information regarding policies in EU and other BSBEEP countries please check the analytical study "GA1.2: Collection of information about funding opportunities, programs and political initiatives at EU, national and local level and evaluation in order to meet the needs of partners" developed by BSBEEP team, freely available on BSBEEP website: **www.bsbeep.com/library/reports/**.

4. Energy efficiency in buildings METHODOLOGY

The basic objective underlying the Energy Efficiency Directive is to promote the improvement of the energy performance of buildings within the EU, ensuring in so far as possible that only such measures as are the most cost effective are undertaken. The Directive lays down a framework that should lead to increased coordination between Member States of legislation in this field. The Directive covers four main elements:

1. Establishment of a general framework of a common methodology for calculating the integrated energy performance of buildings.
2. Application of minimum standards on the energy performance to new buildings and to certain existing buildings when they are renovated.
3. Certification schemes for new and existing buildings on the basis of the above standards and public display of energy performance certificates and recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public.
4. Specific inspection and assessment of boilers and heating/cooling installations, the latter for boilers older than 15 years.

This methodology can be set either at national or regional level, and must be regularly updated and easy to understand. It may include an indicator of the CO2 emissions from the building. The methodology for assessing and improving energy efficiency in buildings includes theoretical and technical procedures that concern both engineers and non-engineers. For engineers, this methodology is a formula that allows them to evaluate a building's energy performance. Through standardized steps they can evaluate and certify the energy efficiency of a building and propose specific interventions for improvement. The key steps include the identification of typical energy flows of a given building, the determination of current energy performance of the building, benchmarking its performance with a reference building, and the acquisition of an Energy Performance Certificate (EPC).

4.1. Typical energy loads in buildings

A **building envelope** is the physical separators between the conditioned and unconditioned environment of a building including the resistance to air, water, heat, light, and noise transfer. The three basic elements of a building envelope are a weather barrier, air barrier, and thermal barrier. The weather barrier may be in a different location than the air and thermal barriers such as in house with an unheated attic. The term building envelope is sometimes used synonymously with building enclosure but the latter term also includes the broader aspects of appearance, structure, safety from fire and security. The act of creating a building envelope is sometimes called weatherization. Weatherization (American English) or weatherproofing (British English) is the practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency.

Weatherization is distinct from building insulation, although building insulation requires weatherization for proper functioning. Many types of insulation can be thought of as weatherization, because they block drafts or protect from cold winds. Whereas insulation primarily reduces conductive heat flow, weatherization primarily reduces convective heat flow.

The role of the envelope is to retain the desired conditions (temperature, humidity, air quality and lighting) inside the building according to the needs of the occupants regardless of the weather conditions outdoors. For this purpose, typical energy flows (including internal and external heat loads, solar loads), air movement and moisture penetration must be controlled.

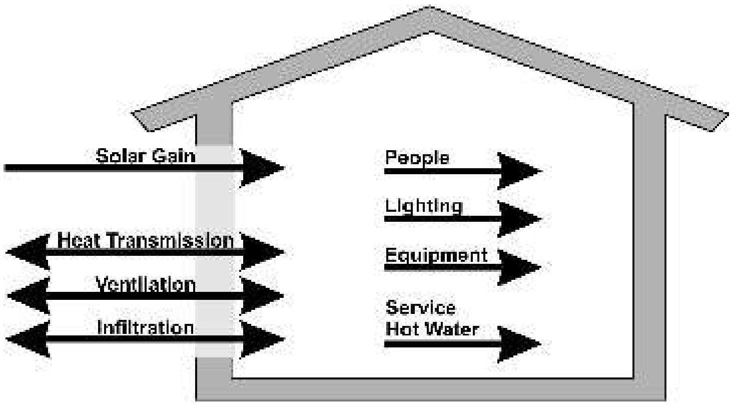

Figure 2 Typical energy flows in buildings

The desired conditions can be only preserved if, firstly, all imposed energy loads by the climatic conditions stay outside the building and, secondly, energy loads that originate from factors inside the building are controlled properly. Consequently, the buildings must consume energy to balance external and internal loads.

The building is subjected to both internal and external energy loads (Figure 2). Three of the external loads—transmission, ventilation and infiltration— are primarily a function of the difference between indoor and outdoor temperature. Since the outdoor temperature will vary, these loads may be either a heat loss (requiring heating energy to compensate) or a heat gain (requiring cooling energy compensate). The solar load is independent of temperature and is always a heat gain to the building. The four internal loads—people, lighting, equipment and domestic hot water (DHW)—are heat gains since they give off heat energy to the building space. The lighting, equipment and DHW have a two-fold effect on energy consumption. First, they are a direct consumer of electrical energy as required to power the lights, motors and heating elements. Their second effect on building energy consumption occurs when the direct power usage to these systems is converted to heat energy and they become heat gain loads in the building. In the DHW system, the heat gain comes as a result of heat loss to the building from the hot piping and storage tanks.

4.2.Determining a building's energy performance

According DIRECTIVE 2010/31/EU [1], all Member States should harmonize their national methodology for the calculation of building energy performance within a common general framework. This framework, which leads to a standardization of European Policy, contain all main characteristics and variables that are included in the calculations of a building's energy performance. The minimum energy performance requirements must be based on the calculation methodology. These shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and age of the building. When setting requirements, governments may differentiate between new and existing buildings, and different categories of buildings. These requirements must be reviewed at least every five years, and updated to reflect technical progress.

