Interreg CENTRAL EUROPE
ENERGY@SCHOOL
European Union
European Regional Development Fund

COMMON SMART SCHOOL STRATEGY

DELIVERABLE D.T2.4.2 *01/03/2019*

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Edited by City of Stuttgart (Germany)

Index

1. Introduction

The building sector has high potential for energy optimization being the most consuming one in the EU. In terms of public buildings, energy consumption in schools is the second highest expenditure after personnel costs of municipalities total running costs. Thus, this sector offers potential remarkable achievements in terms of Energy Efficiency (EE), Renewable Energy Sources (RES) application and carbon footprint reduction and several disparities exist among Central Europe countries as for planning and implementing performances of proper sector-based strategies, action plans and managerial capacities.

With reference to the public stock of buildings and infrastructures, for sure educational facilities are an important opportunity to achieve substantial energy savings, as they constitute a relevant part of the overall amount of energy consumption and therefore of the expenses paid by the national budgets. Energy consumption in schools account up to 70 % of the thermal energy cost of municipalities. Schools, being such an important line in energy-related budget, represent an important sector of public administration to tackle with reference to buildings' upgrade, retrofitting and renovation. Furthermore, schools are the best environment for behaviour change and awareness raising of students and, indirectly, their families because they are the privileged place for the dissemination of culture and information as a whole and therefore also in the field of energy saving and efficiency. Consumption in schools can be quite variable depending on country, climate, building year of construction and type. However, considering an average energy use profile, consumes can be roughly divided. As shown in Figure 1, energy consumption in schools is dominated by heating with nearly 50 %, followed by lighting with 14 %.

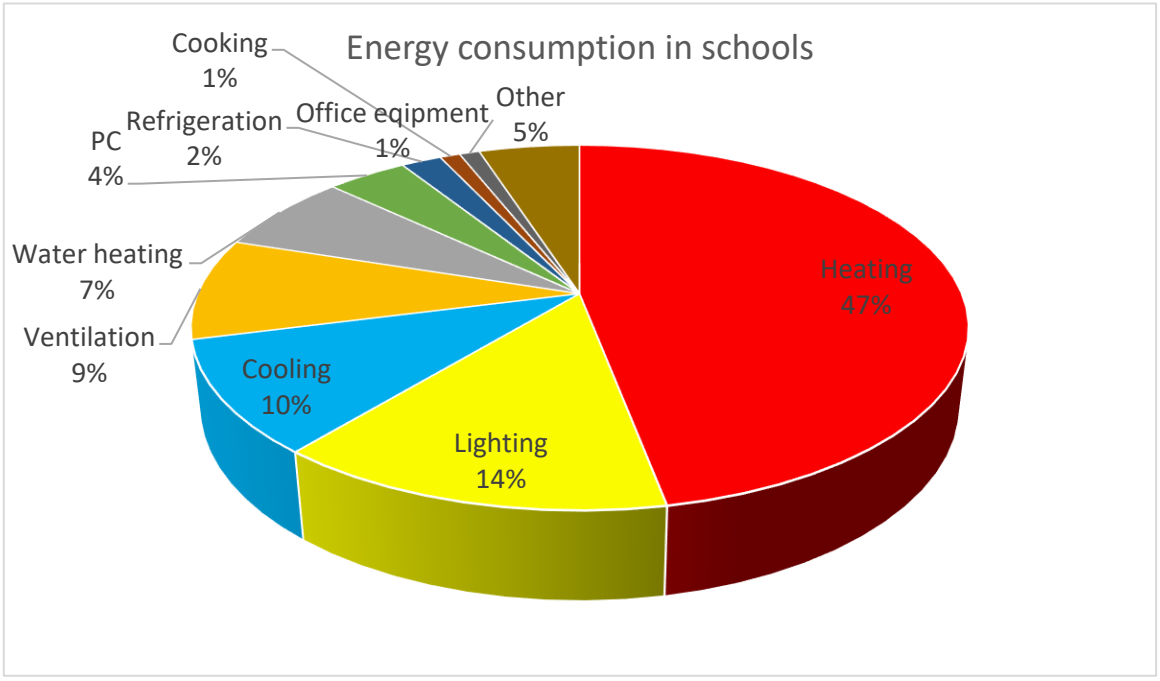

Figure 1: Average energy consumption in schools

It is estimated that just by making small changes in behaviour, schools could save up to 20% of their energy use (and bills). This amount can noticeably increase if energy retrofit interventions are associated to behavioural changes (e.g. around 50 % with 0.5 to only 2 years payback period).

Public building sector with reference to schools is therefore one of the main issues and there is concrete need to develop energy-efficient management for schools and strategies on how to improve the energy efficiency. There is also need to raise the awareness of school staff and students, and to involve them in the energy saving activities. People have a crucial role in this process, therefore they need to be supported and provided with the best available solutions.

2. The Project ENERGY@SCHOOL

The Interreg CENTRAL EUROPE programme was set up by the EU to improve regional development in the fields of innovation, carbon dioxide reduction, protection of natural and cultural resources, transport and mobility.

The ENERGY@SCHOOL: ENERGY OPTIMIZATION AND BEHAVIOUR CHANGE INTO SCHOOLS OF CENTRAL EUROPE was carried out as part of this programme. It started in July 2016 and ended in June 2019, involving 12 partners from 7 European countries. During the project, 8 different pilot solutions for increasing energy efficiency and integrating renewable energies were tested in the participating schools.

List of Project Partners

1. Union of Municipalities of Low Romagna Region , Lead Partner – Italy
2. CertiMaC s.c.r.l. - Italy
3. City of Bydgoszcz - Poland
4. ENERGY AGENCY OF SAVINJSKA, ŠALEŠKA AND KOROŠKA REGION - Slovenia
5. City of Karlovac - Croatia
6. University of Bologna - Dept of Industrial Chemistry - Italy
7. Municipality of the CITY Szolnok with County Rank - Hungary
8. Local Government of Town Újszilvás - Hungary
9. City of Stuttgart - Germany
10. City of Klagenfurt - Austria
11. Graz Energy Agency - Austria
12. City municipality of Celje - Slovenia

The aim of ENERGY@SCHOOL was to get the best conditions for learning with the minimum possible energy use. This will ensure minimum carbon emissions and maximum funds available for education or implementing further EE-measures. According to this, an energy management plan is how a school protects itself from rising energy prices, engages pupils and staff, provides a

comfortable space for learning and integrates this work into the curriculum. The system comprises improvements to buildings and equipment, behaviour change and energy awareness, policies and management processes and curriculum based learning. All these elements are necessary for a successful energy management system, which will reduce energy school costs and carbon emissions, whilst creating a more comfortable learning environment and equipping pupils with the skills and knowledge they need for the future.

The main ENERGY@SCHOOL objective was to increase the capacity of the public sector to implement Energy Smart Schools. Using an integrated approach, teachers and staff were educated and trained to become Senior Energy Guardians (SEG) and students to become Junior Energy Guardians (JEG). They were committed to engage on progressive and sustainable energy efficiency of buildings and an adequate transfer of a correct attitude towards energy consumption ("energy culture").

