Interreg
CENTRAL EUROPE
European Union
European Regional Development Fund
TOGETHER

CE51 TOGETHER

TRAINING MATERIAL ON ENERGY EFFICIENCY IN PUBLIC BUILDINGS

Technical aspects

The training material, which is included in this publication, has been developed within the **TOGETHER** project (full name: **Towards a goal of efficiency through energy reduction**), co-funded by the Interreg CENTRAL EUROPE programme, which encourages cooperation on shared challenges in Central Europe. The project, implemented from June 2016 till May 2019, aims at promoting the concept of integrated energy management in public buildings through implementation of selected technical, DSM and financial measures in 85 pilot buildings from different EU countries. The training material focuses on technical aspects related to the overall topic of energy efficiency in public buildings. It is completed with 2 other publications - focusing respectively on financial and DSM issues.

Deliverable no: D.T1.2.1

Deliverable name: Training material on EE and RES in public infrastructures

Author: University of Maribor, Faculty of Energy Technology

Editing: Association of Municipalities Polish Network "Energie Cités"

March 2017

INTRODUCTION

This publication contains the training material on energy efficiency in public buildings developed within the TOGETHER project, co-funded from the Interreg CENTRAL EUROPE programme. The project supports implementation of the concept of **integrated energy management** in public buildings through implementation of selected technical, DSM and financial measures in 85 pilot buildings from different EU countries. The measures implemented will lead to significant reduction of energy consumption and change of behaviour of building users.

An important part of the project was focused on the development of a comprehensive, transnational training model and material that could be used to increase knowledge, capacities and skills of building owners, managers and decisions makers, enabling them to successfully implement sustainable energy measures in their buildings and to engage users in this process.

The training material prepared by the consortium discusses wide variety of topics, which fall under three main categories: technical aspects, financial aspects and DSM aspects, where DSM stands for "demand side management" and concerns users' behaviours and energy management practices. This publication contains the training material focusing on technical **energy efficiency measures and solutions** that can be implemented in public buildings. It is complemented by two other publications - one concentrating on financial aspects of the process (such us choosing funding for energy renovation projects and economic and financial assessment of planned interventions) and the other one - on DSM aspects (changing users' behaviours and application of ICT technologies for optimisation of energy consumption).

The **technical training material** aims at increasing trainees' knowledge, skills and capacities regarding technical aspects related to EE in public buildings, with the specific focus on integration of different solutions, choosing most optimal scenarios, ensuring efficient monitoring and involving building users in the processes. The material has been divided into 9 training modules presented in the table below:

Module no	Module topic
Module 1	Introduction to energy efficiency in buildings
Module 2	How to use energy more efficiently
Module 3	Basic characteristics of energy saving
Module 4	Energy audit and energy performance certificate
Module 5	Energy using products
Module 6	Energy retrofitting of the buildings
Module 7	Installation of RES
Module 8	Choosing most optimal EE improvement scenario for a specific building
Module 9	Integration of technical measures with each other and with other types of EE solutions

For each module there is a comprehensive theoretical introduction accompanied by at least one exercise and a set of guiding questions allowing the trainees to test new knowledge gained. In order to support the trainers in the preparation of respective training sessions there are also included further suggestions concerning e.g.:

- list of reference material that can be consulted to elaborate specific topics in more detail;
- other relevant issues that could be raised and discussed with the trainees;
- suggestions for further exercises and practical application of new knowledge and skills.

The publication is also accompanied by **model PPT slides** that may be used by trainers during their work.

What is very important about the TOGETHER training material, is that it not only provides knowledge but also address practical aspects related with the implementation of energy efficiency improvements in public buildings, such us choosing optimum improvement scenarios, overcoming most typical barriers or integrating different types of measures to create synergies. For those, who would like to learn more about the issues raised here, the TOGETHER consortium developed special on-line library, which is a repository of existing materials and tools on energy use and energy efficiency in public buildings. It can be accessed from the project website:

http://www.interreg-central.eu/Content.Node/TOGETHER.html

LIST OF CONTENT

PART 1: TRAINING MODULES

MODULE 1:
INTRODUCTION TO ENERGY EFFICIENCY IN BUILDINGS

Saving energy and its efficient use begins with raising awareness that energy should not be taken for granted and that it is not available in unlimited quantities. Its production requires relatively high costs and has a big influence on the environment. One has to take into consideration that thoughtful and planned use of energy not only affects the family budget but also the whole economy, public sector and the environment.

Most of public buildings, above all older ones, have a great potential for the efficient use of energy. The reduction of energy consumption by 10% could be achieved without bigger investments, with a more rational use of energy and better organisation. This mostly means the energy needed for space heating, electrical energy and water. Further 5% of energy consumption could be saved by better organisation of work and better awareness of end-users.

According to the estimates appropriate technical investment measures could bring the potential of efficient use of energy up to 30%.

The consumption of energy depends on external factors such as changeable weather conditions and temperature oscillation, the price of energy sources, plus the number, structure and mentality of users change. The awareness of users for the efficient use of energy, renewable sources of energy and ecology also have a big influence on energy consumption. Great improvement is the introduction of regular monitoring of current consumption and energy costs in buildings. The monitoring can be carried out with auditing and verifying the accounts for individual energy sources, or with computer-aided energy bookkeeping.

Table 1: Energy efficiency: transposition of the energy performance of buildings directive, Directive (2010/31/EU of 19 May 2010), Transposition date: 9 July 2012

Member State	Energy performance of buildings directive*		
	Transposition	NZEB** report	Cost-optimal calculations
Austria	Orange	Red	Red
Belgium	Orange	Green	Red
Bulgaria	Orange	Green	Red
Cyprus	Green	Green	Red
Czech Republic	Green	Red	Red
Denmark	Green	Green	Green
Estonia	Orange	Red	Red
Finland	Orange	Green	Red
France	Orange	Green	Green
Germany	Orange	Green	Red
Greece	Green	Red	Red
Hungary	Green	Green	Green
Ireland	Green	Green	Green
Italy	Red	Red	Red
Latvia	Orange	Red	Red
Lithuania	Green	Green	Green
Luxembourg	Orange	Red	Red
Malta	Green	Red	Red
Netherlands	Orange	Green	Green
Poland	Orange	Red	Red
Portugal	Red	Red	Red
Romania	Orange	Red	Red
Slovakia	Green	Green	Red
Slovenia	Red	Red	Red
Spain	Red	Red	Red
Sweden	Green	Green	Green
United Kingdom	Green	Green	Red

Transposition status is based on declared transposition by Member States

Green: Full;

Orange: Partial;

Red: No

- The Commission is undertaking prima facie and conformity checks for those Member States having notified transposition measures.
- For the NZEB (Nearly-zero energy buildings) reports and the cost optimal calculations, the status is based on whether or not reports have been received and not on the completeness of the reports. The Commission is undertaking analysis of the reports received.

CHECKLIST FOR TESTING TRAINEES KNOWEDGE:

- What is the cheapest measure for reduction of energy consumption?
  (a more rational use of energy and better organisation)
- Does the energy consumption depend on the weather conditions? (Yes)
- Does the behavior of users affect the energy consumption in the building?

FURTHER SUGGESTIONS FOR TRAINERS:

- Energy efficiency is a broad term, specifically in a manner of public buildings. Perhaps it should be presented in a more detailed way for specific buildings, for example sports facilities. Their energy cards are calculated in the same way as any other public building, but the problem is the working hours. These facilities are often closed for some periods and energy class of the building is calculated based on consumed energy per year per square meter. It is obvious that the facility might not be so energy efficient as the card states, since the facility is not in use for a longer period of time.

MODULE 2: HOW TO USE ENERGY MORE EFFICIENCY

Organisation of work (up to 10% of possible savings):

- with on-going monitoring and consumption measurements
- with energy bookkeeping
- raising users' awareness
- with other organisational measures (considering lower tariffs, time coordination of activities)

Heating:

- with suitable and efficient insulation (15% to 25% of possible savings, big and long-term investment)
- with the insulation of attic, which brings the reduction of transmission loss (up to 50 kWh/m^2 of savings, medium and medium-term investment)
- with high quality windows and doors (10% to 60% of possible savings),
- with sealing of windows, which enables lower ventilation loss (up to 15% of savings),
- with appropriate arrangement of heating units and heating secondary heating circuit, and with the use of thermostatic radiator valves (up to 10% of savings, low or medium and short-term investment)
- with hydraulic balancing of heating pipes (up to 8% of savings, low or medium and short-term investment)
- with the introduction of automatic temperature regulation depending on external temperature (up to 7% of savings, medium and short-term investment),
- with appropriate and rational organisation of work
- with the introduction of renewable sources of energy

Electricity consumption:

- with the use of modern energy-saving appliances/devices
- with the use of modern lighting, energy-saving bulbs and taking advantage of daylight (20% do 40% of savings, medium and short-term investment),
- with the compensation of reactive energy, monitoring and regulation of peak electrical power (up to 10 % of savings, medium and short-term investment)
- with regular maintenance

Water consumption:

- with deliberate use of hot and cold water (up to 20% of savings, low and short-term investment),
- with regular maintenance and device check-ups
- with the use of energy-saving washing machines and dishwasher

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- On which areas can we work to reduce the consumption?
- List at least five small interventions to reduce heating energy consumption!

FURTHER SUGGESTIONS FOR TRAINERS:

- Small technical interventions are very much connected with the building users. If for example the valves are changed at the radiators with the thermostat valves, it is not much use for it if the users are not familiar with the principle of the valve itself.

  A presentation would be useful - a thermostat in any building could be set at a certain temperature and the windows opened so that all could see what happens in such case.

  Many times, it is unclear to people that the valve is set to achieve a certain temperature, no matter of outer temperature. If the window is open and the valve is set to 22°C, with the window open (in winter conditions) the valve will work with 100% of energy available to try to achieve the temperature.

  In addition, demonstration of a temperature change should be shown when the room is ventilated by opening a window for small periods. If the room is at 22°C and the air needs to be changed, opening the window will change the air, but cool the room also. If the window is open multiple times for smaller intervals, the radiator will spend less energy to achieve the required temperature again.

  Third demonstration - closing the valves and opening the window as the proper way of ventilating the room.

MODULE 3: BASIC CHARACTERISTICS OF ENERGY SAVING

There are different forms of energy. Its parameters are measurable by its power, consumption, insulation properties of materials, efficiency etc.

Energy saving in households

The question is whether such saving can be realized since we need comfortable residential environment, hot water, conditions for preparing food etc. It seems that the organisation of modern households does not allow for the efficient use of energy. But poorly sealed windows and doors, poorly insulated walls, leaking hot water, lights switched on when not necessary represent possibilities of household energy saving.

Heating and the efficient use of

Heat needed for spatial heating comes from various energy sources: wood, coal, fuel oil, gas, electrical energy, district heating. Spatial heating is the compensation of heat loss, which amounts to 70% of total household energy consumption. Heat loss is closely connected to various factors which can be reduced (but not prevented) with some simple technical solutions, which brings energy savings and the reduction of heating costs.

Water

The awareness that clean uncontaminated drinking water is invaluable is crucial. Saving water is not only an energy challenge but also an ecological need. When using hot water one has to keep in mind the use of energy. On average, households consume 10% do 20% of total amount of energy for hot water preparation. Different habits and different types of water heaters have a strong influence on energy consumption for domestic hot water preparation.

Lighting

Quite a large amount of electrical energy is used for internal and street lighting. The costs of electrical energy are often high because of inappropriate and careless use of lights. An empty room lit-up or an energy saving bulb in a seldom used room is not a good choice.

New trends in the field of the efficient use of energy

In the future, the following areas of measures will be taken up:

- energy efficient glazing and windows
- cogeneration of heat and electricity

- heat regulation systems in apartment and bigger public buildings
- target monitoring of the efficient use of energy in industry and public sector with central monitoring systems/information system of energy bookkeeping
- woody biomass as an unexploited domestic source of energy
- gas fuels and heating devices

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- Shortly describe the characteristics of energy saving regarding heating.
- Name a bad example regarding lightning.

FURTHER SUGGESTIONS FOR TRAINERS:

- Special consideration should be given to water consumption. An example of a person shaving or brushing their teeth should be shown. Average person leaves the water running while brushing teeth or shaving. A simple example can be shown by measuring the amount of water consumed in the period of time a person brushes their teeth or shaves (no meter is needed, a simple bucket is placed under the pipe, the time is measured and then the water volume in the bucket is measured).

MODULE 4: ENERGY AUDITAND ENERGY PERFORMANCE CERTIFICATE

The term “energy audit” is widely used and may have different meanings depending on the energy service company. Energy auditing of buildings can range from a short walk-through of the facility to a detailed analysis with hourly computer simulation. Generally, four types of energy audits can be distinguished:

- Walk-Through Audit
- Utility Cost Analysis
- Standard Energy Audit
- Detailed Energy Audit

4.1. WALK-THROUGH AUDIT

This audit consists of a short on-site visit of the facility to identify areas where simple and inexpensive actions can provide immediate energy use or operating-cost savings. Some engineers refer to these types of actions as operating and maintenance (O&M) measures. Examples of O&M measures include setting back heating set-point temperatures, replacing broken windows, insulating exposed hot water or steam pipes, and adjusting boiler fuel-air ratio.

Reporting a Walk-Through Audit

The walk-through audit can be a standalone task or one part of a standard energy audit. Typically, this type of audit is sufficient for small buildings with simple energy systems including residential buildings and low-rise commercial buildings. The basic tasks to be carried out for a walk-through audit include:

- Describe the basic energy systems of the building including building envelope, mechanical systems, and electrical systems. Observations from the walk-through as well as specifications from architectural, mechanical, and electrical drawings can be utilized to describe the building features.
- Perform basic testing and measurements to assess the performance of various energy systems. These measurements may depend on the type of building and its systems as well as on time available for the auditor. For residential buildings, it is highly recommended to perform a pressurization or a depressurization testing using the blower door test kit. In all building types, spot measurement, and, if possible, monitoring indoor air temperature and relative humidity within the space for at least one day, is helpful to estimate the indoor temperature settings and identify or check any comfort issues.
- Meet and discuss with building occupants or building operators to identify any potential discomfort problems and sources of energy waste within the building. This task is often helpful to define potential operation and maintenance measures as well as energy conservation measures,
- Identify some potential operation and maintenance (O&M) measures and energy conservation

measures (ECMs) as well as any measures required to improve comfort problems. Provide the implementation details and the cost of implementation (try to seek direct quotations from local contractors/stores).

- Evaluate the energy savings (or requirements if measures are needed to improve comfort) using simplified analysis methods presented in this book. Compare the results between the two approaches and comment on the accuracy of both approaches.
- Perform cost analyses based on the simple payback period method to determine the cost-effectiveness of the identified O&Ms and ECMs. You should make appropriate assumptions and, if necessary, estimate the energy cost savings. Provide recommendations based on the economic analyses. Cost data should be taken from actual estimations from contractors. This cost data will be provided.

4.2. UTILITY COST ANALYSIS

The main purpose of this type of audit is to carefully analyse the operating costs of the facility. Typically, the utility data over several years is evaluated to identify the patterns of energy use, peak demand, weather effects, and potential for energy savings. To perform this analysis, it is recommended that the energy auditor conduct a walk-through survey to get acquainted with the facility and its energy systems.

It is important that the energy auditor clearly understand the utility rate structure that applies to the facility for several reasons including:

- To check the utility charges and ensure that no mistakes were made in calculating • the monthly bills. Indeed, the utility rate structures for commercial and industrial facilities can be quite complex with ratchet charges and power factor penalties.
- To determine the most dominant charges in the utility bills. For instance, peak demand charges can be a significant portion of the utility bill especially when ratchet rates are applied. Peak shaving measures can then be recommended to reduce these demand charges.
- To identify whether the facility can benefit from using other utility rate structures to purchase cheaper fuel and reduce its operating costs. This analysis can provide a significant reduction in the utility bills especially with implementation of electrical deregulation and the advent of real-time pricing (RTP) rate structures.

Moreover, the energy auditor can determine whether the facility is a candidate for energy retrofit projects by analyzing the utility data. Indeed, the energy use of the facility can be normalized and compared to indices (for instance, the energy use per unit of floor area—for commercial buildings—or per unit of a product—for industrial facilities).

4.3. STANDARD ENERGY AUDIT

The standard audit provides a comprehensive energy analysis for the energy systems of the facility. In addition to the activities described for the walk-through audit and for the utility cost analysis described above, the standard energy audit includes the development of a baseline for the energy use of the facility and the evaluation of the energy savings and the cost-effectiveness of appropriately selected energy conservation measures. The step-by-step approach of the standard energy audit is similar to that of the detailed energy audit described later on in the following section.

Typically, simplified tools are used in the standard energy audit to develop baseline energy models and to predict the energy savings of energy conservation measures. Among these tools are the degree-day methods and linear regression models (Fels, 1986). In addition, a simple payback analysis is generally performed to determine the cost-effectiveness of energy conservation measures. *Examples of standard audits are provided in Chapter 17.*

Reporting a Standard Audit

The report of a standard audit is more comprehensive than a report for the walk-through audit outlined above. Indeed, a standard audit, as defined in Chapter 1, includes additional tasks and requires more effort and time to complete. This type of audit is typically suitable for large buildings such as those with complex energy systems. Moreover, the utility bills for large buildings such as commercial and institutional are significantly high and can justify the level of detail required by a standard audit. In addition to the tasks described for the walk-through audit, the following tasks can be carried out as part of a standard audit:

- Carry out a detailed survey of lighting and electrical equipment. The main goal of this task is to estimate the lighting and equipment power densities within various spaces of the building.
- Identify heating, ventilating, and air-conditioning (HVAC) systems and their operation schedules. This task is often crucial because energy used by HVAC systems is a significant portion of the total energy consumed in large buildings.
- Determine the main discomfort and complaints of occupants through a well-designed questionnaire. Surveying occupants very often provides valuable information about the performance of the building and its energy systems throughout the year.
- Collect and analyze utility data for at least three years. Utility data for only one year is often insufficient to estimate the historical energy performance of a building. In some cases, certain conditions such as special events or extreme weather may create biases in the energy use of the building.
- Perform any relevant measurements such as lighting levels, IR photos, indoor temperatures, airflow rates supplied by air-handling units, and electrical energy end-uses as well as indicators of electrical power quality.
- Model the existing building using a detailed energy simulation tool. Ensure that the simulation model is well calibrated using utility data. Typically, monthly calibration within 10 percent is required to increase the confidence level in the predictions of the building energy simulation model
- Carry out calculations to estimate energy savings from potential energy conservation measures using both the calibrated energy simulation model and simplified calculation procedures outlined in this book
- Perform an economic analysis using simple payback, net present worth, or life-cycle cost (LCC) analysis methods for all the energy conservation measures. The implementation details and costs should be provided for each measure.