The calculations building's energy performance must be based on a general framework incorporating the following items:

1. The methodology of calculation of energy performances of buildings shall include at least the following aspects:
    a) thermal characteristics of the building (shell and internal partitions, etc.); these
    b) characteristics may also include air-tightness;
    c) heating installation and hot water supply, including their insulation characteristics;
    d) air-conditioning installation;
    e) ventilation;
    f) built-in lighting installation (mainly the non-residential sector);
    g) position and orientation of buildings, including outdoor climate;
    h) passive solar systems and solar protection;
    i) natural ventilation;
    j) indoor climatic conditions, including the designed indoor climate.
2. The positive influence of the following aspects shall, where relevant in this calculation, be taken into account:
    a) active solar systems and other heating and electricity systems based on renewable energy sources;
    b) electricity produced by CHP;
    c) district or block heating and cooling systems;
    d) natural lighting.
3. For the purpose of this calculation, buildings should be adequately classified into categories such as:
    a) single-family houses of different types;
    b) apartment blocks;
    c) offices;
    d) education buildings;
    e) hospitals;
    f) hotels and restaurants;
    g) sports facilities;
    h) wholesale and retail trade services buildings;
    i) other types of energy-consuming buildings.

Building energy performance is mainly determined by six factors: (1) climate, (2) building envelop, (3) building services and energy systems, (4) building operation and maintenance, (5) occupants' activities and behavior and (6) indoor environmental quality provided.

The European standard EN 15217 [2] is an attempt to describe methods for expressing energy efficiency and certification of buildings.

4.3.Benchmarks

Building energy benchmarking consists of a comparison of the energy performance index (EPI) of a building with a sample of similar buildings [3]. A common EPI used for many building types is annual energy use per unit area but others such as energy per worker or energy per bed may also be used. Energy services companies use the EPI as a starting point in energy audits and assess saving opportunities by comparing with existing references (benchmarks) of average (typical), above average (good) and excellent (best) practice. At the design stage, energy performance indices for different designs are of great use when choosing suitable technologies, particularly if benchmarks for similar buildings are available. Last but not least, governments should consider benchmarking in the early conception, development and implementation of energy efficiency policies within the building sector.

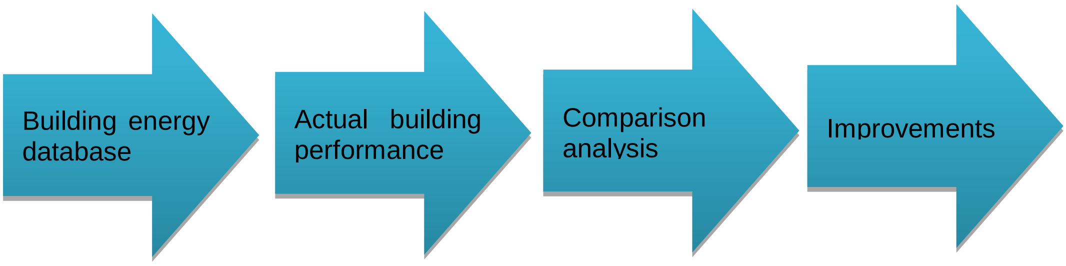

Figure 3 Building energy benchmarking process

The benchmarking process consists of four stages (figure 3):

- First, it is necessary to hold or develop a database with information on the energy performance of a significant number of buildings. This information should be categorized, at least, by building type and size.
- Second is gathering the relevant information for the evaluation of the EPI for the actual building.
- Third, a comparative analysis of the building energy performance against the samples held in the database gives a quantification of the quality of the building in terms of energy use.
- Finally, energy efficiency measures that are feasible from both technical and economical perspectives should be recommended.