ENERGY@SCHOOL aimed to achieve the following results:

I. Optimization of energy consumption in schools,

II. Concrete and progressive increase of EE and RES use in schools not only thanks to technical application of smart solutions, but also to non-technical factors such as a better management capacity and responsible behaviour toward energy use,

III. Increase of capacity of public sector to deal with increase of EE and RES use in schools thanks to strategy, action plans, tools (methods, approaches), trainings, pilot actions defined and implemented within the project,

IV. Increase in managerial and organizational competences as well as in human resources to ensure the progressive and sustainable energy efficiency and renewable energy se in public schools (trainings),

V. Creation of conditions for new job opportunities (trainings)

VI. Creation of an "energy culture", thus responsible attitude towards energy use, thanks to education and raising awareness activities, as it is demonstrated that amount of saved energy can noticeably increase if energy retrofit interventions are associated to behavioural changes

Thanks to a commitment to high-performance schools, many school districts are discovering that smart energy choices can have lasting benefits for their students, communities, and environment. The key idea is to provide concrete technical tools and devices and specialized trainings for School Planning Managers on financing opportunities, designing, operating & maintaining energy solutions. The innovative character lies in the active involvement of employees, experts, students, teachers, families in the process of transforming the school into an energy smart school through specific and targeted training and education activities.

3. What is an Energy Smart School

In general, the energy costs for schools are second to personnel costs, and energy consumption in a school district governed by a municipality accounts for up to 60% of the total administrative energy consumption. The following chapters describe more in detail what actions can be done to decrease the energy costs in schools. The most effective way to reduce school consumption is to engage in a portfolio-wide, systematic approach for improving energy efficiency. In particular, it is important to define the Energy Smart School Management Plan as a strategic document that outlines the key energy saving opportunities that can be adopted by schools and demonstrates how simple actions can result in significant cost savings.

Developing energy efficiency in schools creates significant environmental, economic and energy benefits. These include the following:

- Reducing greenhouse gas emissions, reducing the use of fossil fuels
- Reducing energy costs, e.g. heating energy, electricity. (School Energy Consumption: Heating / Cooling / Hot Water / Lighting / Office Supplies / Cooking / Ventilation / Other)
- Increasing economic benefits: energy efficiency investments stimulate the local economy and promote the development of an energy-efficient market.
- Improve indoor air quality, optimize internal temperature and humidity.
- Increasing educational opportunities: raising awareness of energy and environmental issues.

To facilitate the introduction of Energy Smart Schools, we must first understand why we need this type of educational institution. Children's energy consumption habits are mostly part of the habits and knowledge of home. If the parents live in an environmentally conscious way, children are most likely to follow them and take home the knowledge and habits they have learned at home, and they will continue to give it to the next generation. However, what if the children do not get this example at home?

In the latter case, the educational and exemplary processes in schools should help students to develop and establish the necessary change in attitudes. All this will be effective if children are able to pass on their knowledge obtained in school even to their narrow environment.

It is characteristic of an Energy Smart School that the energy developments and the results generated by them are jointly examined and analysed by the pupils and teachers of the school. All this is done by both children and adults getting to know the tools and technologies implemented during the development. Their observations are recorded and analysed at specified intervals. The recording of the data is carried out in a pre-agreed manner by the teachers and students participating in the project. The analysis of the obtained data is carried out on the surface prepared by energy experts, thus continuously auditing the development results. In the event that there is a large discrepancy between pre-calculated expectations and measured data, they will initiate actions as outlined in the pre-formulated and ratified action plans. Continuous data recordings and analyses ensure that improvements and upgrades in schools lead to sustainable, long-term energy savings.

The basic objective of Energy Smart Schools is to integrate sustainability into everyday school activities by saving energy and increasing energy efficiency, which indirectly encourages the environment of students to achieve responsible energy management, as students are expected to report on their learning at home and among their acquaintances.

The process is additive, because due to the energy-related awareness the operating costs of the environment concerned (in this case the school in question) can be reduced, which means that more investments can be made, occasionally investments for energy efficiency, if necessary, to improve the quality of life.

It is necessary to emphasize appropriately to the students in the school environment that energy savings are possible not only through the implementation of large energy projects and investments (although their efficiency is undoubtedly outstanding), but can actually be the result of many responsible mini-actions.

The project launches a process in which teachers are very important players, as the knowledge they pass on can create a joint energy management team by involving students, presenting them in an interactive way and implementing specific energy-conscious activities.

4. Energy Guardian Smart School Management Plan (EGSMP)

The most effective way to reduce energy consumption in schools involves a comprehensive, systematic process to improving energy efficiency, which is called Energy Guardian Smart-School Management Plan. It is a comprehensive plan clearly setting technical, management and behavioural virtuous actions to be undertaken by an Energy Team and the school to progressively achieve higher energy savings.

The strategic approach to develop the Action Plan for an Energy Smart School involves seven main steps, as shown in Figure 2:

1. Set up an Energy-Team: Make a commitment to identify a team of qualified and motivated personnel to develop a general pilot policy on energy efficiency. The ENERGY@SCHOOL program involves professional energy experts in the energy audit, in which they have to determine the different consumption of energy. The Energy-Team is divided into:

a. Senior Energy Guardians (teachers and school staff), who work on the technology

b. Junior Energy Guardians (students), who work the daily practice.

Senior Energy Guardians (SEGs) are involved in the implementation of the Smart Energy Management Plan of the total energy consumption and the technological solutions for energy efficiency, as well as in the selection and training of Junior Energy Guardians (JEGs). Junior Energy Guardians are involved in the audit process, as it is a significant learning opportunity. They have to do the check-up of the school to determine how the school's energy is being used for a calendar year, in terms of the amount of each fuel used and the cost of supply, taking into account different energy sources such as electricity, gas, coal, firewood, solar, wind and wood pellets. They also have to measure the energy consumption of specific electrical appliances.

2. Baseline inventory consumption. After making a commitment, the next step is to look at how energy is used in the school building to identify priority opportunities to improve energy efficiency and to set goals. This is achieved through an energy audit carried out by an expert. Senior Energy Guardians are responsible for preparing the Energy Guardians Smart School Management Plan.

3. Set goals for improving energy efficiency. The school can establish a portfolio of energy efficiency goals based on the indications by the technical audits.

Assessing potential energy savings helps to determine an appropriate portfolio of goals that are clear and measurable. The school has to establish both short-term and long-term goals for improving energy efficiency.

4. Create an action plan. A regularly updated action plan is a necessary roadmap to achieve the energy efficiency goals. Creating an action plan involves establishing energy performance targets, starting from data collected from the energy consumption inventory.

5. Monitoring progress and implementation of the action plan. The fifth step in implementing an action plan is to develop a tracking system and to use it to continuously track and monitor energy consumption data, which is critical for evaluating program progress. Maintaining an effective centralized tracking system involves the following actions:

a. Perform regular updates,

b. Conduct periodic reviews,

c. Identify necessary corrective actions.