- Select the energy conservation measures to be recommended for implementation. In addition, specify the additional benefits of each measure (such as improving thermal or visual comfort), the implementation costs, and any information to help the client implement these measures.

The report of a standard energy audit should summarize the results of all the completed tasks. A recommended outline for the standard energy audit report is provided below. It should be noted that the same outline can be used to report the findings for a detailed energy audit.

4.4. DETAILED ENERGY AUDIT

This audit is the most comprehensive but also time-consuming energy audit type. Specifically, the detailed energy audit includes the use of instruments to measure energy use for the whole building or for some energy systems within the building (for instance, by end uses: lighting systems, office equipment, fans, chillers, etc.). In addition, sophisticated computer simulation programs are typically considered for detailed energy audits to evaluate and recommend energy retrofits for the facility.

The techniques available to perform measurements for an energy audit are diverse. During the onsite visit, handheld and clamp-on instruments can be used to determine the variation of some building parameters such as the indoor air temperature, luminance level, and electrical energy use. When long-term measurements are needed, sensors are typically used and connected to a data-acquisition system so measured data can be stored and be accessible remotely. Recently, nonintrusive load monitoring (NILM) techniques have been proposed (Shaw et al., 2005). The NILM technique can determine the real-time energy use of the significant electrical loads in a facility using only a single set of sensors at the facility service entrance. The minimal effort associated with using the NILM technique when compared to the traditional submetering approach (which requires a separate set of sensors to monitor energy consumption for each end-use) makes the NILM a very attractive and inexpensive load-monitoring technique for energy service companies and facility owners.

The computer simulation programs used in the detailed energy audit can typically provide the energy use distribution by load type (i.e., energy use for lighting, fans, chillers, boilers, etc.). They are often based on dynamic thermal performance of the building energy systems and typically require a high level of engineering expertise and training. These simulation programs range from those based on the bin method (Knebel, 1983) to those that provide hourly building thermal and electrical loads such as DOE-2 (LBL, 1980).

In the detailed energy audit, more rigorous economic evaluation of the energy conservation measures are generally performed. Specifically, the cost-effectiveness of energy retrofits may be determined based on the life-cycle cost (LCC) analysis rather than the simple payback period analysis. Life-cycle cost analysis takes into account a number of economic parameters such as interest, inflation, and tax rates. Chapter 3 describes some of the basic analytical tools that are often used to evaluate energy efficiency projects.

General Procedure for a Detailed Energy Audit

To perform an energy audit, several tasks are typically carried out depending on the type of audit and the size and function of the audited building. Some of the tasks may have to be repeated, reduced in scope, or even eliminated based on the findings of other tasks. Therefore, the execution of an energy audit is often not a linear process and is rather iterative. However, a general procedure can be outlined for most buildings.

Step 1: Building and Utility Data Analysis

The main purpose of this step is to evaluate the characteristics of the energy systems and the patterns of energy use for the building. The building characteristics can be collected from the architectural/ mechanical/electrical drawings or from discussions with building operators. The energy use patterns can be obtained from a compilation of utility bills over several years. Analysis of the historical variation of the utility bills allows the energy auditor to determine if there are any seasonal and weather effects on the building energy use. Some of the tasks that can be performed in this step are presented below and the key results expected from each task are noted:

- Collect at least three years of utility data (to identify a historical energy use pattern).
- Identify the fuel types used (electricity, natural gas, oil, etc., to determine the fuel type that accounts for the largest energy use).
- Determine the patterns of fuel use by fuel type (to identify the peak demand for energy use by fuel type).
- Understand utility rate structure (energy and demand rates; to evaluate if the building is penalized for peak demand and if cheaper fuel can be purchased).
- Analyze the effect of weather on fuel consumption (to pinpoint any variations of energy use related to extreme weather conditions).
- Perform utility energy use analysis by building type and size (building signature can be determined including energy use per unit area: to compare against typical indices).

Step 2: Walk-Through Survey

From this step, potential energy savings measures should be identified. The results of this step are important because they determine if the building warrants any further energy auditing work. Some of the tasks involved in this step are

- Identify the customer concerns and needs.
- Check the current operating and maintenance procedures.
- Determine the existing operating conditions of major energy use equipment (lighting, HVAC systems, motors, etc.).
- Estimate the occupancy, equipment, and lighting (energy use density and hours of operation).

Step 3: Baseline for Building Energy Use

The main purpose of this step is to develop a base-case model that represents the existing energy use and operating conditions for the building. This model is to be used as a reference to estimate the energy savings incurred from appropriately selected energy conservation measures. The major tasks to be performed during this step are

- Obtain and review architectural, mechanical, electrical, and control drawings.
- Inspect, test, and evaluate building equipment for efficiency, performance, and reliability.
- Obtain all occupancy and operating schedules for equipment (including lighting and HVAC systems).

- Develop a baseline model for building energy use.
- Calibrate the baseline model using the utility data or metered data.

Step 4: Evaluation of Energy Savings Measures

In this step, a list of cost-effective energy conservation measures is determined using both energy savings and economic analysis. To achieve this goal, the following tasks are recommended:

- Prepare a comprehensive list of energy conservation measures (using the information collected in the walk-through survey).
- Determine the energy savings due to the various energy conservation measures pertinent to the building using the baseline energy use simulation model developed in Step 3.
- Estimate the initial costs required to implement the energy conservation measures.
- Evaluate the cost-effectiveness of each energy conservation measure using an economic analysis method (simple payback or life-cycle cost analysis).

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- What is the first step in energy audit (what kind of audit)?
- Shortly describe the steps for general Procedure for a Detailed Energy Audit.

FURTHER SUGGESTIONS FOR TRAINERS:

- A study trip showing an energy audit (at least walk through) would be very useful.
- More examples are shown in: Energy Audit of Building Systems – An Engineering Approach. It can be found in the TOGETHER library available at

  http://www.interreg-central.eu/Content.Node/TOGETHER.html

MODULE 5: ENERGY USING PRODUCTS

Energy-using products, such as electrical and electronic devices or heating equipment, account for a large proportion of the consumption of natural resources and energy, having also significant environmental impacts. In this context, the EU has published Directive 2005/32/EC for setting eco-design requirements for Energy-using Products.

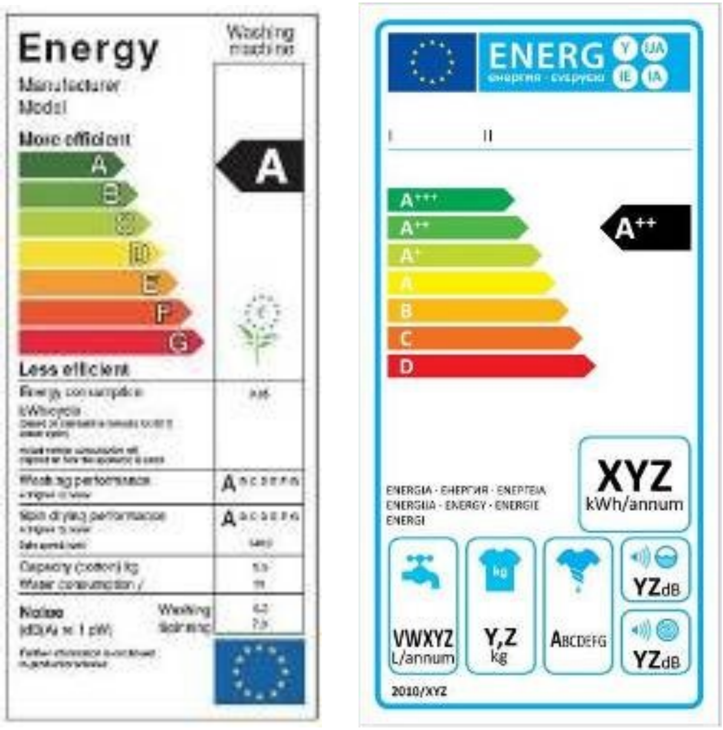


Figure 5.1: Old (left) and new (right) label for washing machine energy class

The new energy label contains:

- energy efficiency information of the product (seven-class color code),
- energy and water consumption,
- performance (volume, filling, sound power level).

Eco-design is a preventive approach, designed to optimize the environmental performance of products, while maintaining their functional qualities. The Directive does not introduce directly binding requirements for specific products, but does define conditions and criteria for setting, through subsequent implementing measures, requirements regarding environmentally relevant product characteristics and allows them to be improved quickly and efficiently. In particular, this Directive promotes the products' energy efficiency improvement.

Energy-using products and, in particular, household appliances (the so-called white appliances) already have the indication by labelling and standard product information of the energy consumption. This was promoted by Directive 92/75/EEC. Energy labels aim at informing and convincing purchasers to make a greener and more energy efficient decision in what concerns household appliances. Energy labels provide information on the economic impact of investment decision by showing that higher initial costs are paid back by lower energy costs throughout the lifetime of the appliance.

When buying new equipments it is advisable to choose more efficient, rather than less efficient ones. They perform best and spend less energy. The replacement of old equipment by new and more efficient ones is also advisable, but in this case a techno- economic analysis may be provided to evaluate this investment properly.

Energy efficiency in the EU is rated in energy levels ranging from A++ (the most energy efficient) to G (less efficient). Apart from a colour-coded classification there is also other information on the energy label such as the energy consumption, the water consumption or the noise production. A similar labelling is foreseen for the whole building, according to the Directive on Energy Performance of Buildings (EPBD - 2003/30/EC). Also a number of web-tools have been created to help consumers to choose more energy efficient appliances, such as Top ten (www.topten.info). This is a consumer-oriented online search tool, which presents the best appliances in various categories of products. In public institutions the Green Procurement Directives (2004/17/EC and 2004/18/EC), in addition to the energy efficiency labels, are also valid. These Directives include environmental considerations in the selection, award criteria and contract performance clauses for public procurement. The following table shows other energy efficiency and environmental labels that are also in use both in the EU and worldwide.

A very important aspect of energy-using products, especially of electronic equipment, is that it keeps on using electricity even when it is in stand-by mode or off power due to certain electrical devices that it possess. At any house, a lot of Watt-hours per year may be spent due to stand-by or off power. The producers are improving the equipments trying to reduce this con-sumption, so when buying new equipments their technical characteristics must be analyzed in order to choose those that has small stand-by power consumptions (typical values, together with the consumption of the devices when they are ON, are shown in the Table of Annex 1).

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- How are efficient energy products labelled? (Which letter)?
- In which units is the consumption of electrical energy measured?

FURTHER SUGGESTIONS FOR TRAINERS:

- Price comparison of the energy efficient equipment should be presented. Many times consumers simply buy the cheaper equipment, not realizing that in long term they are wasting a lot of energy and money. Presentation (exercise) is shown in the later part of this document, but the prices are not included. A presentation of a classical light bulb and led bulb prices should be given (compared to energy consumption).

MODULE 6: ENERGY RETROFITTING OF THE BUILDINGS

6.1. BUILDING ENVELOPE

The building envelope, also known as the building fabric, comprises the roof, walls, floors, windows and doors of a building. Even a properly constructed and well maintained building will lost heat from all these components of the envelope, to a percentage that may reach 10-15% of its total fuel bill, as shown in the figure.

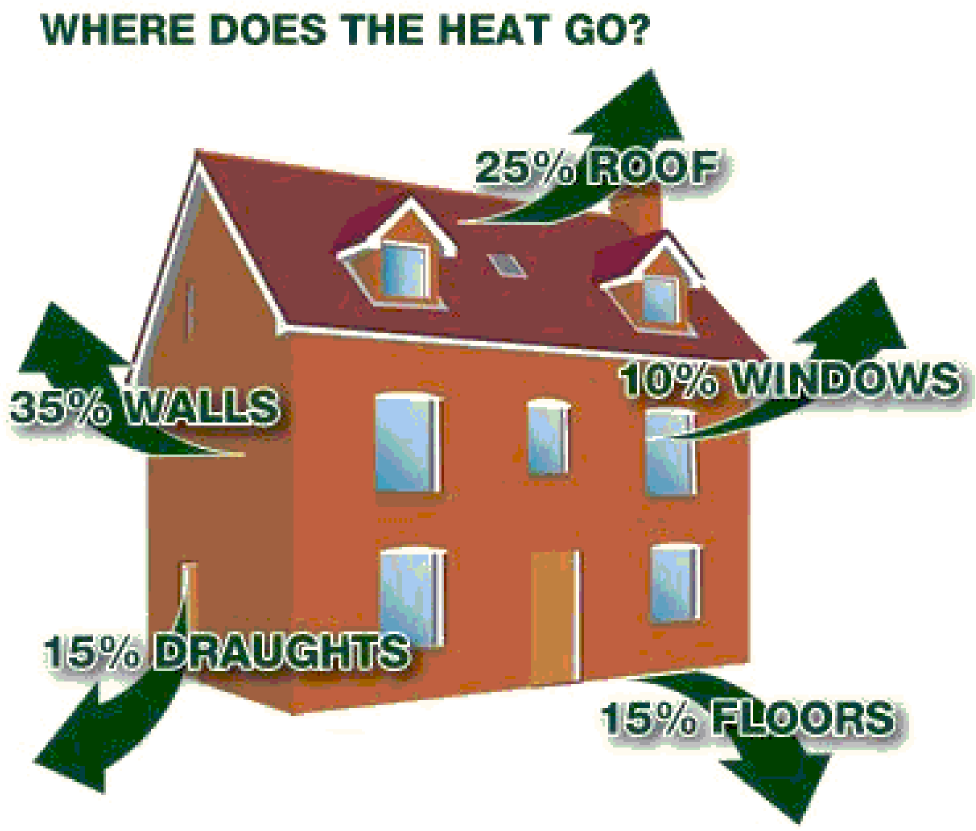


Figure 6.1: The heat losses of the building

Some of the commonly recom¬men¬ded ECMs to improve the thermal perfor¬man¬ce of the building's envelope are:

- **Insulating the roof** reduces the need for heating in winter and cooling in summer, and makes the building a more comfortable place to be. Radiant heat from an uninsulated roof makes the occupants feel uncomfortable, and they will run the air-conditioner at a lower temperature to counteract this problem. If the building is not insulated at all, roof insulation is generally more cost effective than floor or wall insulation.

Figure 6.2: Thermal insulation to prevent thermal bridges

- Many buildings are built on an uninsulated, suspended slab. In cooler climates this will probably cause occupants to suffer from cold feet. **Insulating the slab** will improve occupant comfort, but is generally less cost-effective than insulating the roof.
- **Insulating walls** will also reduce the need for heating and cooling in your building. The cost effectiveness of insulating the walls depends on the external wall area, the wall-to-window ratio, and the kind of insulation chosen. Generally, wall insulation is less cost effective than roof or floor insulation.
- **Increase window shading:** Both internal and external blinds and shutters are available as shading options. Internal shades are less effective at keeping heat out of a building than external shades. Internal blinds give occupants some control over the light and temperature of their environment. On the east and west sides, vertical shutters may be more effective than horizontal shutters, which are most effective on the north and south.

Figure 6.3: Version of the window shading by using blinds

- **Increasing glazing insulation:** The air layer trapped between the sheets of glass acts as insulation. Thus, an extra layer of glazing decrease heating needs when it is cold outside, and cooling needs when the weather is warm. However, retrofit of glazing is expensive, and may not be cost effective as an energy conservation measure.
- **Increase frame insulation:** Heat can be transferred into (or out of) a building through the window frame itself. Thermally broken aluminium frames contain an insulating layer between the inside and outside layers of aluminium, and conduct less heat than standard aluminium frames. Wood is less conductive than aluminium. Although window replacement is expensive, it is important to consider the frame material when installing new windows or selecting new premises.
- **Install a reflective light shelf:** This is a horizontal shelf about two-thirds of the way up the window. The shelf serves the double purpose of shading occupants close to the windows from glare and distributing daylight to occupants seated a long way from windows. Light is reflected from the shelf, onto the ceiling and deep into the office.
- Installing a light shelf involves expensive modification of the fabric, and produces significant savings only if there are automatic daylight controls for artificial lighting.
- **Change the roof colour:** Darker colour roofs will absorb more heat from the sun, while lighter colour roofs will reflect more light, leaving the building cooler. Keeping heat out is particularly important for office buildings.
- **Change the wall colour:** Light coloured external walls will reflect more sunlight than dark coloured walls, and may reduce the heat absorbed into the building. Lighter internal walls will also brighten the work areas with reflected light.

6.2. HEATING AND COOLING

Although a building may be heated and/or cooled to a comfortable level, it does not mean that it is efficiently heated and/or cooled. Several types of Heating, Ventilating and Air-conditioning (HVAC) systems may be used in buildings. Boilers, pa¬cka¬ged heating units, individual space heaters, furnaces, or district heating systems are just some examples of the heating part of HVAC systems. Accordingly, a large number of measures can be considered to improve the energy performance of both primary and secondary HVAC systems, and some of them are listed below.

Figure 6.4: Some examples of heating and cooling equipment

6.3. SYSTEM AIRFLOW

Grilles may be located or adjusted so that the effective distribution of air throughout the occupied space is not achieved. It may be simple to re-adjust or relocate a supply grille to improve this.

Remove blockages from airflow: Partial or full blockages can develop within an air duct, due to dirt and dust accumulation or obstruction by a solid object (sometimes occupants mount cardboard or rags in such a way as to alter the air distribution to their own tastes).

This result is a system which does not operate as it should, with a possible reduction in energy efficiency.