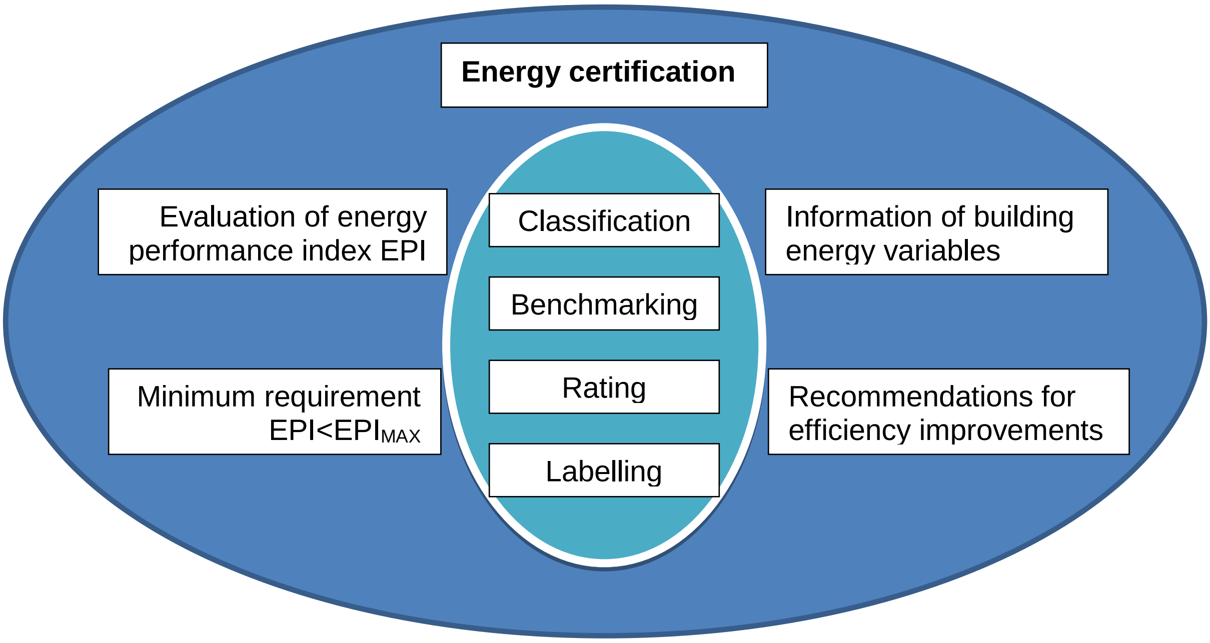

Figure 4 Scope of the European building energy certification scheme

4.4. Certifying energy efficiency

Energy Performance Certificates (EPCs) play a significant role in enhancing the energy performance of buildings. According to EN 15217, EPC is redefined within the development of a certification scheme (Fig. 3) which must contain at least:

- An overall energy performance index (EPI) stated in terms of energy consumption, carbon dioxide emissions or energy cost, per unit of conditioned area to allow the comparison between buildings.
- An overall minimum efficiency requirement to be established by the legislation as a limit of the energy performance index (EPI_{MAX}). The standard recommends its correlation with other parameters (such as climate and building type) or a self-reference method.
- A label based in the A–G bands to achieve a suitable grading of buildings. A key issue is the definition of the scale that should make reference, at least, to the building energy regulations (R_r), the existing building stock (R_s) and the zero-energy building (R_0).
- Energy consumption by the main building components, such us building envelope and services, together with recommendations of energy efficiency measures for building owners' consideration.

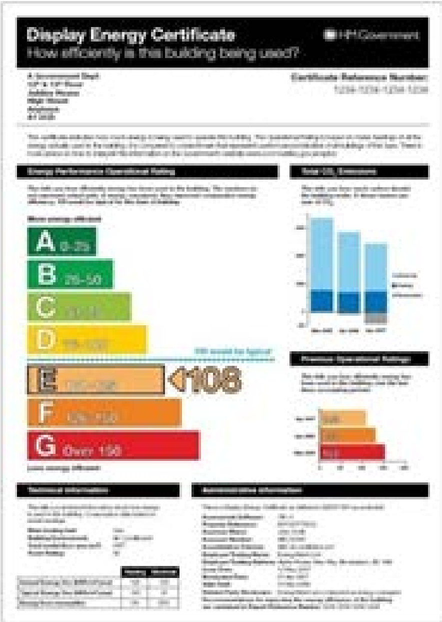

Figure 5 Building energy certificate example

The scope of the certification is therefore extended not only to the energy performance of the building but also to include a minimum requirement and a label or class that allows users to compare and assess prospective buildings. The certificate must contain, amongst other information, a classification of the building energy efficiency based on an energy label.

The implementation of the new European building energy certification scheme is a complex task facing seven critical issues:

- definition of the energy performance index,
- development of an energy performance calculation tool,
- setting a threshold value for the performance index,
- definition of the comparison scenario,
- definition of the scale for energy labelling,
- identification of potential energy efficiency measures
- gathering energy information in the certification process.

Therefore, energy labelling is only one step in the implementation process. The words energy rating should only be used for the assessment of the energy performance, both for new and existing buildings, in standard or actual conditions. Energy benchmarking tools provide a comparative appraisal of the energy performance of an existing building within a comparison scenario. Assigning classes or labels implies a step forward: defining a scale based on a labelling index.

The definition of the scale is more a political issue than a technical one, with the overall aim of reducing the energy consumption.

The success of building energy certification schemes will almost certainly depend on:

- the ability to obtain better labels cost-effectively;
- the credibility achieved by real energy savings;
- the degree of commitment to the global environmental crisis of the building sector stakeholders.

5. Energy efficiency MEASURES for buildings

Key elements that significantly influence the energy efficiency of a building are:

1. Building envelope;
2. Electro-mechanical systems which ensure the interior comfort;
3. Management of the energy use of the facility.

The building envelope performs various tasks, which includes protection from wind, rain, irradiation, heat and cold, visibility and glare protection, fire protection, noise protection, and physical security. At the same time, the building envelope must fulfill internal space requirements, which include thermal, acoustic, and visual comfort along with requirements for humidity conditions for both comfort, and mold and mildew growth prevention.

5.1. The building envelope optimization concept

A building envelope optimized for energy aspects has a maximized passive capacity and hence represents the foundation for viable energy concepts in the future. Furthermore, by integrating active solar technology, it can make an important contribution to a building's energy supply. The building envelope should therefore be devised in close conjunction with the energy supply technologies [5]. A structured overview of the optimization approaches possible in principle. According to the energy themes – heating, cooling, ventilation, lighting, electricity – the individual targets, concepts and measurement are presented (table 1).