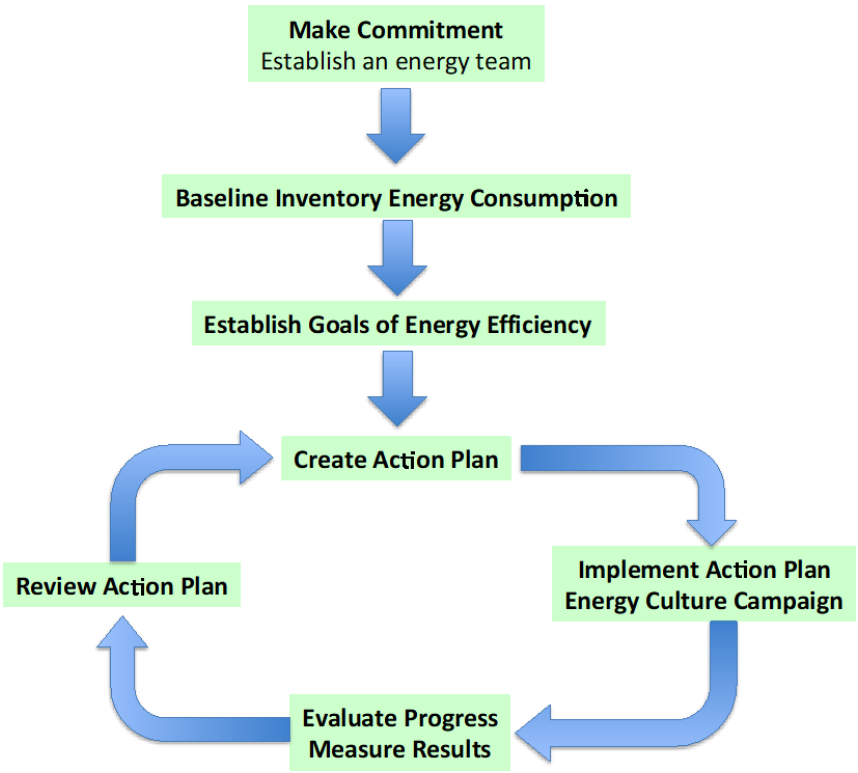

Figure 2: Main steps to become an Energy Smart School

For more information and templates look at *D.T1.6.1 - Energy Guardians Smart School Management Plan*.

5. Set up an Energy-Team in your school - Make a Commitment

The first step of becoming an Energy Smart School is to establish an Energy-Team in your school and to make a commitment to decrease the school's energy consumption to reduce its energy costs by integrating sustainability into everyday school activities by saving energy, increasing energy efficiency and integrating RES.

5.1. Setting up an Energy-Team

The definition of pupils and staff which will play an active role in the energy management process in schools is the first important step in order to achieve high results in energy savings. The process should involve the whole school, from students to teachers, principals and other staff.

Step 1: Decide which staff will be in your team and then open it out to self-selection or election by the pupils.

The Energy-Team usually consists of pupils with teachers supporting them. It is possible to combine it with the school council, but this group does need to include senior management staff as well. Students who belong to the Energy Team are referred to as JEGs and teachers and other staff are referred to as SEGs.

Step 2: Educate your team about climate change and energy efficiency

Make sure they are knowledgeable about the importance of energy and climate change, at an appropriate level for their age. It is important that JEGs have significant input into the decision-making process.

Step 3: Set up the times and places for your team to meet, including when they will report to the management team and governors.

Your Team may not meet as a whole but one group could focus on building use and one group focus on occupant use. The team should report to the person(s) responsible for energy management and the governing body on a regular basis.

You can find more information in *D.T1.5.2 – Upgraded Decision-support Toolbox for School Energy Guardians*.

5.2. Education of the Energy Team

The Senior Energy Guardians (SEG) and facility managers of each school receive two trainings in energy efficiency awareness, energy-related topics, climate protection, heating technology, window ventilation and ecological as well as economical topics. The task of the SEGs is then to pass on the knowledge gained through the trainings to the Junior Energy Guardians (JEG), according to their level of education.

The training programme is developed with the intent of facilitating the reduction of energy costs in schools to allow reinvestment in more energy efficiency measures or simply leaving schools and local authorities with more funds to carry out their primary activity – education.

The focus of the trainings will foster a marketable and relevant skill set from the pre-investment phases of energy renovation activities, to advanced monitoring solutions and behavioural impact on building users. The main target groups of the training activities for senior EGs will include local authorities (municipal representatives), personnel in charge of operation and maintenance in schools in addition to educated (postgraduate students, research students) persons from the local environment with no gainful employment.

The training activities will be divided with respect to their scope and desired level of impact into three separate programs:

- **Training program for teachers** (Simplified crash course for basic insight)
- **Vocational Energy Guardian Training Program (VEGTP)**

  Basic, all-inclusive programs providing a straightforward overview of educational topics.
- **Continuing Energy Guardians Education (CEGE)**

  In-depth and practical upgrade, meant for EGs that already participated in VEGTP.

The sections of the training manual as well as specific training activities are distinguished according to their scope and complexity between these 3 target audiences with the following symbols:

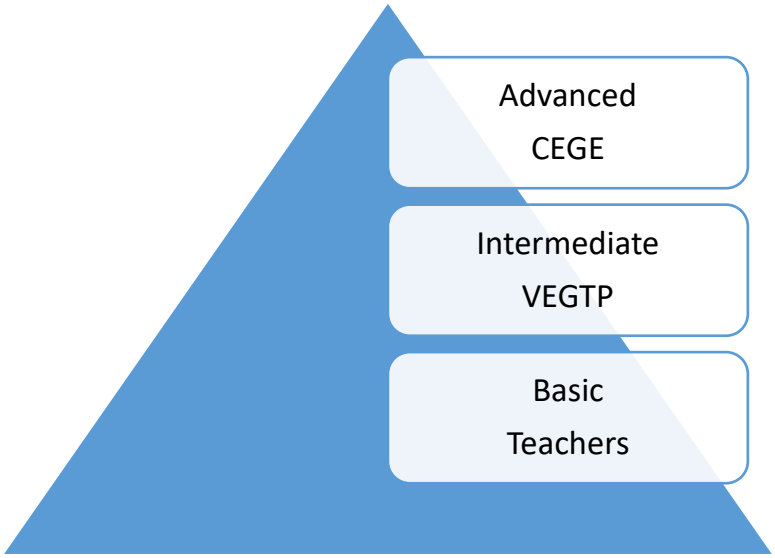

Figure 3: Training programs sorted according to requirement profile

The level of complexity preceding the more advanced category is also applicable to the group in this respective category. For example, BASIC is applicable for teachers while all levels BASIC, INTERMEDIATE and ADVANCED are applicable to the CEGE category.

For the first part of the training, materials and activities for the first two groups, teachers and VEGTP, were prepared in *Deliverable D.T3.2.1 - Training materials to deliver VEGTP training Programme to Senior Energy Guardians*. For the CEGE group, the programme is represented in *Deliverable D.T3.2.2 - Training materials to deliver CEGE training Programme to Senior Energy Guardians.*

By the end of the process, all students and teachers in the school, working on a similar value-based approach, will work together to ensure that the energy upgrades and energy efficiency measures are sustainable and deliver the programme's long-term goal.

The appropriately selected and trained Junior Energy Guardians, by the end of training and professional education, will be able to involve also the other students of the school in their daily tasks, getting to know and practicing the desired behaviours.