A Flter cleaning: Air filters are used to remove particles of dust and pollutants entering the building or being spread throughout the building. These must be cleaned regularly or excess particles trapped in the air filter will reduce airflows and cause poor fan efficiencies.

6.4. SYSTEM USE OF CONTROLLING - CENTRAL CONTROL SYSTEM

Install optimised controls, which will turn on and off the HVAC so that the building will operate at set-point temperature whilst the building is occupied. The control system records the outside and the inside air temperatures and determines how long the building will take to heat up or cool down, switching the air conditioning on and off at the appropriate times.

Reduce scheduled hours of operation: This is simply to reset the time-clock so as to restrict the hours of operation of the HVAC system. If the temperature rises or falls slightly at the end of the occupancy period is not a problem, and the energy advantage of such a small adjustment, particularly in peak seasons, could be significant.

Reduce effects of out-of-hours use: By reducing the heating and increasing the cooling set-point temperatures for out-of-hours operation, the HVAC system energy use will be considerably reduced. **Reduce area serviced for out-of-hours demand:** Out-of-hours operation of the HVAC system may only be required for a small part of the building. It may thus be possible to isolate part of the system to be alone served during out-of-hours operation.

Chiller plant: Significant energy savings may be available from the **replacement of the existing chiller** with a more appropriate or updated unit.

Improved match to load profile: Different types of chillers operate more efficiently at different loads, thus the load profile of the installation should be matched to the most appropriate chiller type to optimise energy efficiency.

Correct adjustment of the chiller controls sequencing is important to the efficient operation of the system, especially where there are more than one chillers.

Cooling tower fans can be variable speed controlled to reduce power consumption.

Condenser water can be used for heat reclaim for the heating of DHW or space heating.

Chiller compressor: Depending on the size and type of installation the most efficient type of compressor to be used will be determined.

Replace cooling towers: Existing cooling towers may be inefficient in their operation, allowing energy savings to be made by replacing them with new units.

The **chilled water control system** and **condenser water set-points** can be adjusted to better suit the load demand, thereby achieving improved energy efficiencies.

6.5. BOLIER PLANT

Significant energy savings may be available from the replacement of the existing boiler with a more appropriate or updated type.

Improved match to load profile: Energy efficiency can be optimised by matching the size and number of boilers operating at a given load.

Minor adjustments to boilers' settings and calibrations can improve efficiency.

Correct adjustment of boilers' sequencing controls, according to the variations in the heating load, will be important to the efficient operation of the heating system.

Adjust hot water set points: The heating control system set-points can be adjusted to better suit the load demand, thereby achieving higher overall energy efficiencies.

Stack sensor control: Automatic boiler controls are able to vary the forced draught fan speed according to the excess air sensed in the boiler flue. This achieves improved boiler efficiency.

6.6. BOLIER PLANT

- **Decentralise chilled/hot water production:** Centralised chiller and boiler installations may include extensive pipework giving rise to high pipe losses. Greater
- energy efficiency may be achieved using a number of smaller chillers/boilers located nearer to the loads.
- **Centralise chilled water and/or heating production:** Where there are a number of smaller chillers/ boilers which are relatively close, and depending on the load profile,
- energy savings are possible using a single centralised chiller unit or boiler. Reductions in maintenance costs will also be achieved.

Figure 6.5: Modern distributor of hot water

- **Variable speed motor drives:** The use of variable speed motor drives for chilled/hot water circulation pump sets can greatly improve the energy efficiency of the installation.
- **Reduced circulation volume:** It is possible that a greater amount of chilled/hot water than is necessary is being circulated around the building to meet the peak load. Rebalancing of the system will enable the flow rate to be reduced.
- **By reducing the pump capacity** to suit the load energy saving and greater pump life can be achieved.
- **Modulation of circulation temperatures to match demand:** The reduction in operating temperatures may be possible with consequent savings in heat lost from the distribution pipework.
- **Reduce hours of circulation:** Many systems operate longer than required. By reducing the operating hours of the pump the energy consumption will be also reduced.
- **Improve pipe insulation:** If the pipe insulation is in bad state of repair or is not of sufficient thickness, it will be beneficial to replace the insulation with new, reducing the energy wasted.
- **Improve valve insulation:** The insulation around valves breaks down over time. By replacing it with a more flexible type the losses from the valves will be reduced.
- **Reduce pipe length:** Pump capacity as well as pipework energy losses are associated with the length of pipe run. It may be possible to redirect pipework such that the lengths are reduced.

6.7. PLANT GENERAL

- Replace pump/pump motor/ drive: Equipment which is close to the end of its serviceable lifespan is unlikely to operate efficiently. By replacing the equipment overall efficiencies will be greater, and energy savings and maintenance cost reductions will be made.
- Matching to load: When installing any plant item it is important that it is sized to match the demand. By reducing the equipment capacity to match the load, unit efficiency will be improved allowing savings and greater equipment lifespan.
- Install economy cycle: An economy cycle allows air to be recirculated during periods when fresh air is not required. The result will be reductions in unnecessary heating or cooling of outdoor air and consequent energy savings.
- Where air cannot be re-circulated, air-air heat recovery equipment will allow the transfer of heat between intake and discharge air-streams. The result will be reduction in unnecessary heating/ cooling and consequent energy savings.
- Install chiller heat recovery: This uses heat normally rejected to atmosphere from the chiller to preheat water for space heating or domestic hot water. The overall result is a saving in energy.

6.8. DOMESTIC HOT WATER

Domestic hot water (DHW) may be produced using boilers, RES systems or district heating. Choosing between them depends on the energy resources availability, demand requirements, safety, and economic conside¬ra¬tions. There are four basic ways to cut the water heating bills: use less hot water, turn down

the thermostat on the water heater, insulate the water heater, or buy a new, more efficient model.
Simple measures that can help provide hot water using less energy are:

- **Reduce storage temperature:** If the hot water storage temperature is higher than necessary decreasing this temperature will also decrease the heat loss and energy wasted. The temperature cannot be reduced below 60oC however, as below this limit it is possible that Legionella bacteria (causing the Legionnaires' disease) are going to be developed.
- **Reduce DHW circulation temperature:** If the hot water distribution temperature is higher than necessary, decreasing the distribution temperature will also decrease the heat loss from distribution pipework. The distribution temperature should not be below 55oC however.
- **Reduce tap flows:** By installing a flow restrictor device upstream from the tap, the hot water use can be significantly reduced, without affecting the user.

Figure 6.6: The combination of hot and cold water storage tank, boiler and reversible heat pump in thermal substation

- **Reduce shower flows:** By installing a flow restrictor device upstream of the shower rose, or by replacing the shower rose itself, hot water use can be significantly reduced, without affecting the user.Decentralise DHW production: Centralised hot water generation installations may include extensive pipework reticulation giving rise to high pipework heat losses. Greater energy efficiency may be achieved using a number of smaller hot water generation units located nearer to the hot water points of use.
- **Centralise DHW production:** Where there are a number of smaller hot water generation units which are relatively close, and depending upon the hot water load profile, it is possible that greater energy efficiency is possible using centralised hot water generation.
- **Coordination of DHW/Service hot water production:** Hot water may be used for a number of purposes within a building. By co-ordinating the use of hot water for different purposes and at different times it may be possible to reduce the hot water storage requirements or the maximum simultaneous demand. This could result in a reduction in the DHW generation plant sizing, with a consequent reduction in an overall energy cost.

6.9. LIGHTING

Lighting the buildings needs energy and money, not only due to the electricity consumption, but also due to the maintenance of the lighting system. Energy savings may result from the combination between different types of lamps with their specific supporting hardware (such as luminaires and ballasts) and the way the lighting systems are applied in everyday use. The lighting efficiency can be improved by taking the measures presented below.

Lighting Design

- The reflective surfaces of luminaires must be kept clean. Cleaning the luminaires will not save energy in itself, but with cleaner luminaires a better level of lighting for the same energy use can be maintained.
- Replacement of lamps with higher efficiency units: Standard mono-phosphor 26 mm fluorescent tubes are 10% more efficient than their 38 mm predecessors. CFLs are about 4 times more efficient than equivalent incandescent lamps.

Figure 6.7: Modern fluorescent lighting with DALI control

- Where light levels exceed Standards or are poorly matched to user needs (see Annex 2), it is possible to save energy by removing unnecessary lamps and labelling de-lamped holders accordingly.
- Selective replacement of tubes, i.e. replacement of lower light output monophosphor fluorescent tubes with higher light output triphosphor fluorescent tubes. The energy savings from this measure arise through the “selective” component, as fewer tubes are required to meet the same overall lighting levels.
- Installation of autotransformers provides an alternative method for reducing the energy use and light output of an installation. Auto-ransformers work by steeping back the voltage in the lighting circuits, thereby decreasing light output and energy use.
- The replacement of diffusers can improve efficiency if accompanied by de-tubing.
- Reducing the number of luminaires can reduce overlighting problems, this way improving occupant comfort and energy efficiency. Relocating luminaires relative to occupant work areas can reduce the number of luminaires required, reduce glare problems, and improve light levels.

- The replacement of ballasts in fluorescent luminaires can achieve some energy savings.
- It is more cost effective in some cases to refurbish old luminaires than replace them. Their replacement can be more cost effective depending on the type of luminaire being replaced.

Lighting Control

- Improved switching of lights by occupants: The most effective way of insuring that lights are switched off is to assign to one person in each work area the responsibility for checking that lights are switched off at the end of day.
- Improved switching of lights by cleaners and security staff: Cleaners are known for a tendency to light up the whole building and then turn off lights progressively as they clean each area. They have to light up the building on a floor-by-floor basis only.
- Improved zoning of switching:
  - Matching use patterns: Having just one switch to control the lights on a whole floor is very inefficient, especially in hours when one or two people might be in the building. Matching the switching arrangements to individual use zones in the building is much more efficient.
  - Matching daylight availability: Matching the switching groups to daylight availability means that the lights that are not needed during daylight hours can be turned off, while leaving the lights on in parts of the building that are not naturally lit.
  - Improving accessibility: Moving and labelling the switches to make them more accessible will ultimately lead to energy savings.
  - Improved maintenance of controls: Automating lighting controls are only useful while they are working well. Experience shows that the probability of occupant interference with automatic lighting controls is also quite high. It is important to regularly check such controls and ensure that they are working effectively.
- Automated occupancy control systems use movement sensors to determine whether to switch the lights on. Introducing automated occupancy control can sometimes lead to energy savings through reduced hours of operation. Care is required to ensure that the controls work for, rather than against, the occupants' needs.

Figure 6.8: Occupancy and lighting sensor; lighting control cabinet with 4 scenes

- Daylight controls can conserve energy by reducing the hours of lighting operation. Automated control systems contain light sensors that shut down some or all of the lights in an area when the light levels are high enough. If lights are fitted with dimmable electronic ballasts, the lights can also be dimmed according to the ambient conditions. It is preferable to use a continuously variable system rather than a switching system for adjusting light levels, as occupants tend to be irritated by lights turning on and off.

6.10. APPLIANCES

Household appliances

Refrigerators and **freezers** use electricity to produce cold. A few simple measures can help make significant energy savings:

- The equipment take heat from inside the system and release it outside. The warmer the air around the equipment, the less efficient it will be. Therefore, their correct placement makes a huge difference to its efficiency.
- Check the equipment in order to verify that they are not refrigerating below the recommended temperatures: increasing the temperature of the cooled space by just 1ºC could reduce energy consumption by 2% (recommended temperatures of operation for refrigerators: 3ºC to 5ºC, and for freezers: -15ºC).
- Make sure that doors are not left open for longer periods than necessary: complete loading and unloading as quickly as possible.
- Consider cooling rather than refrigeration: some products will stay fresh with very slight cooling rather than active refrigeration.
- Monitor the control settings periodically to ensure they remain at optimum levels.
- Keep external condensers clean and free from blockages.
- De-ice the evaporators regularly.
- Assure a proper insulation by replacing insulators when needed.
- The manufacturers' instructions for maintenance should be followed.
- Keep the food in closed spaces: the water exchange between food and the air consumes energy.
- Avoid introducing food hotter than 35-40 °C (it is recommended to cool it first outside and unfreezing it in the refrigerator in order to release cold there).
- Switch off refrigerators when they are not needed, especially in holiday periods.
- Not filling in excess the refrigerators allowing the air circulation.
- The food must be grouped accordingly to its cold needs (the coldest place in the refrigerator is its lower area).

Ovens and **cookers** use energy to produce heat to cook food. The heat may be generated by electrical resistances, by gas combustion or by radiation (microwaves).

Some tips that can help make energy savings are:

- when cooking, pre-heat the oven in less time than the recommended;
- use the light and a timer to control cooking, avoiding to open the oven;
- promote a better heat circulation and a faster cooking through the use of the fan;
- turn off the oven 15 minutes before finishing the cooking: it will use the remaining heat;
- use glass or ceramic pots since they retain more heat;
- use the microwave as much as possible;
- clean the oven and the cookers in a regular basis.

In any case, and as concerns any type of household appliance, it is important to choose the equipment considering their energy efficiency (i.e. those with the best energy label classification). Currently the market offers innumerable household appliances options, with excellent energy efficiency performances. In addition, the proper capacity for the needs should be chosen each time.

Office equipment

In the office equipment, the following items are generally included: computers, monitors, fax machines, photocopiers, printers, telephones, mobile phones, modems, etc. Although long term energy cost savings in this field can be made by purchasing energy efficient equipment, some relevant energy saving tips are:

- **Turn off equipment at night: Turning off the office equipment at night is a simple measure which can make significant energy savings. PCs, for example, use 100-150 W of power, and office buildings and schools have hundreds of them inside. Assign individuals with the responsibility for turning off equipment, and run a sustained switch-off campaign.**
- **Turn off equipment when not in use:** Encourage staff to switch off equipment at their workstations before leaving for lunch or meetings. If long warm-up times on photocopiers or faxes are annoying, use the 'stand-by' button. If you don't want to wait for computers to boot-up, just turning off the screen can reduce the energy consumption by more than half.
- **Activate Energy Star features:** Most modern office equipment has energy saving features built in under the Energy Star program, but normally these features need to be activated.

Figure 6.9: Printer, speaker ...

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- Name at least 3 measures to improve the building envelope.
- Name at least one measure regarded to water (for example in the field of water circulation).
- What areas can we change in the field of lightning?

FURTHER SUGGESTIONS FOR TRAINERS:

- Additional studying of the literature is suggested. Interesting reference material, that may help in further exploration of the topics mentioned, may be found in the TOGETHER library (available at http://www.interreg-central.eu/Content.Node/TOGETHER.html), including literature on building insulation, energy retrofitting, energy efficient windows, shading, etc.

MODULE 7: INSTALLATION OF RES

This should be wished for our planet. To at least conserve the current natural conditions Slovenia has begun to implement the energy efficiency measures and the use renewable sources of energy. To exploit the latter, there are quite a few technologies available.

There are many options for using renewable energies at buildings, from solar-powered outdoor lights to buying renewable energy from the local utility to even producing electricity at home with photovoltaic (PV) cells.

Renewable Energy tips

- A new building provides the best opportunity for designing and orienting it to take advantage of the sun's rays. A well-oriented building admits low-angle winter sun to reduce heating bills and rejects overhead summer sun to reduce cooling bills.
- Many consumers all over the EU buy electricity produced from RES like the sun, wind, water, biomass, and the Earth's internal heat. This power is sometimes called "green power".
- Buying green power from the utility is one of the easiest ways to use renewable energy without having to invest in equipment or take an extra maintenance.

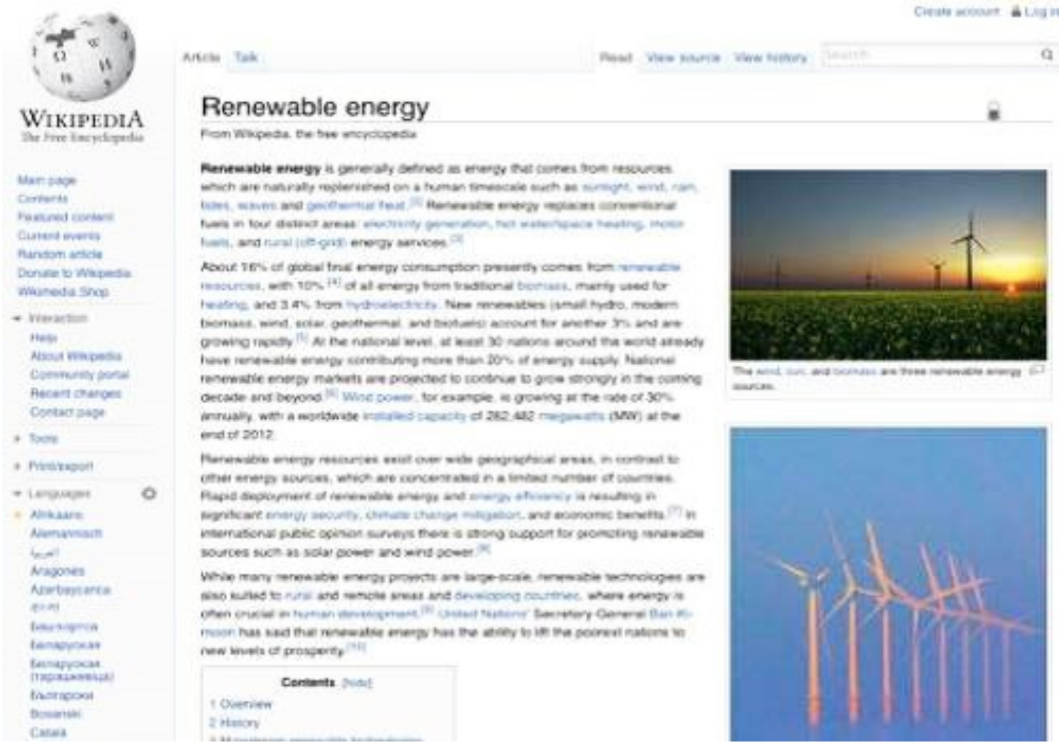


Figure 7.1: Wikipedia Renewable Energy Portal

A main use of solar energy is for heating water. Solar water heating systems are environmental friendly (during a 20-year period, one solar water heater can avoid more than 50 tons of CO_2 emissions), and can now be installed on any roof to blend with the architecture of the building. In addition, if there is a swimming pool or hot tub, solar energy can be used to cut the pool's heating costs. Most solar pool heating systems are cost competitive with conventional ones.