Table 1. Structured building envelope optimization

	Concept	Targets	Measurements
Optimization building envelope	Maintaining and gaining heat	Surface optimization and envelope geometry	Compactness, zoning, thermal envelope
		Thermal insulation of opaque components	Choice of materials, insulation, thermal bridges
		Thermal insulation of transparent components	Proportion of glazing, quality of glass
		Passive use of solar radiation	Buffer zones, transparent thermal insulation, thermal mass
		Minimizing ventilation heat losses	Air change rate, heat recovery, preheating of incoming air, airtightness
		Active solar thermal energy gains	Roof collector, façade collector mass
	Avoiding	Avoiding overheating	Thermal insulation, surface temperature, latent heat
		Reducing the incoming solar	Constructional measures, special

	overheating	radiation	glasses, sun shading systems
		Thermal mass and ventilation	Release of stored thermal energy, preconditioning of incoming air
	Decentralized ventilation	Natural ventilation	Ventilation via windows, using the wind, thermal currents
		Façade-mounted mechanical ventilation units	Spandrel panel elements, underfloor convectors, ventilation via frames
	Using the daylight	Geometry optimization	Building and room geometry, proportion of glazing, arrangement of glazing
		Daylighting systems	Transparency, translucency, reflecting, redirecting and transporting the light
	Generating electricity	Building envelopes with photovoltaic panels	Photovoltaic façade, photovoltaic roof, solar shading
		Solar technology and building envelope	Segregation, incorporation, amalgamation
		Solar technology and architecture	Addition, integration, adaptation

Thermal performance of the building envelope influences the energy demand of a building in two ways. It affects annual energy consumption, therefore the operating costs for building heating, cooling, and humidity control. It also influences peak loads which consequently determine the size of heating, cooling and energy generation equipment and in this way has an impact on investment costs. In addition to energy saving and investment cost reduction, a better insulated building provides other significant advantages, including higher thermal comfort because of warmer surface temperatures on the interior surfaces in winter and lower temperatures in summer. This also results in a lower risk of mold growth on internal surfaces.

When buildings are constructed or renovated, a whole-building perspective is preferred, which involves considering all parts of the building and the construction process to reveal opportunities to improve energy efficiency. Numerous whole-building perspectives and policy mechanisms exist, such as building performance certificates.

Table 2 presents building envelope technologies according to economy, climate and construction type [4].

Table 2. Building envelope technologies

Type of economy	**Climate**	**Technology**	
		New construction	**Retrofit**
		Insulation, air sealing and double-glazed low-e windows for all buildings	
Developed	Hot climate	Architectural shading	Exterior window shading and dynamic glass/shading
		Very low-SHGC windows (or dynamic shades/windows)	Reflective roofing materials and coatings
		Reflective walls/roofs	Reflective wall coatings
		Advanced roofs (integrated design/BIPV)	Window film with lower SHGC
		Optimized natural/mechanical ventilation.	New low-SHGC windows
	Cold climate	Highly insulated windows	Highly insulated windows
		Passive heating gain (architectural feature /dynamic glass/shades)	Low-e storm or interior panels
		Passivhaus-equivalent performance based on LCC limitations.	Insulated shades and other insulating attachments (low-e films)
			Exterior insulating wall systems

			Interior high-performance insulation
Developing	Hot climate	Exterior shading and architectural features	Exterior shading
		Low-SHGC windows	Reflective coatings (roof and wall)
		Reflective roofs and wall coatings	Low-cost window films
		Optimized natural/mechanical ventilation	Natural ventilation
	Cold climate	Highly insulated windows (possibly double-glazed with low-e storm panel)	Low-e storm or interior panels
		Passive heating gain (architectural feature)	Insulated shades and other insulating attachments (low-e films)
		Optimized low-cost insulation and air sealing.	Exterior insulating wall systems
			Cavity insulation, lower-cost (e.g. expanded polystyrene) interior insulation.

The quality and energy efficiency of building envelopes are the most important factors that affect the energy consumed by heating and cooling equipment. Since investments in both envelope and mechanical equipment are attempting to save the same portion of end-use energy consumption, investment in either is likely to result in diminishing returns for the other.

There are two predominant perspectives on the relative importance of the building envelope and heating and cooling equipment. The passive design approach supports high levels of energy efficiency in building envelope components, with any remaining need for heating or cooling met by basic, efficient mechanical equipment. The smart technology approach promotes high energy efficiency in mechanical equipment because it is routinely replaced and installing it is easier than retrofitting old, inefficient building envelopes. Either approach can be appropriate. The balance between advanced envelopes and advanced equipment needs to be established at the regional or local level while considering product availability, cost, climatic conditions and energy prices. Whenever possible, however, it is usually better to invest in the most energy-efficient building envelope that is justified, because it will be in place for many years and in most cases advanced envelopes provide greater comfort. Improved comfort can foster behavior that leads to additional energy savings, such as not raising thermostat set points.

5.2. Rules for an energy efficient building

When asked to describe characteristics of an energy-efficient building, most might list the following: well-insulated walls, a ventilated roof with a thick layer of insulation over the ceiling, quality windows with low-E glass, and a high-efficiency heating and cooling system. Surprisingly, many buildings with these features experience higher than anticipated utility bills, elevated levels of moisture or indoor air pollutants, and premature deterioration caused by moisture accumulation in walls and roofs. This is happening because some essential rules for energy-efficient building are not complied. These rules and what can be done to avoid these are [7]:

1. Seal all joints in the building shell. It doesn't make sense to invest in well insulated walls and ceilings yet do little to block air flow around and through the insulated cavities. Wood-to-wood and drywall-to-wood joints in the exterior shell of a building are not airtight and should be sealed with gaskets, foams, caulks, or air barrier films.