5.3. Make a commitment

The next step of becoming an Energy Smart School is to make a commitment towards sustainability and energy saving – an energy policy. An energy policy is a written document stating the way the school will use energy and what targets it hopes to achieve. It should show how it intends to go about meeting such targets, state how it will involve pupils, what it expects of teaching and support staff and plan for how it will continue improving energy efficiency and reducing carbon emissions in the future.

The policy should be developed by the Energy-Team in consultation with other teaching and support staff and pupils. Although members of the Energy-Team should take the lead on developing the policy, consultation with other pupils and staff can be the first step in securing commitment from the whole school community.

Your energy policy summarises and communicates your energy management system. A good energy policy should include:

- Statement of commitment
- Clear and achievable objectives and targets for energy consumption
- Role, responsibilities and resources
- Action plan and the statement of the mechanism to implement it (see chapter 8. Action Plan)

Both Senior and Junior Energy Guardians have been trained to broaden their knowledge of energy efficiency, and to provide a detailed description of the project activities, the tools, knowledge and processes required for them. In addition, feedback is also very important during training, through teamwork and surveys on ad hoc questionnaires.

The most essential step in energy management is to monitor your energy use in order to identify targets for reducing it. Analysing and understanding your hourly, daily, weekly or monthly, annual use will immediately show you where energy is being wasted. The Energy-Team can have a large

role in monitoring and targeting by regularly checking for waste and communicating energy data to other school users. Pupils and staff are the best asset when it comes to energy efficiency and energy management. Thanks to the monitoring activities made by the Energy-Team, it will make savings overnight by cutting waste, e.g. by moving book cases away from the front of radiators. Using the available data to give information on energy use will ensure they concentrate on the most effective actions.

6. Baseline inventory consumption – Energy Audit

It is not possible to formulate uniform energy measures for different school buildings, as each building has different features. In order to get a comprehensive picture of the state of the school building, an energy audit should be prepared. The performance of an energy audit is regulated in the European standard EN 16247-1.

An energy audit can reveal the essential energy flows and energy costs of a building and identify energy efficiency potentials. The basis for this is the systematic recording and analysis of energy data. As a result, a final report is prepared which identifies existing energy saving potentials and recommends sensible energy efficiency measures as well as measures for the integration of renewable energies based on economic efficiency calculations. In order to evaluate the success of the proposed measures, an energy audit should be repeated at regular intervals (at least every 4 years). For more information see *Deliverable D.T2.1.1 – Reports of energy audits carried out in selected schools to detect ad hoc interventions for pilots*.

6.1. Collection of relevant data

The essential component of an energy audit is the data acquisition process. Before the school building is inspected, the data provided by the school is compiled and evaluated. On this basis, the energy auditor can optimally plan and prepare the inventory of the building, in particular the necessary energy-relevant measurements. The following data should be available:

- Total energy consumption and energy costs by energy source and periods in recent years
- building plans
- energy supply contracts
- (Heated) area of the school building
- number of students
- School operating hours

With *D.T1.1.1 – List of jointly defined homogeneous criteria for implementation of the transnational school-facilities inventory* there is a complete technical checklist available to collect as much technical information as possible on a building, thanks to the definition of homogenous quali-quantitative criteria useful to describe/categorize each building chosen for an analysis.

6.2. Inspection of the school building

The aim of the inspection is to enable the energy auditor to gain an accurate picture of the actual energy status of the school building. In addition to recording the energy input under realistic conditions, this also requires investigating users' behaviour. This includes

- Survey of the performance of individual electrical devices and their operating times;

- Recording and documentation of the temperature level of the heating system;
- Evaluation of building physics.

6.3. Analysis

Following the inspection, the energy auditor must analyse the data collected and the behaviour observed, derive energy-saving potential, evaluate it and record it in writing in a report. For this purpose, DIN EN 16247 requires the balancing of energy flows for the energy consumption and supply side as well as the presentation over time.

In order to make the data relevant to energy consumption meaningful and reliable for future surveys, it is also necessary to clean up the data. In particular, the energy consumption for space heating and air conditioning should be temperature adjusted for this purpose. For this purpose, the consumption is offset against the heating and cooling degree-days.

As a result, the energy auditor must quantify the energy saving possibilities based on the actual state of the school building and evaluate them according to the agreed criteria. The evaluation takes place, for example, with regard to investment costs, energy cost savings and internal rate of return. Indirect effects, e.g. maintenance costs, must also be considered and listed.

6.4. Report

The audit report shall be transparent, of high quality and comprehensible and shall contain the following essential elements: Summary, background, documentation of the energy audit, list of possibilities to improve energy efficiency and a conclusion.

In addition to general information on the school building, agreements reached and relevant regulations and standards, the report shall include all data obtained through data collection or measurements. Where energy consumption data are extrapolated, it is necessary to store the assumptions made. In the case of measurements, detailed information on the measuring instruments used and, where appropriate, calibration certificates shall be attached.

Particular attention shall be paid to the identified energy efficiency potentials. These must be presented in detail, including:

- Description of the energy saving potentials including assumptions for their calculation;
- Economic efficiency calculation incl. assumptions for their calculation;
- Relevant funding opportunities (see chapter 12. Financing);
- Concrete implementation recommendations with flow charts of suitable procedures for evaluating the savings after implementation of measures (see chapter 7. Set goals for improving energy efficiency).

After consultation with the responsible person, the audit report is sent to the city administration or the responsible authority.

7. Set goals for improving energy efficiency

Energy refurbishment is usually associated with high investment costs, so technical measures have to be carefully planned in accordance with the investment funds that are available. Savings when implementing technical measures can be very large, so it is necessary to consult with both the professional as well as financial institutions (in the case of other sources of funding), that will allow quality implementation of investment. It is important to also consider all financing options, including obtaining government grants and EU funds.

This section contains a description of relevant retrofitting measures for energy efficiency in schools that are classified according cost-effective priority. The main aim is to create technical competencies for future Senior Energy Guardians to be able to asses the necessity of certain energy improvements in school buildings and to be able to start necessary steps towards upgrading schools in terms of EE and RES applications. The collection of measures is roughly divided into the following areas of intervention:

- Implementation of Renewable Energy Systems
- Insulation of thermal envelope
- Windows
- Measures on heat generators
- Measures on domestic hot water preparation systems
- Measures on distribution systems
- Regulation measures
- Measures on ventilation systems
- Measures on lighting systems
- Control and energy management systems

For each area of intervention, this chapter tries to present possibilities for upgrading older but sound systems to make them more efficient as well as introducing options for complete refurbishments or replacements. It presents categorizations of measures based on expected savings, investment costs and payback period. Which measures can be applied in a specific building and what savings can be expected, however, depends on the construction material, the way energy is used and how the building and its equipment are maintained. This, of course, varies from building to building. Depending on the specific context, the type of building and the technology available, some of these measures will be more applicable than others.

Some low-cost measures described in this section can be implemented without major investments and without major interruption of the building use. There is no or only little planning necessary and no tenders or public procurement processes have to be started. These measures, such as installation of thermostatic valves, piping insulation, installing occupancy sensors etc., can be implemented only with a little assistance or advice of energy experts and with the help of facility managers.