See: IRENA - Our - World Runs on Energy

http://www.youtube.com/watch?v=hwVJoVW4MN

Long-term saving tips

- If the building was made as energy efficient as possible and very high electricity bills occur while there is a good solar resource in the site, then it might be worthy to consider the possibility of generating our own electricity using PV cells. New products are available that integrate PV cells with the roof, making them much less visible than older systems. However, more research is needed if a decision to invest in a PV system is made.
- There are other systems that exploit the local RES potential, such as biomass systems for heating buildings (burning logwoods, chips or pellets), ground source heat pumps, which are used for both heating the building in winter and cooling it during summer, etc. The decision on whether to proceed with such an installation or not should be based on proper feasibility analysis.

Eventually natural resources will become too costly to harvest and humanity will need to find other sources of energy. The conservation of natural resources is the fundamental problem.

The most important renewable energy sources in terms of building are solar power, geothermal power and biomass.

7.1. PLANT GENERAL

Solar power is the conversion of sunlight into electricity. Sunlight can be converted directly into electricity using photovoltaic (PV), or indirectly with concentrating solar power (CSP), which normally focuses the sun's energy to boil water which is then used to provide power, and other technologies, such as the sterling engine dishes which use a sterling cycle engine to power a generator.

Photovoltaic was initially used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. The only significant problem with solar power is installation cost. But solar power can be combined with other energy sources to provide continuous power.

Figure 7.2: Map of solar electricity potential in Europe

Source: Solar Radiation Map of Europe: Global Horizontal Irradiance Map of Europe, Solar GIS 2011

7.1.1. Solar energy

Solar energy can by all means hold 1st place among renewable energy sources. The Sun gives off electromagnetic radiation, a part of which reaches the Earth. The Earth is heated by solar radiation, which converts into other forms of energy – into kinetic energy of wind and since it drives water circle as well, it converts into potential and kinetic energy of watercourses. There is no photosynthesis and consequently no biomass without solar radiation (Medved and Arkar, 2009).

By measuring solar energy two measures are used:

- solar radiation – the power per unit area radiated by a surface in [W/m^2]
- solar irradiation – energy received on a given surface area and recorded during a given time in [Wh/m^2].

Solar irradiation represents the largest flow of energy on the Earth’s surface and its atmosphere. The flux density on top of the atmosphere is 1367 W/m^2 on average (solar constant). The energy of solar irradiation can be measured in different ways: globally or only its diffuse or direct radiation. Global solar irradiation is defined as the total sum of solar radiation falling on a horizontal surface. It is influenced by five factors:

- astronomical factor: the orbit of The Earth around the Sun,
- solar activity,
- meteorological: cloudiness, humidity,
- permeability of the atmosphere and
- relief: height above sea level, shape of the surface.

Figure 7.3: Different technologies utilization of solar energy

Diffuse irradiation is the direct and reflected sunlight that has been scattered by molecules and particles in the atmosphere. In clear weather diffused and reflected radiation are lower than direct, but become important in case of cloudiness when there is no direct radiation.

Solar radiation energy is measured with radiometers. They measure the difference in temperature between the insulated black and white bodies and calculate the energy flow received. The accuracy of sensors is about 5-10 %. For measuring global and diffused radiation we use pyranometers or solarimeters, and for measuring direct radiation we use pyrheliometers. The sensor for diffused radiation is the same as the one for measuring global radiation, only it has a shadow ring. In case of measuring parts of spectrum (UVB radiation, infrared radiation) the sunshine has to be filtered« (Meteorological measurements: The measurements of solar radiation, 2005).

The amount of annual heat and electricity produced by solar systems depends on the installation efficiency and the annual amount of solar irradiation on certain location. When planning the installation of any system it is necessary to consider the recommendations for selecting the system components and data on sunlight. Finally a quality installation has to be provided.

From the Figures showing annual average solar radiation from 1971–2000 it can be seen how solar radiation changes through different seasons. Primorska region receives the most sunlight. More detailed maps can be found on the Environment Agency's websites and the websites of the Surveying and Mapping Authority of the Republic of Slovenia.

The data from these maps can be interpreted as the potential of exploiting solar energy in Slovenia. Since the amount of the sunlight received varies we have to be cautious when analysing and comparing data. To get an indicative idea of the duration of solar radiation and the potential of exploiting it, data on average values during longer periods are appropriate.

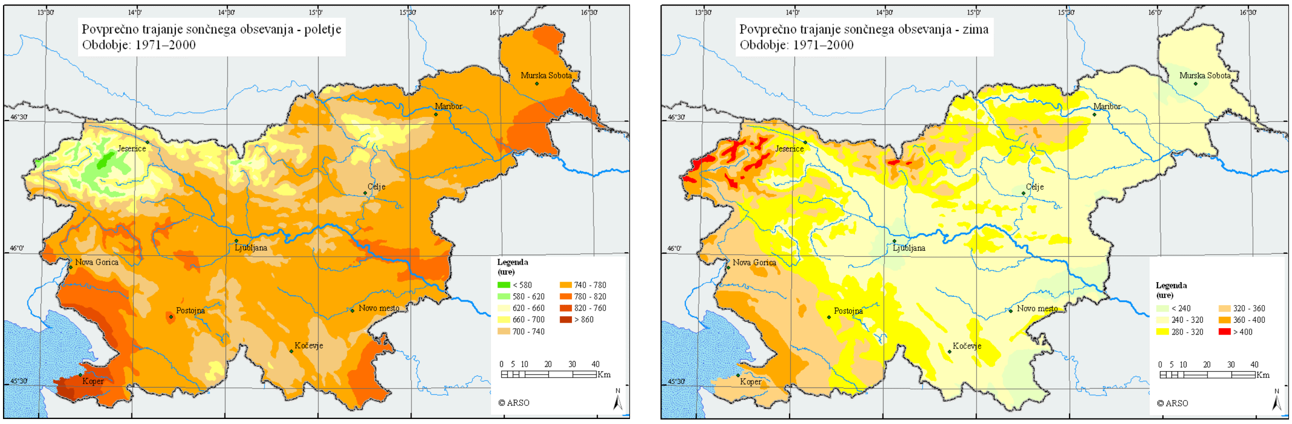


Figure 7.4: Average duration of solar radiation during summer and winter 1971–2000
(Source: ARSO, http://meteo.arso.gov.si/met/sl/climate/maps, 10/6/2011)

7.1.2. Photovoltaic systems (PV)

The Sun is the carrier of energy in the form of sunlight for solar modules. They directly convert light into electricity. The power of the device for direct conversion of electromagnetic waves into electricity depends on the energy requirements of the system and on the available sunlight. Modules are made from solar cells of different materials (monocrystalline or polycrystalline silicon cells, gallium arsenide, amorphous silicon etc.).

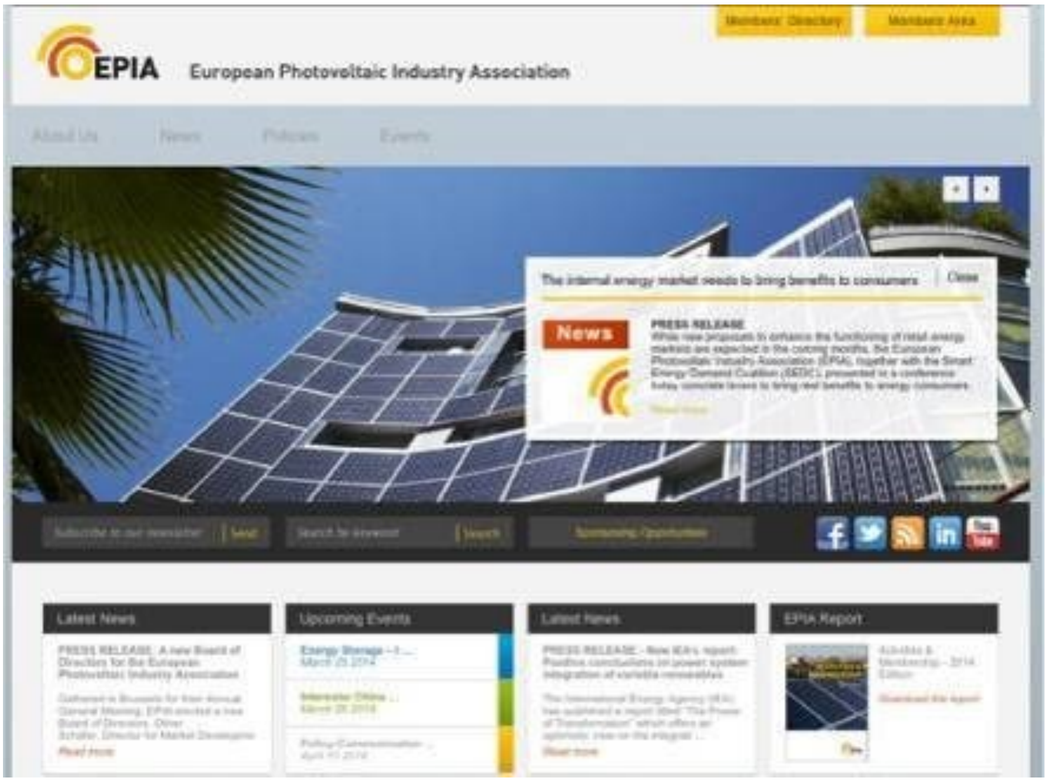
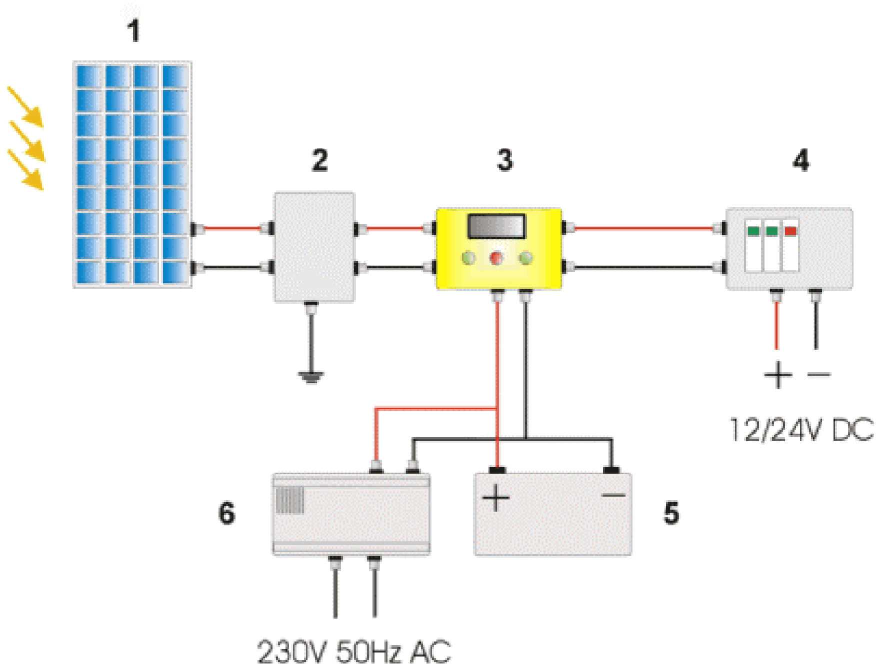


Figure 7.5: European Photovoltaic Industry Association, http://www.epia.org

In a stand-alone system or a system not connected to a distributional network the battery in the system stores energy produced by solar panels for the time when solar radiation does not suffice. Solar regulator is intended for linking together a solar module, the battery and the user. At the same time it protects the battery from overcharging and/or discharging. The users are electrical devices operating in a system. Direct users have to be highly efficient and need a wide input range. Inverters are intended for converting direct battery current into alternating. Due to the inverters one can use ordinary electrical devices which function using network voltage/current. Network inverters are used with solar systems operating parallel to public electricity network, for converting direct current of solar generator into alternating current of the network, and for synchronization. An auxiliary generator in stand-alone systems sometimes has the role of an auxiliary source of electrical energy. Together with battery chargers it is used to supplement batteries in case of higher consumption. (http://lab.fs.uni-lj.si/opet/knjiznica/pv_v_stavbah.pdf, 28/5/2011).



1 - photovoltaic module
2 - over voltage protection
3 - regulator
4 - fuse distribution cabinet
5 - battery
6 - inverter

Figure 7.6: Photovoltaic system scheme

(Source: http://lab.fs.uni-lj.si/opet/knjiznica/pv_v_stavbah.pdf, 28/5/2011)

Network photovoltaic systems: Solar modules are connected to the public electricity network via a network inverter. The surpluses of energy are sent to the public electricity network.

Stand-alone alternating-current photovoltaic systems: Electricity from solar modules is stored in batteries for the time when solar radiation is too weak for the system operation (at night, in case of bad weather). The solar regulator protects the battery from overcharging and/or discharging. The consumers operate at 230 V, which has been converted from direct battery current by means of an inverter.

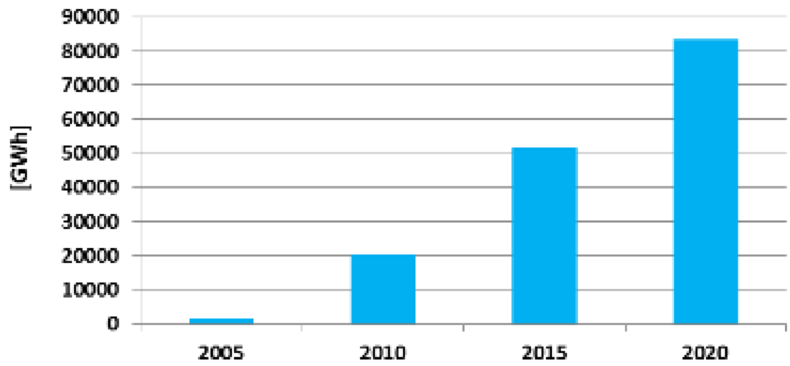


Figure 7.7: Projections of PV electricity production in Europe for the period 2005-2020 [ECN 2011]

After the discovery of the photovoltaic effect in 1839, the amount of photovoltaic applications has grown throughout the years, with a take-off in large scale installations since the beginning of the 21st century. Based on the National Renewable Energy Action Plans of the European Member States, electricity generated from PV in Europe will increase from 1470 GWh in 2005 to 83375 GWh in 2020 (Figure 7.7).

7.1.3. Solar thermal

Solar thermal offers another way of benefiting from the most abundant energy resource, the sun. The working principle of solar thermal is quite simple: the solar energy is captured by the absorber of a collector placed on the rooftop of the building. The absorber converts the solar radiation into heat which is then conveyed to a heat transfer medium- such as fluid or air. Water storage is implemented in solar thermal systems as it is required to store solar heated water for the night and for times when there is low irradiation.

Figure 7.8: Thermo solar web page: http://solarprofessional.com/

A solar thermal system can be installed for a broad range of heat requirements, as small installations or as large thermal systems. Depending on the intended application, solar energy is often used for preparing Warm Drinking Water (WDW) or for auxiliary heating. Due to the variability of solar irradiation during a day and a year, solar thermal systems are built as bivalent heating systems. This means that along with solar storage another heat source is always included in the system technology, such as a condensing boiler. Some different types of utilization of thermo solar energy are shown bellow.

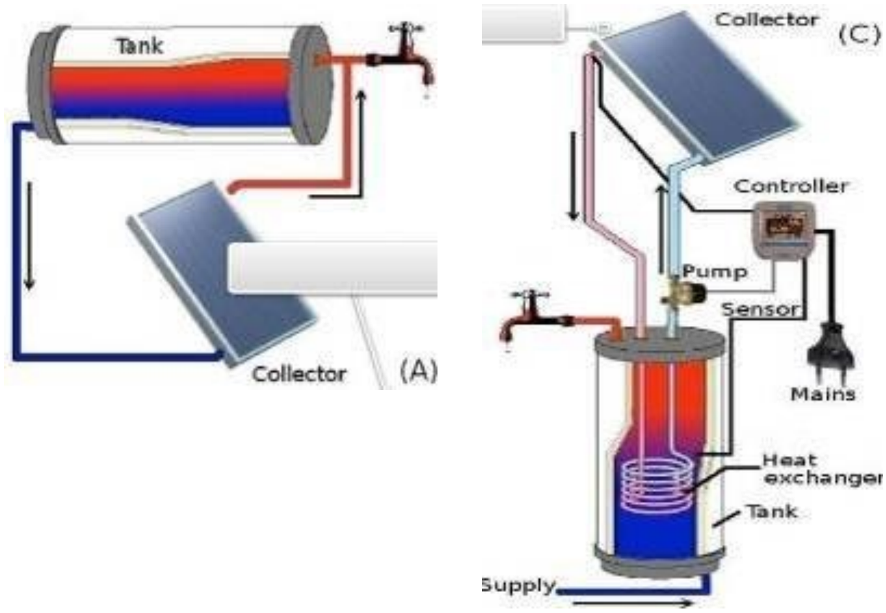


Figure 7.9: Simple direct passive heating system and indirect active heating system

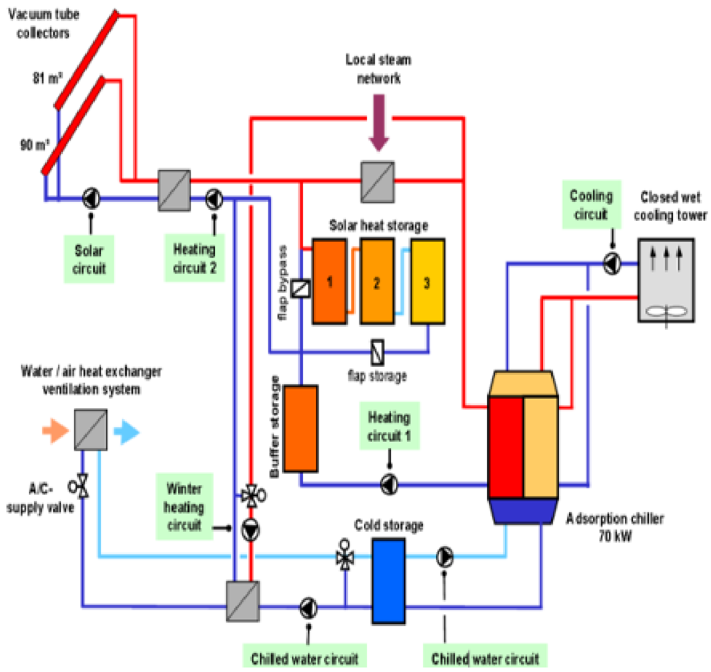


Figure 7.10: Scheme of the solar complex heating-cooling system with adsorber

Basic technical features of adsorbent heating and cooling system:

Central air-conditioning unit	
Technology	closed cycle
Nominal capacity	70 kW cold
Type of closed system	Adsorption
Brand of chiller unit	Nishiyodo NAK 20/70
Chilled water application	supply air cooling
Dehumidification	occasionally
Heat rejection system	closed wet cooling tower
Solar thermal	
Collector type	vacuum tubes
Brand of collector	Seido 2-16
Collector area	167 m^2 aperture
Tilt angle, orientation	30 ^{0} and 45 ^{0}, south
Collector fluid	water-glycol
Typical operation temperature	75 ^{0}C driving temperature for chiller operation
Configuration	
Heat storage	6 m^3 water
Cold storage	2 m^3 water
Auxiliary heating support	condensating steam heat exchanger, driven by the Hospital steam network
Use of auxiliary heating system	Auxiliary driving source for chiller, auxiliary driving source for supply air in winter
Auxiliary chiller	no

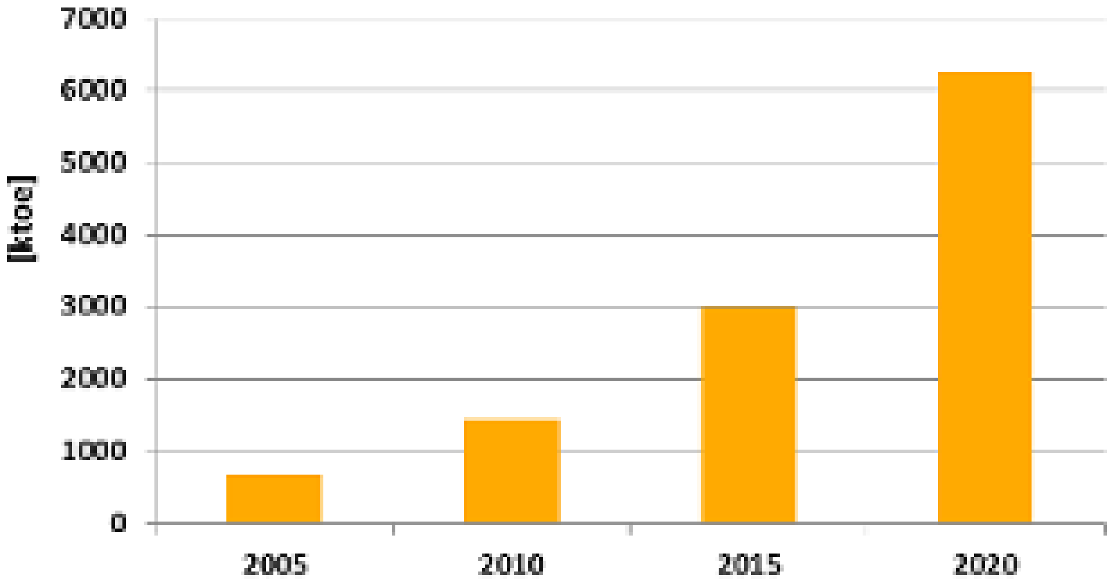


Figure7.11: Projections of solar thermal energy [ktoe] in Europe for the period 2005-2020 [ECN 2011]

The growth in the collector surface area in European countries and Switzerland, according to the data of the European Solar Heating Industry Association (ESTIF), was about 60% higher in 2008 as compared to 20073. Based on the National Renewable Energy Action Plans of the European Member States, the number of solar thermal installations in EU countries will further increase to meet the binding targets of the National Plans of the Member States.

7.1.4. Solar energy in public buildings

Both PV and solar thermal systems are suitable for installation in public buildings. Two things have to be considered for solar energy installation:

- The amount of sun radiation and
- suitability of the roof of the building.

Sun radiation in the specific area can be checked with the use of online tools and by measurements. Measurements are of course obligatory, since the area where the solar system is considered, must not be in a shadowed area. Online tools do not show that. (for example, statistically the location of the building has a lot of sun radiation but the roof of the selected building is in the shadow of the neighbouring taller building).

If the measurements of the sun radiation are suitable, the roof of the building has to be checked. A single 250W PV module has approximately 20 kg with the supporting structure so it is necessary to check the static structure of the roof and the working temperature of the modules are above 50°C so the insulation of the roof should be checked. The same applies for the solar thermal systems.

7.2. GEOTHERMAL POWER

Geothermal energy is a renewable energy source, stored in the shape of heat under the ground. Geothermal energy is energy obtained by tapping the heat of the earth itself, usually from kilometres deep into the Earth's crust. It is expensive to build a power station but operating costs are low resulting in low energy costs for suitable sites. Ultimately, this energy derives from heat in the Earth's core. Three types of power plants are used to generate power from geothermal energy: dry steam, flash, and binary. Dry steam plants take steam out of fractures in the ground and use it to directly drive a turbine that spins a generator. Flash plants take hot water, usually at temperatures over 200 °C, out of the ground, and allows it to boil as it rises to the surface then separates the steam phase in steam/water separators and then runs the steam through a turbine. In binary plants, the hot water flows through heat exchangers, boiling an organic fluid that spins the turbine. The condensed steam and remaining geothermal fluid from all three types of plants are injected back into the hot rock to pick up more heat.

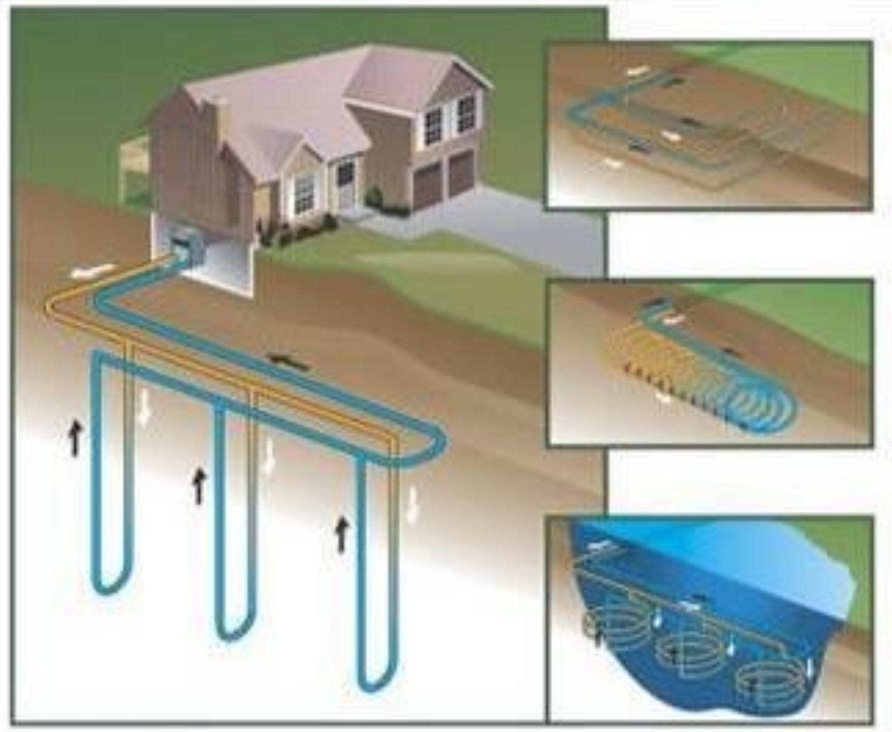


Figure 7.12: Using geothermal energy for heating residential buildings

Source: http://www.geotech.si/sl/geotermalna-energija

Example: In 2005, 24 countries generated a total of 56,786 GWh (204 PJ) of electricity from geothermal power. In 2007, the global capacity was 10 GW.

Geothermal sources that are closer to the surface can be used for heating and cooling buildings by means of heat pumps. These are low enthalpy deposits. Heat pumps enable direct heating of a building or the release of heat into the network with more customers. (Geothermal energy barometer, 2007).

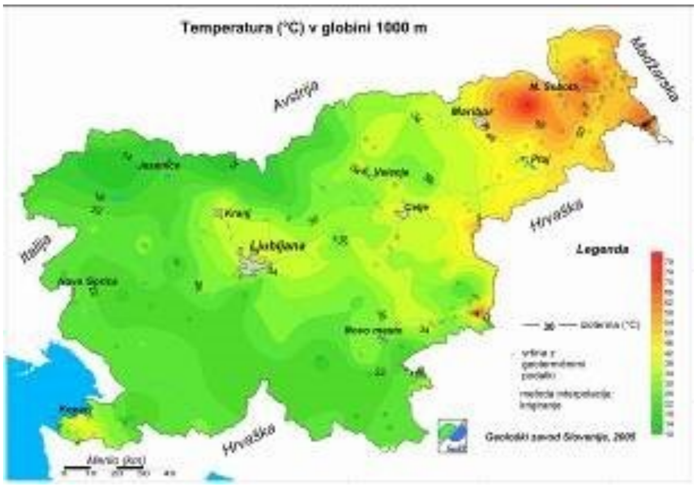


Figure 7.13: Geothermal map of Slovenia

(Source: http://www.geo-zs.si/UserFiles/File/geoterm_karta.jpg, 1/7/2011)

The exploitation of geothermal energy in Slovenia mostly occurs in the form of heat pumps for the purpose of heating. Recently the field of cooling has been added. Figure 4.13 represents geothermal potential – temperature conditions 1000 m deep and suggests that the highest temperatures (up to 78 °C) are 1 km below the surface in the north-east of the country.

7.2.1. Heat Pumps

The heat pump is a universal solution for heating as well as cooling tasks and can be employed for the entire range of air-conditioning needs in domestic and commercial spaces. The heat pump has to be distinguished from the warm water heat pump. While the heat pump is used first and foremost for the purpose of heating (or cooling) rooms, it can also be used for heating water.

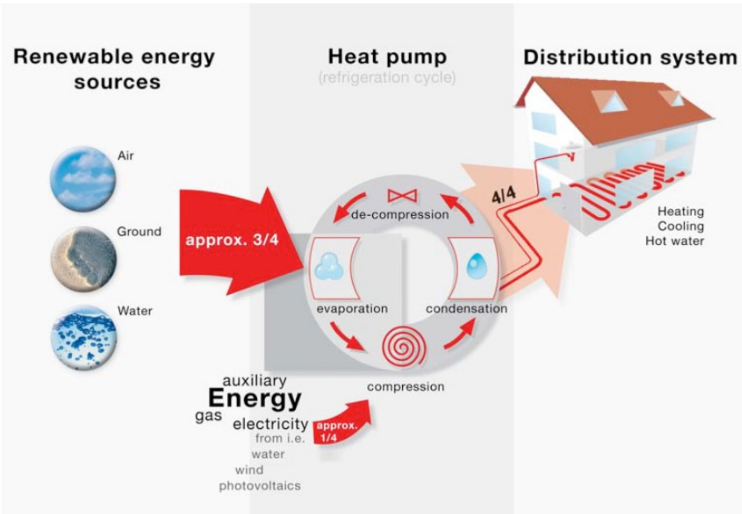


Figure 7.14: Principle of a heat pump

Source: European Heat Pump Association (EHPA)/Alpha Innotec

Many classical heating and cooling tasks can be accomplished using the flameless technology of heat pumps, in an efficient and environmentally friendly manner. By using a small amount of drive energy (electricity, fuel or high temperature waste heat) heat pumps can transfer the energy potential from natural heat sources in the surroundings (such as ambient and exhaust air, soil and ground water) or from man-made heat sources (like domestic waste) to buildings (Figure 4.14). With a heat pump it is possible to acquire 75% of the required energy from the environment, so that with 25% of electrical energy 100% of usable energy can be produced. A particularly widespread utilization range for heat pumps is opened up by combining them with concepts of energy recovery from low temperature sources and other renewable energy concepts.

Figure 7.15: The European Heat Pump Association, http://www.ehpa.org/

7.3. BIOMASS

Biomass is created by photosynthesis which by converting solar energy and together with CO_2, water and nutritive substances enables the growth of plants. The term biomass refers to fresh as well as dead plants. It can be used for direct burning, the result of which is thermal energy, or can - with different technological processes - be converted into liquid or gas hydrocarbons useful as fuels (the so called biogas in biodiesel).

To get fuel from biomass, the latter has to be processed properly. There are different processes such as burning, anaerobic digestion, thermochemical conversion and gasification. Properly processed biomass represents different types of fuels, which are classified in three groups: solid biomass (wood, energy and agricultural crops); liquid fuels from biomass (bioethanol, biomethanol biodiesel); gases from biomass (biogas, landfill gas) (Medved and Arkar, 2009).

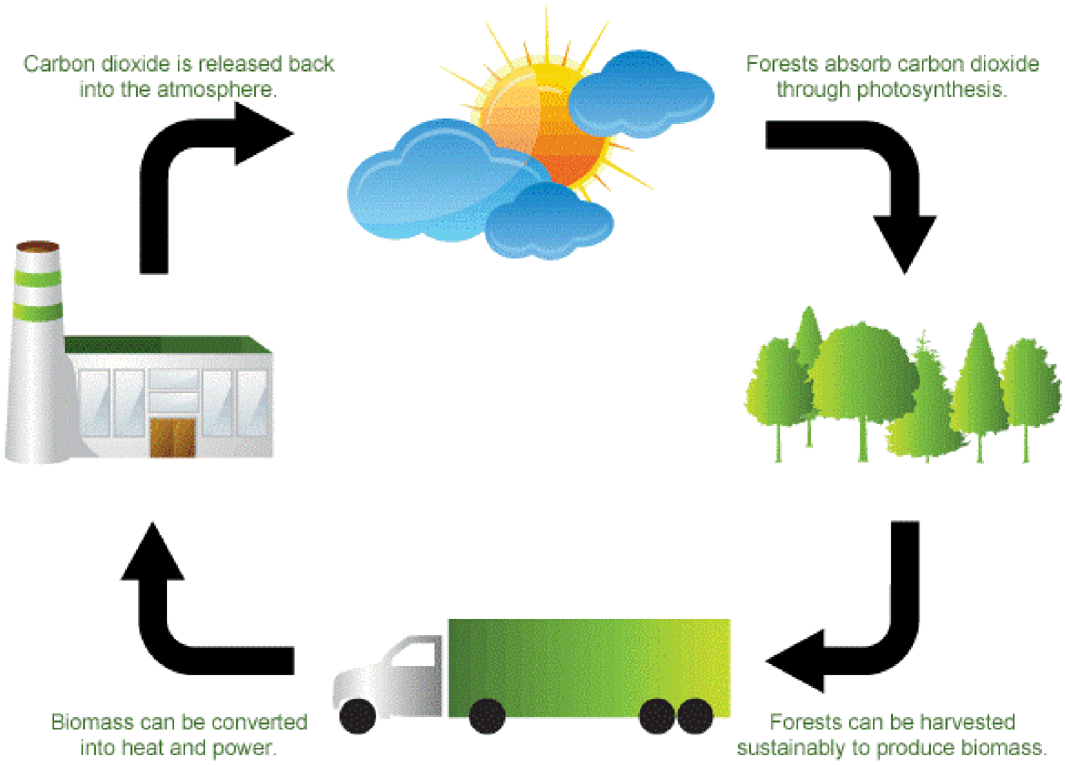


Figure 7.16: Biomass cycles

7.3.1. Biomass potentials

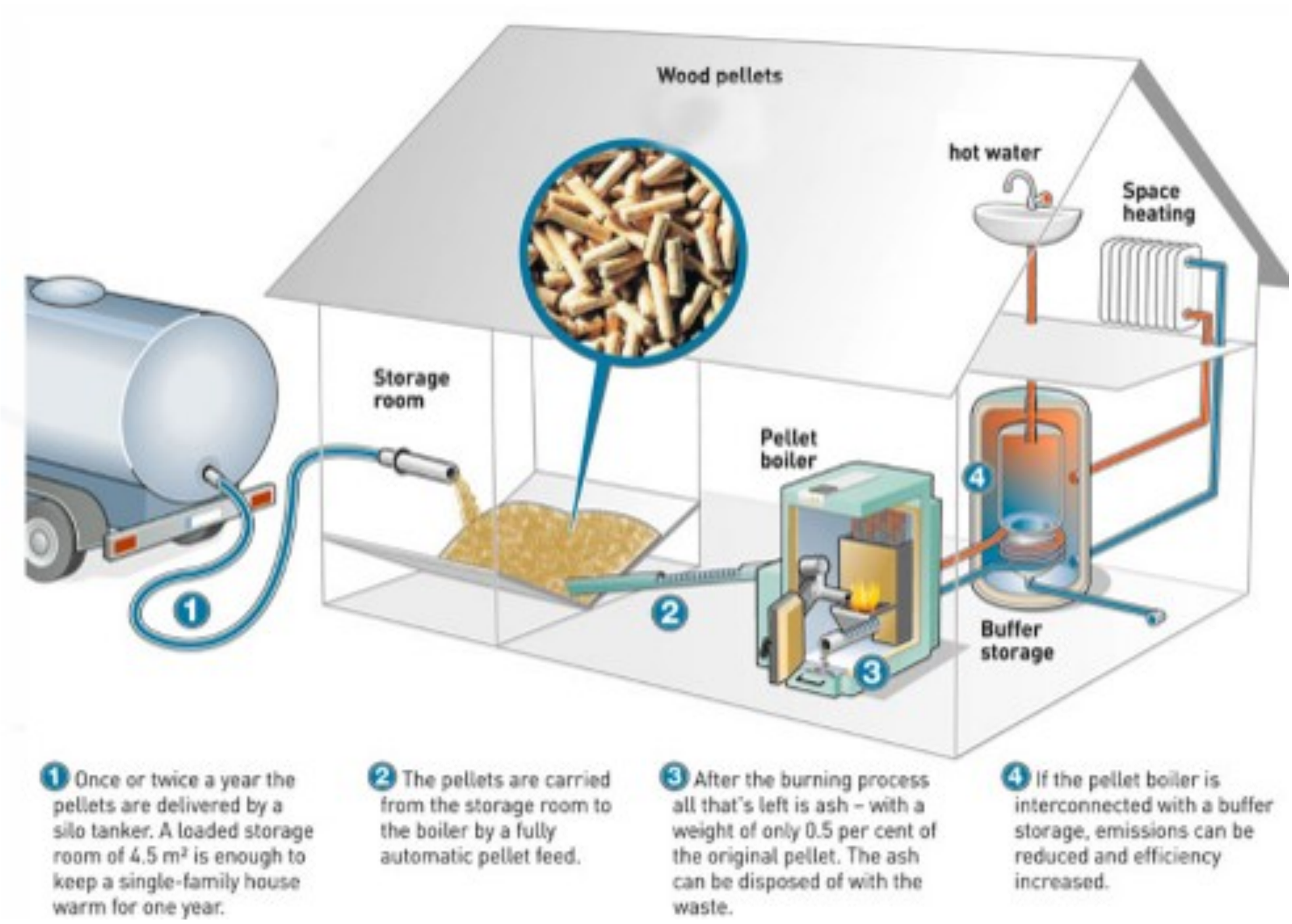
Biomass can be defined as any organic material which is considered as primary energy source. The term biomass includes:

- wood and wood residues (wood biomass),
- agricultural residues,
- non-woody plants appropriate for energy production,
- industrial crop production residues,
- household sorted/separated waste,
- dregs or sediment and organic fraction of municipal waste and waste water of food industry.