2. Eliminate unnecessary holes and seal all those that are unavoidable. Locate electrical outlets and switch boxes on interior walls wherever possible, and try to use surface-mounted lights instead of recessed fixtures on insulated ceilings. Where electrical work on exterior walls and ceilings is unavoidable, tightly seal all box edges and wiring holes. Seal plumbing stacks with sheet-rubber gaskets slid over the pipes and mechanically clamped around the edges.
3. Block heat conduction pathways through framing lumber. Heat loss through window headers, exterior corners, and rim joists can be significantly reduced with simple framing modifications. Install rigid insulation between the inside and outside window and door headers, frame corners so that they are open on the interior and can be filled with insulation, and recess rim joists to create a space for several centimeters of insulation.
4. Completely fill all cavities with insulation. Even the smallest gaps between insulation and framing can cause a significant loss of insulation performance, especially where then is a space between the insulation and the drywall that allows air to move freely. Insulation should completely fill all wall and ceiling cavities and should be installed flush with the interior surfaces.
5. Insulate foundations adequately, preferably on the exterior. Basements are rarely insulated to the same standards as upper floors, even though basement walls often have a similar exterior exposure. Basements should be properly insulated during the initial construction process, preferably on the exterior. Exterior insulation reduces the chance of condensation and eliminates the extreme thermal cycling that causes foundations to crack.

A comprehensive collection of the best available retrofitting actions that can be applied to increase the energy efficiency of municipal buildings, including specific case studies, is freely available on BSBEEP website: **www.bsbeep.com/library/reports/**.

6. FINANCING energy efficiency in buildings

Energy savings are among the fastest, highest impacting and most cost-effective ways of reducing greenhouse gases emissions. Despite the proven cost-effective opportunity to reduce energy consumption, a significant proportion of the energy efficiency improvement potential is not being realized. A key reason for this relates to the financing of energy efficiency [8].

The need to improve energy efficiency in buildings is now greater than ever and presents a unique opportunity to address the challenges of energy security, climate change and economic development. An increase in Member States' building energy performance would allow the European Union to comply with the Kyoto Protocol, and to honor both its long term commitment to maintain the global temperature rise below 2°C and its effort to achieve the 20/20/20 targets by 2020.

European Commission intends to introduce financial mechanisms for funding under a centralized management or under a shared management (between European Commission and Managing Authorities). For the 2014 – 2020 programming period, Managing Authorities can allocate budget to Funding Instruments within all their Operational Program's thematic objectives. Additionally, a combination of Funding Instruments and non-refundable grants (for investments in sustainable energy in buildings) is possible. In Table 3, the existing financial and fiscal mechanisms for the building sector are summarized.

Table 3: Existing financial and fiscal mechanisms for the building sector

Grants	High for large buildings	State budget, funds, international financial institutions, bilateral donors	Short term priority; aimed at determining the level of investment demand and supporting owners in loan applications; energy audits, feasibility studies; public buildings, commercial services, multi-apartment buildings
Preferential loans	High for commercial services and residential buildings	International financial institutions, Energy Efficiency funds, guarantee funds, development funds/banks, local commercial banks	Short term priority; assessed investment demand serves as a base for Government loan applications to international financial institutions
Third Party Financing (TPF)/ESCO (EPC)	Medium	Energy service companies, leasing companies	Mid-term; prerequisites: legislation, standardized monitoring and verification protocols, training, cost-reflective energy carrier prices
White certificates	Low	Developed countries	Mid- to long-term
Tax Rebates	Low to medium	State budgets; more suitable for companies	Mid-term
Tax Deduction	Low to medium	Income tax reduction for legal and natural persons investing in EEI of own buildings	Short- to mid-term
VAT Reduction	Low to medium	State budgets; suitable for measures with short payback	Short- to mid-term

During last five years, a wide spectrum of international organizations and bodies has been involved in preparation and funding of mid-term programmes and short-term projects on energy efficiency either in the building sector or in a more integrate approach. EU member states (Greece and Romania) are almost exclusively dependent on EU structural funds to promote energy efficiency, while the other countries (Moldavia, Ukraine, Armenia and Turkey) have been active to attract funds from a much more differentiated type of donors.

EU-funded initiatives are abundantly funded, have a middle-to-long term perspective, are part of a comprehensive approach for the overall development of EU and finally having a quite "permanent" character, as they constitute part of EU cohesion policy targeting the convergence of EU regions. On the other hand, programmes and projects implemented at rest four countries are documenting their ability to attract funds from a wide array of institutions (most of these though have EU sources).

For further information regarding financing opportunities in EU and other BSBEEP countries please check the analytical study "GA1.2: Collection of information about funding opportunities, programs and political initiatives at EU, national and local level and evaluation in order to meet the needs of partners" developed by BSBEEP team, freely available on BSBEEP website: **www.bsbeep.com/library/reports/**.

7. DEVELOPING and IMPLEMENTING POLICY on energy efficiency

Although the European Union has legislated in the area of energy policy for many years, and evolved out of the European Coal and Steel Community, the concept of introducing a mandatory and comprehensive European energy policy was only approved at the meeting of the informal European Council on 27 October 2005 at Hampton Court. The EU Treaty of Lisbon of 2007 legally includes solidarity in matters of energy supply and changes to the energy policy within the EU. Prior to the Treaty of Lisbon, EU energy legislation has been based on the EU authority in the area of the common market and environment. However, in practice many policy competencies in relation to energy remain at national member state level, and progress in policy at European level requires voluntary cooperation by members' states. As part of the EU's SAVE Programme,[9] aimed at promoting energy efficiency and encouraging energy-saving behavior, the Boiler Efficiency Directive[10] specifies minimum levels of efficiency for boilers fired with liquid or gaseous fuels. As part of the EU's SAVE Programme,[9] aimed at promoting energy efficiency and encouraging energy-saving behavior, the Boiler Efficiency Directive[10] specifies minimum levels of efficiency for boilers fired with liquid or gaseous fuels.

Public and private investments are necessary to develop and implement the increasingly critical mandate of energy efficiency in buildings. Figure 4 provides a generic scheme for developing and implementing policy on energy efficiency in buildings.