Other more costly and technically complex measures should always be planned and implemented by professionals. Only after involving all the relevant actors in the process, such as school management and municipal authorities (or building owners) you are able to cooperatively undertake all important steps from energy audit, assessing priorities, deciding upon most cost-effective bundle of measures, researching all possible financial mechanisms and starting procurement procedures.

7.1. Energy management

The goal when preparing a retrofit plan and choosing proper is usually to follow the objective to maximize the energy savings and minimize the payback period for the given initial investment. To be able to achieve that it is necessary to integrate energy management in a building or organisation, which is a proactive, organized and systematic way of monitoring, controlling and conserving energy taking into account environmental and economic objectives. There are few basic steps of an energy management cycle that should be considered when planning energy investments:

1. **Systematic acquisition of energy data (monitoring)**

Energy data needs to be collected in regular time intervals to be able to understand and evaluate the energy use of a building. It is important to be able to visualize historic data, trends, daily and seasonal cycles etc. The more you know the better you do. Most of it can be done by an energy management software – energy bookkeeping. Accurate and correct data collection is the baseline for all the later processing and calculations of EE and RES implementation.

2. **Processing and analysing energy data**

Once you know your spend, it is time to target areas for reductions and savings. What is possible? What is reasonable and achievable? Detailed analysis of your energy data reveals opportunities for improvement in your building. Energy audits performed by professionals will help identify the list of possible measures of EE and RES to improve energy situation in building.

3. **Planning and implementing EE and RES measures**

Energy audits (see chapter 6. Baseline inventory consumption – Energy Audit) are necessary to assess the existing energy consumption and identify the whole range of opportunities to save energy. Furthermore, energy audits allow prioritization or ranking of measures according to the technical and economic justification and available funds. This should then result in proposals of concrete saving measures for the management, public authorities or building owners and implementing the investment.

4. **Monitoring and evaluating**

It is advisable to monitor the implementation of the measures and the effects after the implementation to see if energy savings are achieved. Quality, precise and detailed evaluation of the success of each measure is the baseline for the continuation of energy-efficient actions.

7.2. Partial and deep building refurbishment

Energy retrofitting can be approached as a partial or deep refurbishment. Partial implementation of measures means deciding on specific measures to be implemented (for example windows or thermal insulation). The positive side is that the costs and the payback period will be much smaller. Energy consumption and costs will still be reduced and the living environment will be improved, but the result of such a partial approach doesn't bring a significant energy optimization and is not that sustainable.

The building still have to undergo additional investment measures in the future and if only 'partial solutions' are implemented, e.g. limited insulation of roofs or walls, it will be more expensive in the long run and perhaps technically impossible to realise the full energy-saving potential at a later date.

Using budget to fund many cheaper, shallow renovations in order to maximize short-term savings may seem more attractive than a deep energy renovation strategy, but it may also fail to achieve long-term energy saving goals. Deep renovation covers energy refurbishment as a whole, improving building structures and modernizing building mechanical systems. It includes measures on the building envelope (insulation of external walls and roofs, replacement of windows and doors, etc.), measures on building technical systems (energy supply measures in boiler rooms, measures on ventilation, cooling, lighting, heat recovery, insulation of piping), connection to district heating and using of renewable energy if possible (RE boiler systems, thermal solar systems, ground water heating pumps in combination with EE measures, photovoltaic systems, wind, hydro power) etc.

Although the negative sides are large investment costs and a long payback period, the positive sides are that the building is thoroughly restored in the long term and significantly reduced operating and maintenance costs can be expected. With deep renovations, 50%-70% savings of the final energy can be achieved. Deep retrofit is the most sustainable approach, but it is also rarely implemented in buildings across the EU. More often, partial renovation of buildings is addressed, but partial renovation of buildings will likely not deliver to the EU its environmental objectives, since EU has committed to cut 80%-95% of its CO2 emissions by 2050.

The following Table 1 is a categorization of the most common measures for energy retrofitting based on expected savings, costs and payback periods. What savings can be expected from a specific measure, however, depends on the building itself - from factors such as construction material, the way energy is used, how building and equipment is maintained etc. Because of this, it is not possible to provide a more specific categorization than the one presented below. For more information and concrete descriptions of each measure look at Deliverable *D.T1.1.2 - Joint inventory of energy-saving and res technologies with best cost-effective bundle of measures for schools*.

To understand the expected savings in the categorization, it is first important to realize, that the savings deriving from specific measures are not cumulative - the table shows the potential impact on energy use by carrying out an individual measure only. That means for example, when implementing several measures at once, such as windows that bring 25% savings, roof insulation that brings 35% savings and the insulation of external walls that can also bring up to 35% savings on heating energy, does not mean you can expect a 95% reduction of energy currently used for

heating. The math is not that simple, however, since we need to consider technical interactions between different measures and systems.

Nevertheless, when planning an energy retrofit, the goal is to maximize the number of implemented measures, because implementing individual and partial measures consequently decreases the potential for more comprehensive energy reconstruction and savings that could derive from more complete renovation plan. Implementing partial measures is more expensive in the long run and perhaps it will be technically impossible to realise the full energy-saving optimization of a specific building at a later date.

Table 1: Categorization of refurbishment measures based on expected savings, investment costs and payback period

Measure	Expected savings	Investment cost	Payback period
Insulation of thermal envelope			
Insulation of external walls (ETICS and ventilated facades)	Up to 35% heating energy	high	high
Insulation of external walls (thermal insulating mortars and plasters)	Up to 10% heating energy	high	high
Ceiling insulation between conditioned space and unconditioned attic	Up to 15% heating energy	high	high
Roof insulation	Up to 35% heating energy	high	high
Windows			
Window replacement (U lower than 1,1 W/Km^2)	Up to 25% heating energy	medium	high
Caulking and weatherstripping	Up to 20% heating energy	low	low
Solar shadings	Up to 25% electrical energy	medium	high

Measure	Expected savings	Investment cost	Payback period
Measures on heat generators			
Burner replacement	Up to 5% heating energy	low	low
Boiler interlock and boiler controls (burner control, weather compensation, sequence control etc.)	Up to 20% heating energy	medium	low
Heat boiler replacement	Up to 20% heating energy	high	high
Installing heat pumps	Up to 45% heating energy	high	medium
Measures on domestic hot water preparation systems			
Installing heat pumps for hot water preparation	Up to 75% energy for hot water preparation	medium	low
Solar water heating	Up to 60% energy for hot water preparation	medium	medium
Measures on distribution systems			
Pipe insulation on heat and water distribution systems	Up to 5% heating energy	low	low
Regulation measures			
Installing thermostatic valves	Up to 15% heating energy	low	low
Hydraulic balancing	Up to 20% heating energy	medium	medium
Installing new circulation pumps with frequency converters	Uses up to 80% electrical energy less compared to conventional models	low	low

Measure	Expected savings	Investment cost	Payback period
Measures on ventilation systems			
Installing HRV system	Up to 25% heating energy	high	high
Installing HVAC system	Up to 50% heating energy	high	high
Measures on lighting system			
Installing energy efficient lighting	Up to 30% - 50 % electric energy	low	low
Installing lighting controls (occupancy sensors, daylight controls, etc.)	Up to 50% electric energy used for lighting	low	low
Replacing light ballasts	Up to 30% electric energy per fluorescent fixture	medium	low
Control and energy management systems			
Building energy management system	15%-20% energy for heating and cooling 50%-60% of energy for lighting	high	medium

7.3. Renewable Energy Sources – RES

Renewable energy is energy that is generated from natural resources that are continuously replenished. This energy cannot be exhausted and is constantly renewed. The most important ones are:

- wind,
- sun,
- water,
- geothermal energy and
- biomass which is partially a renewable energy source.