In the assessment of biomass potentials in Slovenia, wood biomass is most frequently discussed. Namely, Slovenia is one of the most wooded countries in Europe. However, other biomass sources should not be neglected. In the process of acquiring data these are often inappropriately collected and incomplete. Agricultural vegetable residues are theoretical biomass source for exploitation for energetic purposes, yet the established practice in Slovenia is that the residues are composted or ploughed, which increases organic matter in the ground, or are transported away and used for different purposes (bedding). By considering or predicting theoretical source of growing energy crops special precaution must be taken because more and more concern related to self-sufficiency in food arises.

Biomass of wood potential includes:

- wood from forests,
- wood from surfaces in the phase of growing,
- wood from agricultural and urban surfaces,
- wood residues of primary and secondary wood processing and
- waste (uncontaminated) wood.



7.17: Heating system with a pellet boiler, http://www.unendlich-viel-energie.de

The following are considered as an actual biomass potential:

- wood biomass from forest cultivating and protecting works,
- wood biomass from the regeneration of shrub regeneration/drainage
- wood biomass from new constructions or infrastructure maintenance in forestland (deforestation because of road and sledge road building, electrical wiring maintenance etc.)

Biogas is produced by anaerobic digestion with anaerobic bacteria or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops. It is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes. More about biogas is on the website: http://en.wikipedia.org/wiki/Biogas

Figure 7.18: EUBIA, the European Biomass Industry Association, http://www.eubia.org/

7.4. WIND POWER

Wind is available virtually everywhere on earth, although there are wide variations in wind strengths. The total resource is vast; estimated to be around a million GW for total land coverage. If only 1% of this area was utilised, and allowance made for the lower load factors of wind plants (15–40 %, compared with 75–90 % for thermal plants) that would still correspond, roughly, to the total worldwide capacity of all electricity-generating plants in operation today. Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electrical power, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships. Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission network.

Figure 7.19: Outdoor lamp with wind turbine-PV and wind farm;

Figure 7.20: Scheme of island wind power plant; http://www.vetrna-energija.si

7.5. HYDRO POWER

In 2013 hydropower provided a significant amount of energy throughout the world and is present in more than 100 countries, contributing approximately 15 % of the global electricity production. The top 5 largest markets for hydro power in terms of capacity are Brazil, Canada, China, Russia and the United States of America. China significantly exceeds the others, representing 24 % of global installed capacity.

Hydropower is used primarily to generate electricity. Broad categories include:

- Conventional hydroelectric, referring to hydroelectric dams.
- Run-of-the-river hydroelectricity, which captures the kinetic energy in rivers or streams, without the use of dams.
- Small hydro projects are 10 megawatts or less and often have no artificial reservoirs.
- Micro hydro projects provide a few kilowatts to a few hundred kilowatts to isolated homes, villages, or small industries.
- Conduit hydroelectricity projects utilize water which has already been diverted for use elsewhere; in a municipal water system for example.
- Pumped-storage hydroelectricity stores water pumped during periods of low demand to be released for generation when demand is high.

Micro hydro is a type of hydroelectric power that typically produces up to 100 kW of electricity using the natural flow of water. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks. There are many of these installations around the world, particularly in developing nations as they can provide an economical source of energy without the purchase of fuel. Micro hydro systems complement photovoltaic solar energy systems because in many areas, water flow, and thus available hydro power, is highest in the winter when solar energy is at a minimum. Micro hydro is frequently accomplished with a pelton wheel for high head, low flow water supply. The installation is often just a small dammed pool, at the top of a waterfall, with several hundred feet of pipe leading to small generator housing.

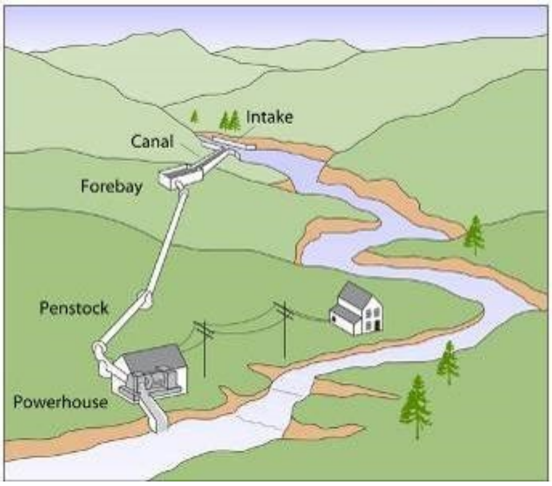


Figure 7.21: Type of Micro hybrid power plant; water is diverted into the penstock. Some generators can be placed directly into the stream, http://en.wikipedia.org/wiki/Micro_hydro#mediaviewer

Figure 7.22: European Small Hydropower The EU Association (ESHA), http://www.esha.be/

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- List the types of renewable energy sources.
- Which RES installation is dependent on the size of the roof of the building and shadowing?
- Name a type of device that uses geothermal energy.
- Can the wind energy be used for powering street lamps?

FURTHER SUGGESTIONS FOR TRAINERS:

- The document presents the simple RES systems and their main principles. More literature on the installation of RES in public buildings may be found in the **TOGETHER library** available at http://www.interreg-central.eu/Content.Node/TOGETHER.html.
- Additional explanation can be given on the principle of geothermal power (demonstration of a heat pump and its operation).

MODULE 8: CHOOSING MOST OPTIMAL EE IMPROVEMENT SCENARIO FOR A SPECIFIC BUILDING

Short summary is presented for choosing the optimal scenario. Detailed description on each can be found in a "Catalogue of “Optimization Scenarios” to enhance decision-making in establishing an efficient energy management programme, Electronic Version, October 2014.

There are several categories for optimization:

1. Ventilation

- Use CO_2 level alarm to initialize the manual opening of the windows
    - To facilitate the air movement within a space, or a succession of spaces, through the opening (manual or mechanical) of the external frames. In many schools, fresh air is changed too often or too rarely, leading to heat losses or CO_2 building up. Utilization of simple CO_2 level alarm systems in the classrooms, in conjunction with clear behavioural rules about the openings of the windows and doors, can help energy savings and comfort optimization.
    - This scenario is particularly effective for schools in hot-humid climates and temperate areas during the summer period because by reducing the percentage of moisture and increasing the air speed, limits the demand for mechanical conditioning.
    - Best applied in large school classrooms, especially after improvement of air tightness. In this case fresh air is changed too often, leading to heat losses or too rarely, leading to CO_2 building up.

The scheduling of window/door openings can be done in one week, depending also on the installation of CO_2 control system.

Step 1: Assessment of current status. It is necessary to check with school managers if there’s a scheduled opening performed by users: if not, please check school users comfort and opinion in order to preliminary asses the user’s current conditions.

Step 2: Install the CO_2 controls system. Once selected the rooms in which is required an improved air quality, the CO_2 control system can be installed where is necessary. It is up to both school manager and technician to choose the number and the position of the sensors.

Step 3: Set a number of predefined openings for the selected rooms. The school manager can verify the number of alarms during the week, and consequently can set a predefined opening of rooms/doors in order to ensure a number of air changes that will guarantee the air quality.

- List Improve Maintenance of the existing forced ventilation system

Often in schools the existing forced ventilation system is not correctly maintained, and this issue leads to a global inefficiency that can heavily affect energy consumptions.

The aim is to avoid waste of energy due to malfunctioning, weak maintenance and components' wear. Checking that HVAC systems are working as intended will help to prevent them from using energy ineffectively and also lower the risk of breakdown and spiralling costs. In this way, regular maintenance of equipment and controls makes good business sense.

IMPLEMENTATION STEPS:

Step 1: Technology and plants assessment

A deep analysis of HVAC systems, electrical devices and all equipment used in school shall be done by a qualified technician, in order to have a clear picture of systems that need maintenance.

Step 2: Scheduling Maintenance

The school manager, together with technicians, shall provide a scheduled maintenance plan according to plants, equipment and budget. It is important to prioritize actions in order to guarantee not only energy savings, but also school users' comfort.

- Install Control of openings (doors, windows) based on Thermal and CO_2 levels

To improve air quality, causing limited interference with educational activities and limiting energy waste, electronic actuators shall be used for opening the frames or aeration grids. The actuators are connected to appropriate sensors, placed within each class, for detecting the amount of CO_2 present in the air.

Through a program of Building Energy Management System (BEMS) can set the required level, maintaining an optimal air mixture for the daily classroom activities.

This scenario is particularly effective for schools in hot-humid climates and temperate areas during the summer period because by reducing the percentage of moisture and increasing the air speed, limits the demand for mechanical conditioning.

The detectors measure the concentration of CO_2 in the air at regular intervals, providing the opening of windows or of the ventilation grilles, or by activating MCV system (Mechanical Controlled Ventilation).

An actuator is a device which enables a window to be opened and closed automatically or by a rotary handle. It is the hardware that fits onto the window which pushes and pulls the window open and closed instead of operating the window manually.

Window automation is used predominately for the purpose of natural ventilation and smoke ventilation.

An automatic window actuator has a cost - range from 50€ to 100€, depending on window, frame and actuator typology.

It should be considered several parameters such as: Vent height, Vent width (locking points & weather performance), Material (Plastic, aluminium, wood), Hinge arrangements, Weight [Force=Stroke/Height x Weight/2], Distance vents need to open, What free area is required?

It may be beneficial for example within a school to limit the opening of the windows within specific time constraints that could simply be achieved by using a 7 day timer.

IMPLEMENTATION STEPS:

The scheduling of window/door openings can be done in one week, depending also on the installation of CO_2 control system.

Step 1: Assessment of current status

It is necessary to check with school managers if there's a scheduled opening performed by users: if not, please check school users comfort and opinion in order to preliminary asses the user's current conditions.

Step 2: Install the CO_2 controls system

Once selected the rooms in which is required an improved air quality, the CO_2 control system can be bought and installed where is necessary. It is up to both school manager and technician to choose the number and the position of the sensors.

Step3: Set a number of predefined openings for the selected rooms

The school manager can verify the number of alarm during the week, and consequently can set a predefined opening of rooms/doors in order to ensure a number of air changes that will guarantee the air quality.

2. Air conditioning

- Inspect to ensure dampers are sealed tightly.

The school building manager/owner shall ensure that the proper damper maintenance is being performed and ensure that inspections are conducted per code requirements set forth by the local laws and regulation.

It is mandatory to rely always on a certified professional that is qualified to properly inspect and maintain dampers.

Every 6 Months: Cycle test (open and closed) all motorized fire and smoke dampers, Test all dedicated smoke-control systems;

12 Months: Test all non-dedicated smoke control systems,

Every 24 months: Visually inspect all fire dampers, ceiling radiation dampers, smoke dampers, and combination fire smoke dampers.

Every 48 Months: Manually operate (open and close) all fusible link operated fire dampers and ceiling radiation dampers.

Rely on a certified professional that is qualified to properly inspect and maintain dampers.

INSPECTION POINTS: Fusible links (where applicable) shall be removed, All dampers must be operated to verify that they close fully, The latch, if provided, shall be checked, Moving parts shall be lubricated as necessary, Inspect fuse link and re-install or replace as needed.

- Improve air filtering in the HVAC system

Keep filters cleaned has several advantages: Better clean air distribution, Less noise, Keep central heating/cooling equipment clean and efficient, Ability to filter outside air before it enters the occupied area, Ability to place occupied space under positive pressure to reduce infiltration of contaminants, Less maintenance than with many portables around the facility, more cost effective than portables for larger areas.

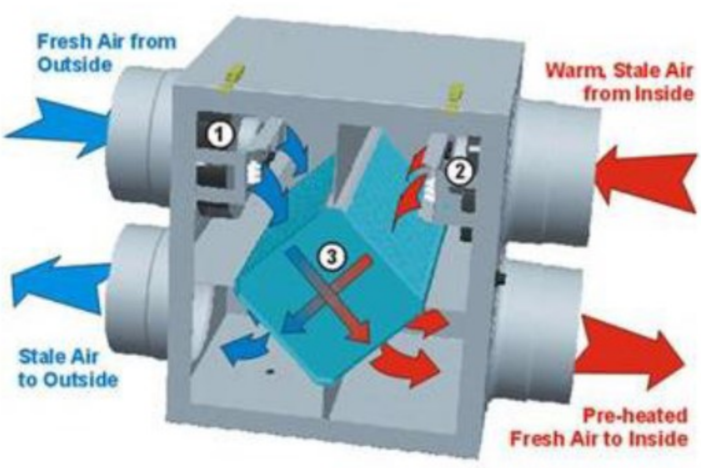
- Insulate ventilation / HVAC air ducts

The HVAC air ducts insulation is used to minimize air leaks through the HVAC ducts, in order to make the HVAC system maximally efficient, and save energy and money. The presence of air leakages can be detected performing an air leakage test. Air leakages mean that the heated or cooled air passing through the HVAC ducts escapes from the heating or cooling system decreasing the efficiency of the air conditioning system, and increasing the thermal energy demand and the amount of air needed to heat or cool the building. Furthermore, even when the heating and cooling system is off, the presence of leaks in the ducts increases the ventilation rate of the house and thus the need for heating.

- Check pipe insulation set up in split system

All pipes for hot water and central heating, which run outside the heated areas of the building, are potential sources of heat loss. For this reason, checking for good quality insulation especially around joints and valves is a recommended operation in order to make the whole heating system maximally efficient and save energy.

- Improve the overall HVAC efficiency by coupling a Variable Frequency Drive Control with multiple temperature sensors
- Install a heat recovery system (Recovering heat from exhaust air of the mechanical ventilation systems)



- Improve the HVAC control system by using CO_2 control sensors: Preventing energy losses from over-ventilation while maintaining indoor air quality. CO_2 sensors are considered a mature technology and are offered by all major HVAC equipment and controls companies.
- Installation of an economizer in AHU (Air Handling Unit) system to reduce the usage of mechanical cooling systems, in order to save energy.
- Refurbish AHU to improve the system efficiency

3. Electrical equipment

- Implement behavioral rules to save energy (remind turning off unused devices, close windows when HVAC system is on, etc.)
- Increase power factor
- Ask contractors to replace inefficient vending machines
- Review the contract in respect to energy consumptions

4. Heating

- Use fans to reduce heat stratification in large rooms
- Perform basic improvements to radiators and terminals
- Verify that heating unit maintenance accordingly complies with existing laws
- Insulate domestic hot water boiler tank
- Install an Outdoor Temperature Compensator for the Heating Unit
- Install thermostatic valves to radiators
- Install a zone heat metering system coupled with cost allocation system
- Retrofit the Heating Unit with burner control
- Retrofit the Heating Unit with flue gas/stack heat recovery
- Replace the Heating Unit

5. Lighting

- Lighting efficiency
- Set up occupancy based lighting control
- Set up dimming lighting control
- Install mobile screening system to adapt brightness
- Split the electrical lighting circuits

6. System setting strategies

- Optimize the thermostat set points during the day by keeping it at minimum allowed level (e.g. 21°C switch to 20°C)

- Optimize the thermostat set points during unoccupancy of the school (trade-off between keeping at minimum level or switching the system off.)
- Night time venting: keep windows open in summer to get fresh air in
- Adjust timers to optimize switching “on” of the heating system before occupancy
- Implement a remote control of radiators (zoning by room), with calendar scheduling option

7. Building elements

- install automatic system to close external doors or vestibule
- Reduce air leakages in the building
- install solar controlled window films
- Replace exterior windows with insulated glass block
- Use cool roof solutions (white shingles, white plastic, reflective coatings)
- Insulate thermal bridges
- Replace windows and glazing
- Install external fixed or mobile shielding to protect from sun
- Insulate the school building envelope

8. Layout options

- Provide shade with trees and or windbreaks

9. Sport facilities

- Swimming pool - Install humidistat to control water pool temperatures
- Swimming pool - Schedule backwashes
- Swimming pool - Use a pool cover
- Swimming pool - Install solar water heating system
- GYM - substitute metal halide lamps
- GYM - replace old heating system

10. Renewables

- Install a Solar Thermal plant
- Improve the use of the Solar Thermal plant
- Install a Photovoltaic (PV) system
- Improve the use of the PV system
- Install a biomass boiler
- Improve the use of the biomass boiler

- Install a small wind turbine
- Improve the use of the small wind turbine
- Install a Seasonal Thermal Energy Storage (STES) system
- Install a Ground Source Heat Pump (GSHP)
- Improve the use of the Ground Source Heat Pump

11. Management-behavior

- Carry out lighting analysis
- Carry out HVAC analysis
- Carry out analysis of other electrical use and appliances
- Conduct energy walk rounds
- Raise awareness of staff, pupils and school personnel
- Identify and Integrate energy savings into student's curriculum
- Ensure lights are switched off at breaks and after school
- Use a Display Energy Certificate (DEC)
- Allow Students and Staff to make energy saving suggestions
- Publicize the size and value of savings in terms of money, energy, CO_2
- Communicate with Staff
- Communication for Students
- Monitoring of energy supply contracts including global service contract

Source: “A Catalogue of “Optimization Scenarios” to enhance decision-making in establishing an efficient energy management programme”

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- What are the main areas, where optimisation measures may be implemented?
- How to improve maintenance of existing building systems (ventilation, heating, lighting) to reduce energy consumption?
- What is BEMS and how it can be used to optimise energy consumption in building.