These actions concern European Union's objectives for climate change, energy and decarburization up to 2020 and 2050. For these objectives to be met, investment funds are required, playing a major role in the sustainable renovation, upgrading, and construction of buildings that are governed by the Common Provisions Regulation and other regulations [11].

Europe's Cohesion Policy for investments in the 2007 – 2013 programming period concerned the improvement of public, commercial and residential buildings. In the 2014 – 2020 programming period the renewable energy and sustainable measures have a higher budget. Considering this fact, Cohesion Policy Managing Authorities, should plan and deploy sustainable energy investments in buildings within Operational Programs and innovative financial mechanisms. They should consider European requirements on buildings, the different financing mechanisms and the various national legislations in the energy renovation of buildings that must adjust to the several EU Directives for sustainable energy.

All these actions are incorporated in a general plan with supplementary major stages concerning priority intervention areas and proper strategies, evaluation framework of economic, social, energy-related and environmental impacts, appropriate financing mechanisms, the design, and implementation and monitoring of sustainable energy programs.

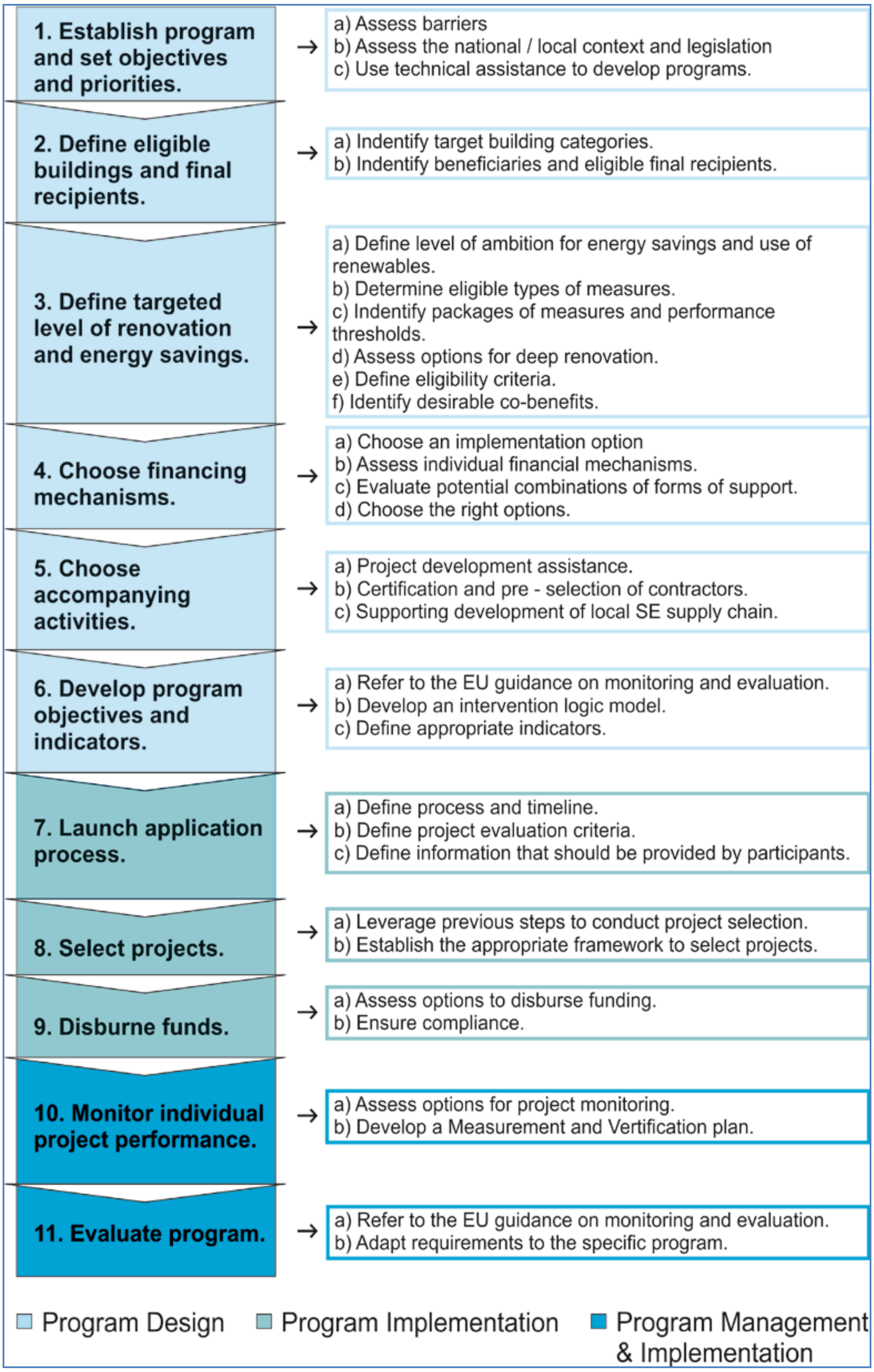

Figure 6 Developing a sustainable energy programme for buildings [11]

8. TOOLS to promote building energy efficiency

There are an important number of initiatives with websites and publications that promote good practice on energy efficiency. Below is a listing of some of these initiatives.