The EU`s Renewable Energy Directive sets a binding target of 20 % final energy consumption from renewable sources by 2020. To achieve this, EU countries have committed to reach their own national renewable targets. By using more RES to meet its energy needs, the EU lowers its dependence on imported fossil fuels and make its energy production more sustainable.

It is important to use local renewable energy because they are pure sources that have very little influence on the environment. Before selecting an appropriate renewable energy technology to apply to an existing building retrofit project, it is important to consider first a number of factors. Examples of these factors include:

- Available renewable energy source at or near the building site
- Available area for placing the renewable energy technology
- Cost of energy purchased from the electrical or thermal energy provider for the building
- Available incentives for offsetting the installation cost of the renewable energy system
- Local regulations affecting renewable energy systems
- Desire to preserve or not alter existing architectural features
- Characteristics of the energy profiles to be offset by the renewable energy installation

There are many ways of integrating the renewable energy sources. Within the following chapter, renewable energy technologies most commonly used in public buildings are represented. We divided them in the sections:

- Solar photovoltaic systems (PV)
- Solar thermal, including solar hot water (domestic water heating and space heating),
- Geothermal heat pump
- Wind turbines
- Biomass systems.

8. Action Plan

All schools are responsible for managing their energy, although it is likely that most schools have historically given little attention to controlling energy costs. Behavioural changes in the management of schools can be an opportunity to give energy management a higher priority. Indeed, the way in which staff and pupils use a school can have a significant effect on its energy bill. By adopting good housekeeping practices, such as switching-off lights when not required, closing windows and regular checking of heating control settings, energy costs can be cut by at least 10%.

The implementation of an Action Plan is fundamental to manage the several activities foreseen for schools' staff and pupils, in order to improve energy saving into schools. It represents, therefore, a good support to orientate EGs on decisions/actions to be undertaken for energy efficiency improvement in schools.

The JEGs have to carry out further energetic audits themselves by which they can observe that improvements to reduce consumptions could be made through behavioural change. Saving energy sometimes costs nothing, yet derives benefits that may be environmental as well as financial.

To plan for reducing energy consumption, the students have to find out first what kind of pattern of use were for the devices.

The following approach should be used:

1. Gauging the equipment energy use in the school;
2. Meeting with the Senior Energy Guardians;
3. Development of an Action Plan;
4. Energy Culture Campaign.

With this approach, it is possible to develop an Energy Culture Action Plan to be implemented continuously across the school and focused to save energy. For more information, see *D.T4.3.1 – Energy Culture Action Plan developed by JEGs in each involved school*.

1. Gauging the equipment energy use in the school

Equipment and appliances typically account for approximately 20% of a school's energy use. Much of this energy use occurs when the equipment is not in use (in standby mode).

Standby loads look small but because they are running continuously, they can amount a large energy use. To become more energy-efficient, it is important to know how energy is currently being used. The students, coordinated by the Junior Energy Guardians, will have to note where energy is being used filling out the template of the energy consumptions in each classroom. The JEGs will collect all the templates and will determine the energy consumptions in the common area and in the classrooms led by busy teachers filling out the template of the total energy consumption. The template will be supplied in the Action Plan Guidelines (see *D.T4.2.1 – Energy Culture Action Plan developed by Junior EGs in each involved schools*). While the Senior Energy

Guardians could delegate or share responsibility for reducing inefficient energy use, this objective need to become part of a school strategy. In this way, students can start the change independently.

2. Meeting with the Senior Energy Guardians

Junior Energy Guardians will meet with the Senior Energy Guardians to discuss their energy audit and the data of the total energy consumption collected with the template. They have to define a strategy in order to reduce the energy consumption revealing a number of items left on unnecessarily.

3. Development of an Action Plan

JEGs have to meet the students in each classroom in order to share and discuss a strategy. They have to plan how raise awareness about energy use among their peers.

JEGs have their focus on the development of a shared Action Plan for improving energy efficiency with a gradual process. Once JEGs have identified and shared what energy the school uses and where, they can implement actions to decrease energy consumption.

Motivating factors relate to personal drivers of behaviour, such as awareness, knowledge, perceived capabilities and a desire to create change. Individuals need to become aware of their energy use and to be aware of the impact of their behaviour. Smart meters are starting to play an increasingly important role in raising the awareness of user's consumption patterns and how they can reduce their energy needs.

Information, that offers the advice and details of energy saving activities and measures, can easily be made available:

- turn off the lights in rooms that are not being used;
- turn off the heating in rooms that are not being used;
- only fill kettles with as much water as needed before boiling;
- turn appliances completely off, not left on standby;
- only print or photocopy items, if absolutely necessary;
- defrost freezers on time;
- turn the heating off at night or set the thermostat to 15 degrees;
- wear warmer clothes during colder months, so that less heating is required

For more information look at *D.T3.4.1 – Format of an energy saving capacity-raising plan for public buildings of municipalities*.

4. Energy Culture Campaign

The challenge of the JEGs is to tell students that they are wasting energy and encourage them to change.

JEGs should be able to:

- present initial findings to the students in each class at a meeting without any judgment and suggestions;
- canvass students for their opinions through survey;
- invite students to a follow-up meeting for detailed presentation of an Action Plan.

There is much more to energy efficiency than measuring usage and setting policies. The team of JEGs is essential. For maximum impact, Senior Energy Guardians have to involve periodically JEGs providing them with information and seeking their ideas.

Energy saving is primarily about behaviour change. Discuss this with staff and encourage them to support each other to change the culture of energy use.

9. Implementing the Action Plan – Energy Culture Campaign

The most important part of communication is to make sure you report back to the school users on your and their progress. It is motivating to know that actions are making a difference. An effective energy management process needs to be communicated to all schools' users regularly. Visual, high level support gives a clear message to the school community. Everyone must know energy management process objectives and be in agreement. If contractors are used for preparing food on site or cleaning the school, make sure energy efficiency behaviour and equipment is written into their contract. Regular slots in staff meetings, assemblies, a dedicated notice board or section of the school newsletter and permanent agenda item for principals meetings can be a structured way to report the progress and results achieved.

Despite all this, if you want to establish your own campaign it can be hard to know where to begin and how to stay on track. Here are some tips to build pressure for change and to make your campaign a success. The four steps to implementing an awareness programme of messages are seen in Figure 4.