FURTHER SUGGESTIONS FOR TRAINERS:

- Choose a specific building (e.g. a building managed by one of your trainees) and ask the group to analyse its situation and come up with possible optimisation measeurs. You may form several groups working on several "pilot" buildings and then ask each of them to present and compare their results.

- More in-depth information on this topic may be found in the publication "A Catalogue of "Optimization Scenarios" to enhance decision-making in establishing an efficient energy management programme", as well as some useful resources gathered in the TOGETHER library: http://www.interreg-central.eu/Content.Node/TOGETHER.html.

MODULE 9: INTEGRATION OF TECHNICAL MEASURES WITH EACH OTHER AND WITH OTHER TYPES OF EE SOLUTIONS

Different technical measures can be integrated with each other. There are two possible combinations:

- Combining the technical measures for reducing electrical energy consumption and
- Combining technical measures for reducing thermal energy consumption.

All the measures were described in previous chapters but for the explanation of options for combining two examples are presented here.

For both possible combinations, the first step is a walk through energy audit for recognition of “weak spot” or area for optimization of consumption/efficiency.

Step 1: walk through energy audit.

Step 2: selection of the area to improve (electrical or thermal)

Step 3: implementation of technical measures for EE improvement.

Let’s take the electrical energy for example. Changing the old inefficient equipment with new energy efficient equipment (light bulbs as the cheapest measure) will reduce the consumption of electrical energy. If we combine this action with installation of RES (PV power plant), the EE measures will reduce the consumed electrical energy and the power plant will produce electrical energy, so we can achieve the surplus of electrical energy and actually receive money for that (sell the extra energy).

The same principle applies for thermal energy. There are many combinations, but they are dependent on the available budget.

- Changing the boiler and retrofitting the building insulation,
- Replacing the valves and purchasing efficient radiators,
- Installing heat pumps or solar collectors and changing the window sealings,
- Etc..

All the technical measures can be combined in some way if the budget allows it (and the building specifics).

A simple example is presented in the next part of material.

It is also worth to ensure integration of technical measures with other types of EE solutions, e.g. combining thermal retrofitting with educational campaign teaching building users how to operate the building properly and encouraging them to save energy. Also, one needs to remember that changing the building envelope, the heat source, etc. will require adaptation of the building's internal systems.

CHECKLIST FOR TESTING TRAINEES KNOWLEDGE:

- What are the benefits (min.5) of integrating different types of measures? What are the possible challenges (min. 5) related to the process?

FURTHER SUGGESTIONS FOR TRAINERS:

- Discuss with the trainees possible links between technical and behavioral EE measures. How and to what extent the building users can be involved in technical interventions?

PART 2: EXERCISES

EXERCISE 1: ENERGY AUDIT AND ENERGY PERFORMANCE CERTIFICATE

Walk-Through Audit of a Residence

A walk-through audit allows the collection of basic information about the building envelope (windows, walls, and doors) as well as the lighting fixtures, appliances, and HVAC equipment. During a walkthrough audit, the auditor should question the building owners and occupants to determine any problematic areas of the building related to thermal comfort and energy performance. *The main purpose of a walk-through audit is to provide recommendations for improving the energy efficiency of the residence by investigating selected operating and maintenance measures and energy efficiency measures (EEMs) with short payback periods.*

Reporting a Walk-Through Audit

The walk-through audit can be a standalone task or one part of a standard energy audit. Typically, this type of audit is sufficient for small buildings with simple energy systems including residential buildings and low-rise commercial buildings. The basic tasks to be carried out for a walk-through audit include:

Task 1: Describe the basic energy systems of the building including building envelope, mechanical systems, and electrical systems. Observations from the walk-through as well as specifications from architectural, mechanical, and electrical drawings can be utilized to describe the building features.

Task 2: Perform basic testing and measurements to assess the performance of various energy systems. These measurements may depend on the type of building and its systems as well as on time available for the auditor. For residential buildings, it is highly recommended to perform a pressurization or a depressurization testing using the blower door test kit. In all building types, spot measurement, and, if possible, monitoring indoor air temperature and relative humidity within the space for at least one day, is helpful to estimate the indoor temperature settings and identify or check any comfort issues.

Task 3: Meet and discuss with building occupants or building operators to identify any potential discomfort problems and sources of energy waste within the building. This task is often helpful to define potential operation and maintenance measures as well as energy conservation measures.

Task 4: Identify some potential operation and maintenance (O&M) measures and energy conservation measures (ECMs) as well as any measures required to improve comfort problems. Provide the implementation details and the cost of implementation (try to seek direct quotations from local contractors/stores).

Task 5: Evaluate the energy savings (or requirements if measures are needed to improve comfort) using simplified analysis methods presented in this book. Compare the results between the two approaches and comment on the accuracy of both approaches.

Task 6: Perform cost analyses based on the simple payback period method to determine the cost-effectiveness of the identified O&Ms and ECMs. You should make appropriate assumptions and, if necessary, estimate the energy cost savings. Provide recommendations based on the economic analyses. Cost data should be taken from actual estimations from contractors.

The report of a walk-through energy audit can be brief and should include at least the basic recommendations for cost-effective O&Ms and ECMs, that is, the results of Task 6 described above. However, it is strongly recommended that a more detailed report be drafted to document the findings and observations obtained from the completed tasks. In particular, the report should describe the basic features of the audited building as well as any potential problem areas identified during the walk-through. Moreover, the calculations to estimate energy use and cost savings should be presented for the recommended energy conservation measures. In addition, references and specifications for implementing the recommended O&Ms and ECMs should be provided. A final report for a walk-through energy audit can include the following sections:

1. Legible and complete drawings showing the floor plan and at least two elevation views.
2. Brief description of the architectural features of the building (construction type, orientation, solar systems, etc.).
3. An analysis of the utility bills to estimate energy use intensity, the building BLC, the balance temperature, and base-loads. It is useful to perform this task before visiting the building.
4. Description of any testing or measurements carried out during the walk-through audit including temperature and air leakage. For air leakage testing, provide all the relevant details of your testing and calculation analysis including any assumptions. Ensure that you provide the air leakage area as well as the infiltration rates (in ACH) under reference conditions (i.e., $\Delta P = 4$ Pa) and for average weather conditions (annual average and heating season average).
5. Discussion of the walk-through audit tasks and the outcome. In particular, highlight any occupant concerns and complaints and any identified potential O&Ms and ECMs.
6. Describe the calculation details to estimate energy use and cost savings for the considered O&Ms and ECMs. References for these calculations should be provided in the report including any assumptions that were made to carry out the estimations.
7. Discuss the results of the economic analysis. In particular, provide the general procedure and the cost of implementing each ECM.
8. Provide specific recommendations to the client to reduce the utility bills or to improve the indoor environment within the building.
9. Take some photos to highlight some of the features and the problem areas of the house.

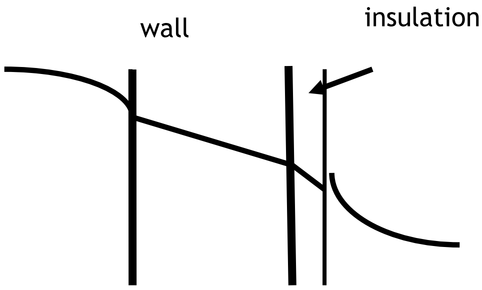
EXERCISE 2: ENERGY RETROFIT OF THE BUILDING

HEAT TRANSFER

When the heat is transferred from a fluid to another fluid (it may be air, watter, etc..) through a wall between them, then we can talk about the heat transfer.

For the straight roof:

$$\dot{Q} = k \cdot A \cdot \Delta T \quad [W]$$



Heat transfer happens through convection through the inner wall, wall and outer layer (insulation).

Meaning of symbols:

Q Heat flow [W]

k Heat transfer coefficient [W/m² K] – also known as U value

A surface area [m²]

q Heat flow density [W/m²]

ΔT temperature difference (inner temperature – outer temperature) [K]

T temperatue [°C]

To calculate the heat transfer coefficient “k” we take the coefficient of the heat transfer of the inner wall and outer wall. For a fluid that allows the movement for example of air: α = αk+ αs , and for a fluid that doesn’t allow movement, for example water: $\alpha = \alpha_k$.

For a straight roof:

$$\frac{1}{k} = \frac{1}{\alpha_i} + \frac{1}{\alpha_o} + \frac{\sum d_i}{\lambda_i}$$

α_i coefficient of the heat transfer of the inner wall

α_o coefficient of the heat transfer of the outer wall

d layer thickness (single material thickness)

Let's say that inner wall has a constant α_i = 8 W/m² K (usual value) and the outer wall α_o = 25 W/m² K (according to standard for heating calculation – DIN 4701).

d_{wall1} = 60 cm = 0.6 m λ_{brick1} = 0.75 W/m K (cement is excluded)

We are searching for the value of the Heat transfer coefficient k!

Compare the values:

λ_{brick2} = 0.6 W/m K, d_2 = 0.3 m

$\lambda_{insulation}$ = 0.75 W/m K, d_3 = 7.3 m

Calculation:

$$\frac{1}{k} = \frac{1}{\alpha_i} + \frac{1}{\alpha_o} + \frac{d_{wall1}}{\lambda_{wall1}} = \frac{1}{8} + \frac{1}{25} + \frac{0,6}{0,75} = 0,965 \Rightarrow k = 1,04\left[\frac{W}{m^2 K}\right]$$

This calculation has to be performed for each wall. It is a simple calculation, but the problem is that one calculates with the data that is recorded in the building plans documentation (project documentation) if the data is even available. Sometimes the buildings are very old and there is no data about the aterials and thicknesses of the walls. The calculations are somewhat accurate but mostly useful for new or soon to be built buildings. For the older ones we recommend measuring the Heat transfer coefficient such as TESTO 635.

Excersise: measure the Heat transfer coefficient of a wall using the TESTO 635.

1. Place the thermocouples on the inner wall as shown in the figure below

2. On the outside wall place the wireless probe on the approximate height as the thermocouples are.

More in the video: https://www.youtube.com/watch?v=QJ0bK4HrRp4

EXERCISE 3:
CHANGE OF THE HEATING SOURCE

Change of the heating source is best to be left to the experts. There are many facts to be taken into account before determining the most suitable power of the heating or cooling source.

The correct choice of thermal power of the heating source

If we just buy the heating source with the same installed power as the previous one would be a bad choice. Without the project of heating and thermal calculation it is not possible to determine the correct power of the source.

The heating sources, in most cases, are heavily over dimensioned, have too high installed power and operate with very low efficiency. Therefore, before buying a new boiler it's necessary to check it's power. This work should be carried out by a designer of central heating.

EXERCISE 4: INSTALLATION OF RES

Lets say that the roof of a public building has a 150 m^2 of suitable surface for the PV powerplant installation. Calculate the approximate installed power and the annual production of the PV power plant if a 250W PV module has 2 m^2.

Solar cells indirectly convert the solar energy into electrical energy. Typical array is shown in the figure below. The characteristic of a solar cell is a curve that connects the relationship between electrical current and voltage at different resistance of electrical circuit that connects the electrodes of a solar cell.

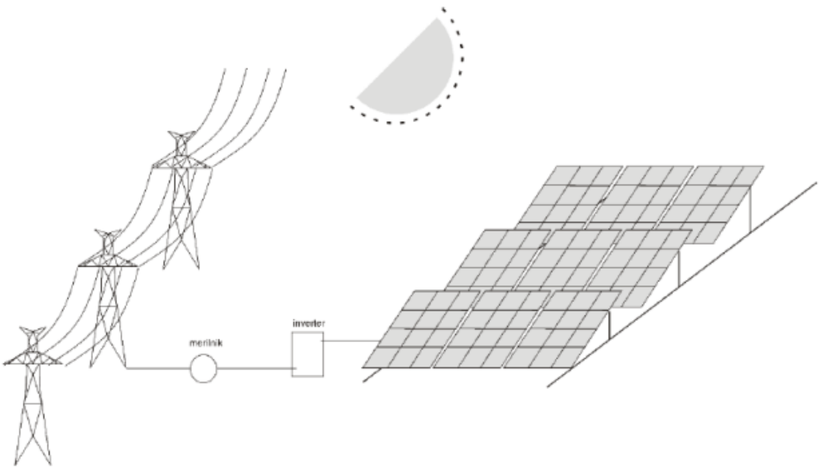


Figure 8.1: Typical array of a PV power plant

For more authentic comparison between solar cells there are international standards for testing solar cells, called reference conditions of operation. These are the intensity of solar radiation 1000 W/m^2 and ambient temperature25°C.

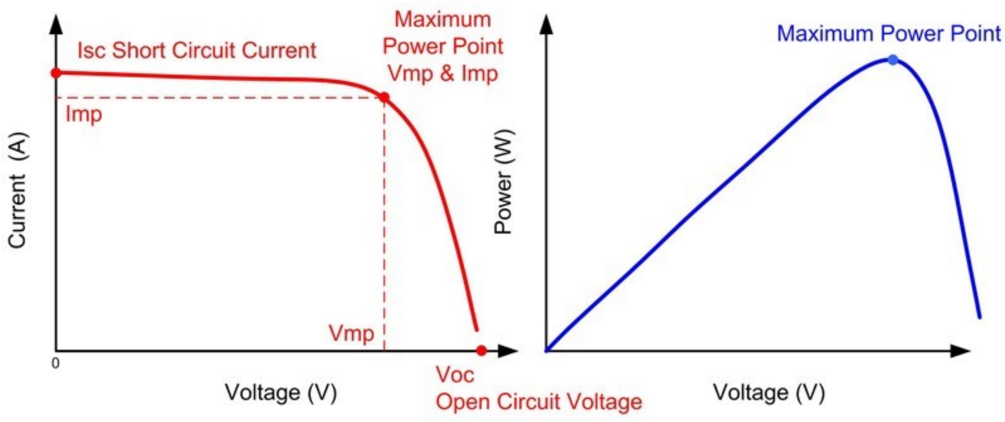


Figure 8.2: PV cell characteristic

Maximum value of power is called Watt peak (W_p). The efficiency of production of electrical energy depends on solar radiation and ambient temperature and can be calculated by:

$$\eta_{PV} = \eta_r \left[1 - \frac{\beta_{PV}}{100} \left(T_{PV} - T_r \right) \right]$$

Where η_{PV} is solar cell efficiency, η_r PV cell efficiency at reference conditions, β_{PV} temperature coefficient (%/°C), TPV temperature of solar cells and T_r reference temperature.

Reference efficiency of a PV cell is:

$$\eta_r = \frac{W_p}{G_r A_{PV}} 100\%$$

Where W_p is the peak power of a solar cell at reference conditions (W_p), G_r reference level of solar radiation (W/m^2), and APV area of PVcells (m^2).

Annual production of a PV power plant is defined by:

$$Q_{el,PV} = A_{PV,cel} \eta_{PV} H_\beta$$

Where $Q_{el,PV}$ production of electrical energy with PV system (W/year), A_{PV} total area of PV cells (m^2) and H_β annual solar radiation on the surface of a PV system (kWh/m^2year).

Number of PV modules:

$N=150m^2/2m^2$ = 75 PV modules

Installed power: W_p = 75*250W = **18750W or 18,75kW**

$$\eta_r = \frac{W_p}{G_r A_{PV}} 100 = \frac{18750}{1000 \cdot 150} 100\% = 12,5\%$$

To calculate the approximate annual production of the PV power plant the annual solar radiation on the surface of a PV system is needed. It can be read froma a number of online tools or pictures. An example is figure 8.3.