- The Covenant of Mayors (CoM) is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO_2 reduction objective by 2020. For its unique characteristics - being the only movement of its kind mobilizing local and regional actors around the fulfilment of EU objectives - the Covenant of Mayors has been portrayed by European institutions as an exceptional model of multi-level governance (http://www.covenantofmayors.eu/).
- Energy-Efficient Buildings (EeB) PPP is a partnership between the European Commission and the private sector as represented by the Energy Efficient Buildings Association (E2BA), an initiative of the European Construction Technology Platform. The multiannual EeB roadmap is the document containing the research and innovation priorities of the private sector, which are essential inputs for the design of the research work programmes by the European Commission. To improve transparency, this partnership is based on a contractual agreement between the Commission and the industry partners, setting out the objectives, commitments, key performance indicators and outputs to be delivered. The EeB cPPP intends:
  - to create and integrate technologies and solutions enabling to reduce energy consumption and GHG emissions in line with the 2020 goals;
  - to turn the building industry into a knowledge-driven sustainable business, with higher productivity and higher skilled employees;
  - to develop innovative and smart systemic approaches for green buildings and districts, helping to improve the competitiveness of the EU building industry.
- Energy Efficient Building European Initiative (E2B EI) steered by the Energy Efficient Buildings Association (E2BA) founded in November 2008, was created by European Construction Technology Platform, in order to help the construction industry reach the 20/20 targets and achieve energy neutral buildings and districts by 2050. The overall vision of the Energy Efficient Buildings European Initiative is to deliver, implement and optimize building and district concepts that have the technical, economic and societal potential to drastically decrease energy consumption and reduce CO2 emissions in both new and existing buildings across the European Union (EU).

  The E2B EI will work to achieve the following objectives:
  - deliver high quality, cost effective research that secures confidence from industry, public and private investors, decision-makers and other stakeholders;
  - leverage further industrial, national and regional RTD investment;
  - build close cooperation with research being carried out at national and regional levels;
  - enable the market entry of energy efficiency technologies, allowing commercial market forces to drive the associated public benefits;
  - place Europe at the forefront of energy efficient buildings and district technologies worldwide;
  - focus on achieving long-term sustainability and industrial competitive targets for cost, performance and durability aimed to overcome critical technology problem areas;

   - stimulate innovation and the emergence of new value chains including SMEs;
   - facilitate the interaction between industry, universities and research centers;
   - encourage the participation of the new Member States and candidate countries;
   - perform broadly conceived socio-techno economic research aimed to assess and monitor technological progress;
   - target non-technical barriers to leverage markets and carry out research modes to support the development of new regulations;
   - review existing standards to eliminate artificial barriers to markets;
   - provide reliable information to the general public on the benefits of new technologies to the environment, security of supply, energy costs and employment. http://www.e2b-ei.eu/ .
- The BUILD UP initiative, the European portal for energy efficiency in buildings, was established by the European Commission in 2009 and support EU Member States in implementing the Energy Performance of Buildings Directive (EPBD). The BUILD UP web portal is intended to reap the benefits of Europe's collective intelligence on energy reduction in buildings for all relevant audiences. It will bring together new practitioners and professional associations while motivating them to exchange best working practices and knowledge and to transfer tools and resources (www.buildup.eu)
- ManagEnergy is a technical support initiative of the Intelligent Energy - Europe (IEE) programme of the European Commission which aims to assist actors from the public sector and their advisers working on energy efficiency and renewable energy at the local and regional level. It was established to enable local energy agencies to work together more effectively. The initiative provides a range of services for this purpose: directories and interactive maps, partner search facilities, information on successful projects, and regularly scheduled workshops. http://www.managenergy.net/
- The European Network of Building Research Institutes (ENBRI) was founded in 1988 to bring together principal building and construction research institutes in Europe. The ENBRI Network provides a full coverage of topics for the construction and built environment and guarantees a steady up-dating of international knowledge and experience for the construction sector. The aims of ENBRI are to:
   - Promote the benefits of investment in construction research and development in construction and the built environment at national, regional and European levels.
   - Promote co-operation among its members, and work with the European Commission and stakeholders of the European Construction Sector in order to contribute effectively to the improvement of competitiveness, sustainability, quality and safety of the built environment.
   - Advice policy makers and wider public on issues related to research and innovation in the built environment in a proactive and agenda-setting approach. http://www.enbri.org/
- TRA-EFCT (Targeted research action on environmentally friendly construction technologies) is a thematic network whose the main objective is to establish a well-organized and efficient interface between the various construction related RTD projects supported by the EC. In particular the TRA-EFCT aims at:
   - providing a European forum for the development, dissemination and exchange of scientific and technological knowledge and of ideas relating to all aspects of construction;
   - accelerating dissemination and exploitation of research results;

  - improving the synergy and co-ordination of research being carried out in EC programmes;
  - informing RTD programme planners of future research needs and priorities http://ec.europa.eu/research/brite-eu/thematic/html/2-3-01.
- DEEP - Dissemination of energy efficiency measures in public buildings is an European project aimed at promoting opportunities for increasing energy efficiency in the public buildings sector. The tools developed by DEEP project are:
  - The DEEP energy efficient procurement toolkit, providing:
  - Guidance on developing and implementing an energy efficient procurement policy;
  - A Life-cycle cost analysis tool, to help demonstrate cost savings through reduced energy consumption;
  - A self-assessment of energy consumption tool (SASESATO), to identify potential energy effi ciency improvements in the building stock;
  - Purchasing advice and criteria for sustainable construction, green electricity, and energy effi cient IT products;
  - The tools are available for download at www.iclei-europe.org/deep
  - The Procura+ Manual, A Guide to Cost-effective Sustainable Public Procurement – providing an introduction to the topic of sustainable procurement, and straightforward advice on implementation www.procuraplus.org
  - Policy recommendations, providing advice for European and national decision makers on how to foster the promotion of sustainable construction
  - and green electricity through public procurement. www.iclei-europe.org/deep

9. The BSBEEP E-TOOL

The numbers of buildings that fall under a municipality's jurisdiction are in the order of hundreds and in that aspect the analytical energy assessment of every building is costly in terms of time and effort. Analytical tools are already available in the market that can comprehensively assess various aspects regarding energy efficiency and performance of buildings. However, often, using these tools requires a degree of expertise. In many situations municipal authorities need to decide quickly using evaluation and results that have been obtained by civil servants or other staff with limited scientific knowledge.