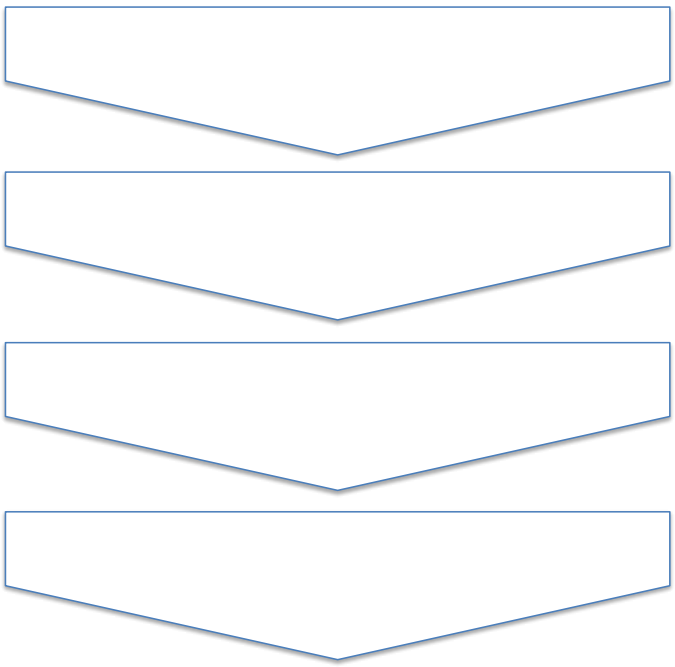

Figure 4: The four steps of an information campaign

People are constantly bombarded with promotional messages. Be aware of promotional overload: people tend to look at subjects or issues that interest them and ignore the rest. Your messages and slogans will have to be punchy and varied to interest different people.

For more information, see D.T4.2.1 - Informative and educational material for energy culture campaign. This guide is for whoever in school is responsible for managing energy, together with

those who have supporting roles, including internal training and communications staff. This guide provides ideas and resources to motivate everybody, not only students, to save energy. This will ensure long-term benefits for people, the organisation and the environment. The best way to create an energy awareness programme depends on your own circumstances. Think how the information in this guide relates to your own organisation and tailor your energy awareness programme accordingly. You may already have initiatives in place that you can develop, or you might need to try different tactics to get your campaign noticed.

10. Evaluate Progress – Measure Results

Energy data needs to be collected in regular time intervals to be able to understand and evaluate energy use. It is important to be able to visualize historic data, trends, daily and seasonal cycles etc. Therefore, the most essential step in energy management is to monitor your energy use in order to identify targets for reducing it or to control, if previously set targets were matched. Analysing and understanding your hourly, daily, weekly or monthly, annual use will immediately show you where energy is being wasted. The Energy-Team can have a large role in monitoring and targeting by regularly checking for waste and communicating energy data to other school users. Pupils and staff are the best asset when it comes to energy efficiency and energy management. Thanks to the monitoring activities made by the Energy-Team, it will make savings overnight by cutting waste, e.g. by moving book cases away from the front of radiators. Using the available data to give information on energy use will ensure they concentrate on the most effective actions. For more information, see *D.T3.5.3 - Criteria for monitoring results of the energy saving plan* and *D.T4.3.1 - Guidelines for the monitoring*.

11. Review action plan

A detailed analysis of the energy consumption and the measures defined in the Action Plan is scheduled at regular intervals. Care should be taken to assess the results honestly and without prejudice. If it appears that objectives have not been achieved or other difficulties and problems have been identified, the current strategy should be reconsidered.

Further adjustments and optimizations within the Action Plan are also part of this phase. If it is determined that there is a need for further action in order to really achieve the energy savings targets set, action and the necessary measures should be taken. Once all targets and expectations have been met, new, more ambitious targets can be set or further measures be developed.

The system can only be considered successful if it is maintained and operated continuously. That is, if the control of the monitoring indicators, occasionally an intervention, the solving of problems encountered are all constantly working.

12. Financing

The goal of any finance planning is to minimize overall capital cost, secure liquidity and reduce transaction costs. Also legal aspects, tax implications and balance sheet issues have to be considered. Of course, financing needs depend on the individual circumstances of the borrower. Moreover, they depend on the specific project. Nevertheless, we aimed at developing a customizable methodology for describing generic characteristics of financing needs for Energy Efficiency projects, which can be adapted to the specific situation. Here we are talking about properties such as financing cost and terms, legal implications, tax and balance sheet effects as well as management expenditure. Only a comprehensive look at the sum of the financing implications allows the choice of the best financing option.

In order to structure financing implications, the relevant categories are:

- Direct financing costs (financing conditions, interest rates, fees)
- Legal aspects (Rights and duties, ownership, contract cancellation, end of term regulations)
- Required collateral (securities) by financing institution
- Taxation implications (VAT and purchase tax, corporate income tax, acquisition of land tax)
- Balance sheet & accounting implications (who activates the investment (on or off balance?), balance sheet effects like credit lines, performance indicators, Maastricht criteria)
- Management expenditure (transaction cost, comprehensive consultancy)

There are different ways to finance an intervention.

European Regional Development Fund (ERDF). The ERDF is one of the European Structural Funds. The objective of the ERDF is to strengthen economic and social cohesion in the European Union by reducing disparities between regions.

The ERDF finances:

- Direct support for investment by enterprises (especially small and medium-sized enterprises) to create sustainable employment;
- Infrastructures, in particular related to research and innovation, telecommunications, environment, energy and transport;
- Financing instruments (risk capital investment, regional development fund, etc.) to support regional and local development and to foster cooperation between cities and regions.

Further information available at the official web site:

http://ec.europa.eu/regional_policy/en/funding/erdf/

ELENA (European Local Energy Assistance). ELENA is a joint initiative by the EIB and the European Commission under the Horizon 2020 program. ELENA provides grants for technical assistance focused on the implementation of energy efficiency, distributed renewable energy and urban transport projects and programs. The grant can be used to finance costs related to feasibility and market studies, program structuring, business plans, energy audits and financial structuring, as well as to the preparation of tendering procedures, contractual arrangements and project implementation units. Further information available at the official web site: http://www.eib.org/infocentre/publications/all/elena.htm

JESSICA (Joint European Support for Sustainable Investment in City Areas). JESSICA - Joint European Support for Sustainable Investment in City Areas - is an initiative of the European Commission developed in co-operation with the European Investment Bank (EIB) and the Council of Europe Development Bank (CEB). It supports sustainable urban development and regeneration through financial engineering mechanisms. The investments can take the form of equity, loans and/or guarantees. Further information available at the official web site: http://ec.europa.eu/regional_policy/en/funding/special-support-instruments/jessica/

JASPER (Joint Assistance to Support Projects in European Regions). JASPER is a technical assistance partnership between three partners (European Commission, EIB and EBRD) provides independent advice to beneficiary countries to help prepare high quality major projects to be co-financed by two EU Structural and Investment Funds (European Regional Development Fund and Cohesion Fund). Further information available at the official web site: http://ec.europa.eu/regional_policy/en/funding/special-support-instruments/jaspers/

National/Regional Funding. In every country, there are different national and ministerial/federal programs for retrofitting and incentives for the production of energy from RES and energy efficiency. Most of the funding are aimed to municipalities and Public Bodies but not directly dedicated to schools. In the following chapters, a brief overview related to funding programs is presented for each project partner. For more information, you can download the whole document (D.T1.4.2 – Transferrable Business Model for implementation of energy performance contracting through ESCO) at this link: https://www.interreg-central.eu/Content.Node/WP1-project-results.html

The Availability of financial resources is one of the key success factors for the implementation of energy efficiency projects. (Pre-) Financing energy efficiency investments has become increasingly burdensome for cities and public bodies, because they reach their credit lines and credit liabilities (Maastricht criteria).