The BSBEEP e-tool (Figure 5) can enhance decision making of municipal authorities and relevant agents by helping them assess the energy consumption of buildings fast but effectively. The proposed e-tool is based on the following concepts:

- The inputs are easily accessible or easily calculated by the e-tool user,
- The e-tool has a qualitative and quantitative output,
- The e-tool is easily installed and operated in every PC (with Microsoft Excel application) by experts or non-experts,

General Characteristics	
Country	Greece
Building use	Educational
Year of constr.	1991

Qualitative assessement data	
Heating (HS)	
Type	Oil boiler
Automation	None
Maintenance	Yes
Cooling (CS)	
Type	AC (regular)/Floor fans
Automation	None
Maintenance	No/Unknown
Lighting (LS)	
Type	Fluorescent lamps
Automation	None
Day lighting	Required
HDW	
Type	Electrical boiler
Automation	None
Maintenance	No/Unknown
Building envelope (BE)	
Insulation	Only in building frame
Glazing	Double insulated
Frames	Aluminum/steel
Renewable source	
RES ?	No/Unknown

Quantitative assessement data		
Number of floors	3	
Building floor perimeter	274	[m]
Building height	12	[m]
Building envelope area	3288	[m2]
Windows area	452	[m2]
Wall area without windows	2836	[m2]
Building floor/ceiling area	1580	[m2]
Building volume	18960	[m3]
Wall material	Brick	
External wall thickness	25	[cm]
Insulation material	Expanded polystyrene (EPS)	
Insulation thickness	3	[cm]
Exterior carpentry	Double/metal	
Total annual energy consumption per use		
Heating	67606	[kWh]
Cooling	1734	[kWh]
DHW	0	[kWh]
Lighting	8667	[kWh]

Figure 7 The BSBEEP e-tool

The proposed assessment mechanism consists of two levels of assessment:

1. **Qualitative assessment (0-50 points)**

Focus: Energy saving potential:

- The specific procedure assesses the current features of the examined building in order to provide a quick qualitative image of the performance of the building based on best available practices.
- The qualitative assessment is performed through the evaluation of five generic categories related with the features of the examined building namely: a) Building envelope (BE), b) Heating system (HS), c) Cooling system (CS), d) Lighting system (LS) and e) Domestic hot water (DHW)
- The specific method requires simple qualitative inputs (questions in multiple choice form) to perform the assessment. In that aspect, if someone is not aware of the energy consumption of the building can also use the tool.
- Buildings with high score are energy efficient and have therefore low potential for energy efficiency interventions. On the other hand, buildings with low score have high potential for energy efficiency interventions.

2. **Quantitative assessment (0-50 points)**

Focus: Building energy demand and building actual consumption:

- The specific procedure takes into account European energy assessment methodologies and legislation and provides sound and more technical analysis of the expected energy demands/consumption of the building. More concretely, it compares the annual energy consumption of the building (per end use) with the national average for the specific type of buildings (in KWh/m^2). In that respect, even if someone has only energy consumption information (not knowing type of insulation, glazing type etc.) can also use the tool.
- Many users despite the fact that they live in relatively energy efficient buildings act irresponsibly in terms of energy saving (e.g. air condition with open windows on municipal offices). In that way the e-tool can also capture in its score energy irresponsible behavior.

With the categorization of the assessment in two levels, someone is able to use the e-tool even with a small amount of data, whereas those who wish to have a more analytical assessment can also apply it. The compilation of quantitative and qualitative assessment provides the final score ranging from 0-100 Pts, with 100 representing maximum performance.

The BSBEEP E-tool and all supportive material for its efficient implementation are available on **www.bsbeep.com**.

GLOSSARY

Building envelope: integrated elements of a building that separate its interior from the outdoor environment.

Heat transmission: an exchange of thermal energy between physical systems by three mechanisms (conduction, convection, radiation).

Ventilation: the process of "changing" or replacing air in any space to provide high indoor air quality.

Infiltration: a heating, ventilation, and air conditioning term for air leakage into buildings.

Thermal capacity: the heat capacity of a defined system is the amount of heat (in calories, kilocalories, or joules) needed to raise the system's temperature by one degree (in Celsius or Kelvin). It is expressed in units of thermal energy per degree temperature.

Passive heating: passive heating uses the energy of the sun to keep occupants comfortable without the use of mechanical systems. The systems for passive heating are called passive solar systems (e.g. solar thermal collectors, solar walls, Trombe walls).

Thermal bridges: the parts of the building which have an increased heat transmission and cause heat loss. There are geometrical thermal bridges due to parts of the building and material thermal bridges due to different materials' conductivity when combined.

Active solar systems: Active solar systems collect solar radiation and convert it in the form of heat to water, air, or some other fluid.

Cogeneration: (or Combined Heat and Power) is the simultaneous production of electricity and useful heat, both of which are used.

Cost-optimal level: Cost-optimal level means the energy performance level which leads to the lowest cost during the estimated economic lifecycle.

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