Consequently, innovative finance options like operate, finance lease or “pure” forfaiting options have to be considered and compared to classical finance instruments like credits. In addition, crowd financing and crowd funding is a new opportunity, but very often limited in extent and legal circumstances (partly unclear so far) and sometimes risky with high costs.

The energy performance contracting model (EPC) with ESCOs (Energy Service Companies) is a well-tested and good opportunity to pre-finance EE-measures without touching own budgets, but still has some hurdles to overcome to exploit the full market potential.

For more information on financing energy-saving measures see Deliverable D.T1.4.1 – *Report on sources of funding and support instruments to finance EE interventions in schools*.

13. Legal Framework

Climate protection is one of the political priorities of the European Union. In the Paris Convention 2015, the international community committed itself to limiting global warming to below two degrees Celsius and, if possible, below 1.5 degrees Celsius compared with pre-industrial levels. The aim is to limit the negative effects of climate change.

On its way to a climate-friendly economy, the European Union is relying on overarching objectives, EU-wide measures and binding national climate protection targets. Of course, each country in the EU has its own legal framework to promote climate protection in the building section, but in consideration of the large number of members in the European Union, only the European framework conditions are discussed.

Table 2: Overview of the legal framework conditions in the field of climate protection in the building sector within the EU

Title	Year
Ecodesign Directive (ErP)	2009
Directive on the promotion of the use of energy from renewable sources	2009
Directive on labelling of energy-related products	2010
Energy Efficiency Directive (EED)	2012
2030 climate & energy framework	2014
Energy Performance of Buildings Directive (EPBD)	2018
2050 long-term strategy	2018

With regard to the buildings sector, the agreements and directives seen in Table 2 apply at European level. The Energy performance of buildings directive (EPBD) is, together with the Energy efficiency directive, the main legislative instrument to promote the energy performance of buildings and to boost renovation within the EU.

13.1. 2030 climate & energy framework

The 2030 climate and energy framework includes EU-wide targets and policy objectives for the period from 2021 to 2030.

Key targets for 2030:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 32% share for renewable energy
- At least 32.5% improvement in energy efficiency

The framework was adopted by the European Council in October 2014. The targets for renewables and energy efficiency were revised upwards in 2018. More information available at https://ec.europa.eu/clima/policies/strategies/2030_en.

13.2. 2050 long-term strategy

The European Commission calls for a climate-neutral Europe by 2050.

On 28 November 2018, the Commission presented its strategic long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050.

The strategy shows how Europe can lead the way to climate neutrality by investing into realistic technological solutions, empowering citizens, and aligning action in key areas such as industrial policy, finance, or research – while ensuring social fairness for a just transition.

Following the invitations by the European Parliament and the European Council, the Commission's vision for a climate-neutral future covers nearly all EU policies and is in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5°C. Further information and documents are available at https://ec.europa.eu/clima/policies/strategies/2050_en#tab-0-0.

13.3. The Energy Performance of Buildings Directive (EPBD)

The EPBD (2010/31/EU) has been in force since 2010 and helps consumers to make informed choices allowing them to save both energy and money. It has also resulted in a positive change of trends in the energy performance of buildings; following the EPBD introduction of energy efficiency requirements in national building codes, buildings of today consume only half as much as typical buildings from the 1980s.

The revised EPBD (2018/844/EU), which amends parts of the 2010 EPBD and introduces new elements, is an important part of the implementation of the Juncker Commission priorities to build "a resilient Energy Union and a forward-looking climate change policy". The Commission launched a public consultation in June 2015 to help underpin the revised directive, including for example targets to accelerate cost-effective renovation of existing buildings, with the vision of a decarbonised building stock by 2050, and the mobilisation of investments. It was adopted on 9 July 2018 and constituted an important and concrete first delivery of the 'Clean energy for all

Europeans' package and sent a strong political signal on the EU's commitment to the clean energy transition, as the building sector has a vast potential to contribute to a carbon-neutral and competitive economy.

EU countries have until 10 March 2020 to write the new and revised provisions into national law. Further information is available at https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/energy-performance-buildings-directive.

13.4. Energy Efficiency Directive

The 2012 Energy Efficiency Directive (2012/27/EU) establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. This means that overall EU energy consumption should be no more than 1483 million tonnes of oil equivalent (Mtoe) of primary energy or 1086 Mtoe of final energy. Under the directive, all EU countries are required to use energy more efficiently at all stages of the energy chain, including energy generation, transmission, distribution and end-use consumption. Further information is available on the official website https://ec.europa.eu/energy/en/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive.

14. Recommendations

First, it is important to have engaged people and be convinced of the Energy Smart School idea. Leaders should gather young takers – Junior Energy Guardians who can disseminate main goals among students. However, most important is to have motivated facility managers, because they are in charge for the system technology.

People themselves often represent the major obstacle in the activation of smart school processes, because of their inadequate knowledge, awareness and sense of responsibility. Education and awareness raising of internal staff could at least reduce many regulatory, technical and financial barriers in achieving the smart school concept.

Practice shows that although many schools are implementing various awareness raising activities among students, teachers and other members of the school community, these rarely result in real energy savings. The most difficult and necessary step is making the people apply the knowledge that they have. The students usually show the enthusiasm and creativity when involved in energy efficiency initiatives as it helps them to escape the school routine. Nevertheless, keeping this enthusiasm requires a good teacher, who should keep the activities interesting and give feedback on the results achieved so far. Nevertheless, a teacher also needs some incentives to keep his own motivation.

One fact that is more important is that students and teachers are not the only users of the school as there are also other groups of people taking part in energy consumption of the school building. This includes administration staff, cleaning staff, cooks etc., meaning that all those other group of school users should also needs to be encouraged to take place in energy savings or all the efforts made by students and teachers will be for nothing. Motivating the additional school staff may

require different types of incentives as each group has different sources of motivation and capacities to act.

Introducing the Energy Smart School concept in schools has a fundamental impact related to its educational function as it increases the awareness of students, teachers and indirectly parents about energy culture and sustainable development. At the same time, theory is turned into practice as the implementation of the behaviour previously learned immediately results in energy and money savings. The most important thing is giving the feedback on better results of school building performance to the school users as it shows them that their efforts are well paid off, thus motivating them to continue with the new sustainable behaviour.

By realizing their impact in energy consumption of school building, the students as well as other school users perceive their influence in improvement of their environment thus comprehending their importance as a single being and how much it could be made if everyone work together, enhancing the team spirit of the whole school users.

Positive results as well as a higher level of comfort of the buildings, in which the Energy Smart School concept is implemented, when properly communicated and promoted, results in a motivation to change in other similar buildings. Positive experiences are also transferred into better energy culture into the homes of the students, teachers and other school staff involved, directly influencing on their life quality.