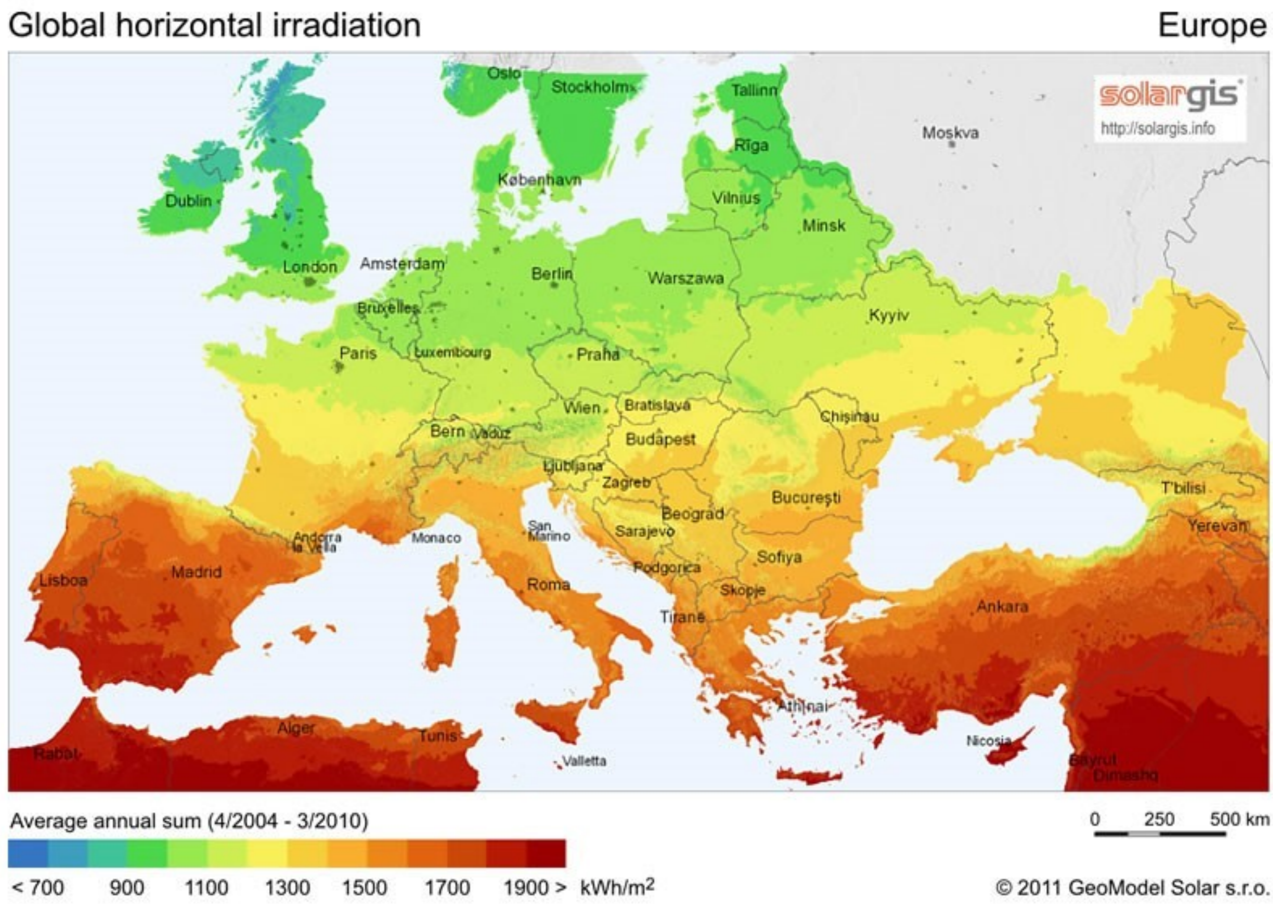


Figure 8.3: annual solar radiation

Let's predict that the PV power plant is in Berlin. From figure 8.3 we can see that the colour is green, which means that the annual solar radiation is around 1000kWh/m^2.

$Q_{\mathrm{el,PV}} = A_{\mathrm{PV,cel}}\eta_{\mathrm{PV}}H_{\beta} = 150\cdot 12,5\cdot 1000 = 1875000\,\mathrm{W / year}$ or **1875kW/year.**

EXERCISE 5: MODERNISATION OF INTERNAL BUILDING INSTALLATIONS

A student house has 10 floors and each floors has 10 student rooms. Each room has 2 100W light bulbs with 1600 lm luminance. Calculate the energy savings if the lightbulbs are replaced with 15W LED bulbs with the same luminance. Let's assume that the lights are on 5 hours a day and that the price for 1kWh is 0,1 EUR.

Installed power for lightning in rooms:

P=10 floors*10 rooms*2*100W lightbulbs=20000W

Energy consumption per day is:

t=5h, P=20000W, W=P*t=20000*5=100000Wh or 100kWh

Price for energy per day:

C=W*price=100kWh*0,1EUR=10EUR/day

Same equations for LED bulbs:

P=10 floors*10 rooms*2*15W lightbulbs=3000W

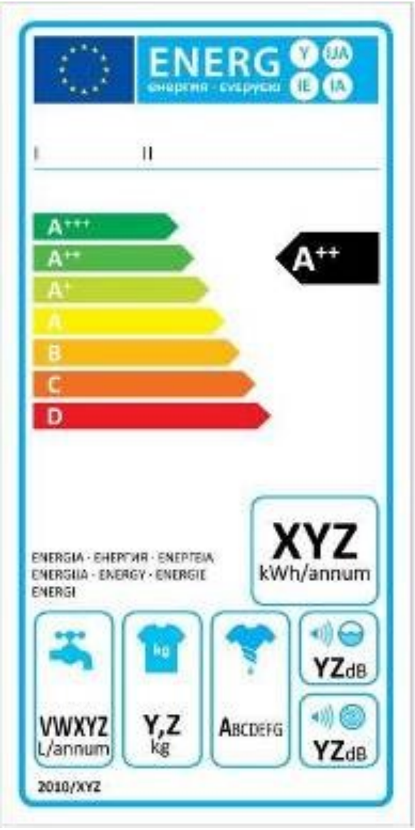
Energy consumption per day is:

t=5h, P=3000W, W=P*t=3000*5=15000Wh or 15kWh

Price for energy per day: C=W*price=15kWh*0,1EUR=1,5EUR/day

Classic lightbulbs	LED lightbulbs
t=5h, P=20000W	t=5h, P=3000W
W=P*t=100000Wh or 100kWh	W=P*t=3000*5=15000Wh or 15kWh
C=W*price=100kWh*0,1EUR = **10EUR/day**	C=W*price=15kWh*0,1EUR = **1,5EUR/day**
	85% SAVINGS

EXERCISE 6:
PURCHASE OF ENERGY EFFICIENT EQUIPMENT



Energy efficient equipment can be recognized from the energy class of the device. The figure tells us the energy class and the annual consumption of the device. Depending on the device, a simple equation can be used to calculate the energy consumption of a device or devices.

Formula for estimating Energy Consumption

You can use this formula to estimate an appliance's energy use:

(Wattage × Hours Used per Day ÷ 1000 = Daily Kilowatt-hour (kWh) consumption

(1 kilowatt (kW) = 1,000 Watts)

Multiply this by the number of days you use the appliance during the year for the annual consumption. You can then calculate the annual cost to run an appliance by multiplying the kWh per year by your local utility's rate per kWh consumed.

Examples: *Window fan:*

(200 Watts × 4 hours/day × 120 days/year) ÷ 1000 = 96 kWh × 8.5 cents/kWh = $8.16/year

Personal Computer and Monitor:

(120 + 150 Watts × 4 hours/day × 365 days/year) ÷ 1000 = 394 kWh × 8.5 cents/kWh = $33.51/year

EXERCISE 7: CHOOSING MOST OPTIMAL EE IMPROVEMENT SCENARIO FOR A SPECIFIC BUILDING

Ventilation

A school manager shall provide a scheduled windows opening in order to favour the entry of outside air in the environments in which activities take place. To increase the air speed and, therefore, the complete replacement, it is preferable to choose cross-ventilation systems that are based on the location of the openings on opposite walls of the same environment (e.g. on a closure and a partition).

School manager and technician must pay particular attention to:

- Areas that are experiencing conditions of air pollution and noise, even inside.
- Relative orientation of the closures and sunscreen.
- Possible formation of harmful air currents inside the classrooms.

Improve Maintenance of the existing forced ventilation system

Some examples of maintenance activities are described in the following points:

- Regular maintenance for optimum performance

HVAC components must be kept free of dirt and other obstructions in order to operate efficiently. The overall system should be serviced annually either by a maintenance technician or a professional contractor. Routine maintenance should be regularly undertaken to identify potential problems at early stage.

- Maintain boilers

Have boilers serviced regularly by a reputable firm. Gas-fired boilers should be serviced once a year; oil boilers twice a year. A regularly serviced boiler can save as much as 10% on annual heating costs.

- Check condensers

Condensers are usually located on the outside of buildings and reject heat that has been removed from inside the building by the cooling system. Ensure condensing and evaporating devices are clean and well maintained. Check condensers are not obstructed, for example by equipment or vegetation.

- Check air conditioning and comfort cooling plant

Ensure cooling plant is regularly maintained to avoid operating at reduced levels of efficiency. Replace insulation on refrigerant pipework as poor condition will affect the temperature of the refrigerant flowing through the system and thus consume more energy in maintaining the required temperature. Pay specific attention to pipework located outside a building. Check for refrigerant charge and leakage. If your refrigeration plant contains more than 3 kg of refrigerant then the F-Gas regulations state that you must have a schedule of regular inspection for gas leaks.

- Clean fans, filters and air ducts to improve efficiency by up to 60%

There is no point in having an efficiently running system if the conditioned air gets stopped by a solid wall before reaching the work space. Blockages in HVAC systems are common and increase running costs, so make sure that the filters are regularly checked. Consider fitting pressure gauges to indicate when replacement of filters is required.

Choosing the most optimal scenario for a specific building depends (among other things) from the available budget.

To select the optimum scenario with a limited budget it is necessary to analyze the consumption of the building, which means that we have to check the bills for electric and thermal energy (for heating energy and hot water).

A couple of examples are listed in tables below:

<table>
<tr><th colspan="2">Optimization of thermal energy use</th></tr>
<tr><td>Status of the building envelope</td><td>status of the façade</td></tr>
<tr><td></td><td>basement insulation</td></tr>
<tr><td></td><td>roof insulation</td></tr>
<tr><td colspan="2">If the building is not insulated, there will not be much effect with replacement of the boilers and heating sources (losses are to high). If the budget allows, insulate the building.</td></tr>
<tr><td colspan="2"><u>Budget</u></td></tr>
<tr><td>HIGH</td><td>LOW</td></tr>
<tr><td>Replace the building insulation if possible.</td><td rowspan="2">☐ Insulate the pipes for hot water, replace the window seals, and use efficient shading (when sunny-use shading to lower the air conditioning need and use the sunlight when possible to reduce the use of lightning.

☐ Use thermostat valves on the radiators.

☐ Close windows when radiators are in use and close the radiator valves when you open the windows to ventilate the room.

☐ Ventilate the room multiple times per day in short periods (the radiator will not cool down and the required temperature will be achieved with less input energy).</td></tr>
<tr><td>Replace the heating source (biomass boilers, heat pumps, and solar collectors).</td></tr>
</table>

Optimization of electrical energy use	
Status of the building equipment	Type of lightning
	Type of office equipment
	TV, LCD, Plasma, LED TV, etc
Budget	
HIGH	LOW
Replace the building equipment with energy efficient equipment (A class or higher, A+.Etc.). Install PV power plants (net mettering-the energy produced by your PV and the consumed energy in the building are compared at the end of the month-only difference has to be payed or you receive payment in case you produce more than you consumed).	Efficient use of the existing equipment: ☐ Turn off when not in use (old devices have high stand-by consumption). ☐ Insulate water heaters (stays worm longer and lowers the frequency of use of the electric water heaters). ☐ Replace the lightbulbs with LEDs. ☐ Install motion sensors on hallways. ☐ Install electric energy meters for each floor (by doing so you will locate the highest consumption and will be able to target a specific floor and not the entire building).

Building engineering and energy supply - Heating

For high density area buildings district heating or shared central heating of multi-unit residential buildings are the best and lowest cost solution, if they are operated with a renewable energy source. Reasons for this:o no boiler, fuel store chimney are provided in each dwelling.

- a central heating equipment is more efficient and imposes less load to the
- environment than single systems in each dwelling.
- comfortable, there is nothing to do with it

For low density area buildings Bio-solar (biomass + solar) heating : combined used of solar energy and biomass is the best solution under our climate.

In case of geothermal heat source, the advantage of the district heating is even bigger!

Building engineering and energy supply – Cooling, ventilation

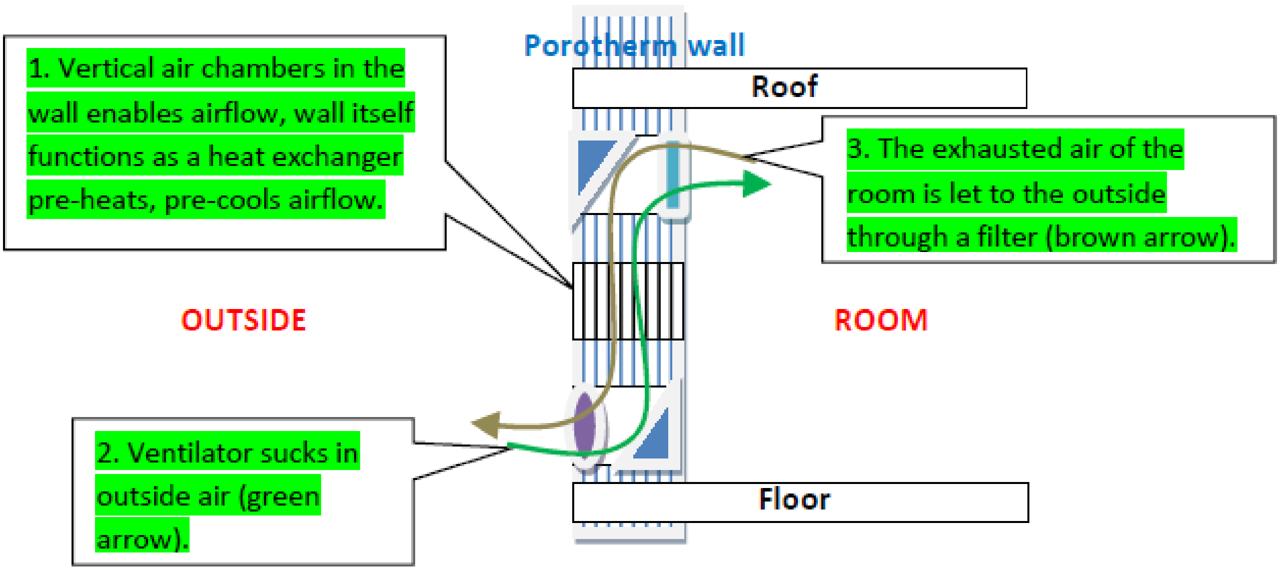
The climate change has lead to the increase of the average temperature and the peak temperature values in the summer. If only mechanical cooling is installed in the building, the cost of summer cooling can be of the rate exceeding by far the cost of heating in the winter, it can be even 2 to 3 times as much. But if a building requires cooling, that means poor design and planning. What should be done:

1. Solar protection by shading
2. Passive cooling – through ventilation at night (i.e. opening the windows)

   This is the most effective if the house is well insulated and the building structure can take up the heat, resulting that this cooling effect lasts the whole day.
3. Applying passive ventilation technologies

   These are modern forms of traditional solutions of ventilation based on gravity, filtration, new solutions have emerged in the form of the further improved versions of solar chimneys and wind chimneys originating from the Arab world. The most important aim of passive ventilation today is the temporary or final replacement of the mechanical ventilation to reduce energy needs.
4. Applying mechanical ventilation systems

- The advanced technology systems are actually heat exchangers and heat pumps. Fresh air is taken in through the pipeline buried underground. This system helps in the winter heating and can also work in cooling mode, making the summer air conditioning unnecessary.
- A witty and low-cost version of the heat recovery systems is the Fluctuvent, see the figure below how this works:



Develop – Building engineering and energy supply

The basic principle of electricity supply: as the generation of electricity is expensive, therefore, electricity power should be used only for its intended purpose and minimize its use as much as you can.

NOTE: The current electricity peak demand can be reduced by means of electricity consciousness (i.e turn off the light when not in the room).

The independent electricity generation is possible in the following ways:

- solar cells (photovoltaic elements, solar cells)
- generator powered by wind or hydro energy
- bio-fuel co-generation (production of heat and electricity at the same time is called co-generation (heat + electricity) or tri-generation (heat + electricity + cooling)).

If energy is generated, but not needed by the building, it has to be stored in some kind of form. The following possibilities are available:

- Smart grid solution – feeding back the energy to the central energy system, this is only a solution if the energy provider makes this option available.
- Local storage of energy can be done using batteries, but there are also some innovative solutions, such as converting electricity to gravity, by pumping up water to higher altitudes, and letting them flow down in low peak time through a hydro generator. This solution is rather costly in small scale.
- When the other energy challenge (i.e. mobility) is also taken into account, Vehicle to Grid (V2G) and Vehicle to House (V2H) systems make the cooperation of the vehicle and the building as well as the electric grid possible. The cars in general spend 90% of the 24 hrs of the day in the car park. On such occasions, the electric cars are connected to the grid. They may take charge from the grid but may also feedback the electricity.

Develop - Forming the outer and the inner part of the house - Shading

Installing glazed structures without proper shading is a brave act. The glazed windows are very useful in the winter, they assist the utilisation of solar energy as a heat trap, but in the summer they can cause an extra cooling demand.

When planning the shading, it is necessary by all means to be aware of the essential characteristics of the movement of the Sun and the theory of design of the shading systems. It is important to consider a simple principle regarding the shading systems:

- The light passing through the glazing is converted into heat and it warms up the interior. Thereby the shading devices mounted on the outside provide protection against heating up with a greater efficiency than the structures installed in the window space or on the inside.

Types of shadings

- Fixed shading systems (fixed louvres, awnings, porches etc.)
- Moving shading systems (rolling shades, Reluxa, Vanish and blinds etc.).
- Shading by plants - In case of smaller buildings, the planting of deciduous trees as shading is the best option possible. In the vegetation period, the leaves of the tree or the rambling plant provide shading, while in the winter the ‘bare’ plants let the sun shine through. Over and above other shadings, the vegetation evaporates, produces oxygen.

Develop – Forming the outer and the inner part of the house – Doors, windows

With respect to energetic, the glazed doors and windows have traditionally been the weakest structures of the building. However, these structures have seen substantial development during the recent years, and in case of good installation they can operate as 'heaters'.

- The first innovation was the introduction of the double-layer thermal insulation glazing,
- The second major step forward was the emergence of the heat-reflection coat (LOW-E)
- The third step forward was the three-layer type glazing with gas charge spread for the impact of the passive house concept.

Doors and windows - buy a new one or renovate?

Speaking about the doors and windows, it is important to clarify the renovation possibilities of the existing doors and windows. Typically choice can be made among four possibilities:

1. Renovation to the original condition of the doors and windows, restoration of the original status can only be justified in heritage buildings under high priority protection only, as far as historical doors and windows are not energy efficient, further to this their renovation is also expensive!
2. Improvement of technical quality with supplementary structures, the cheapest solution is the improvement of air tightness by application of rubber seal sections.
3. Improvement of technical properties by partial replacement is a lower cost alternative to full replacement.
4. Full replacement of the doors and windows, is the best option regarding energy aspects, but it is also expensive.

EXERCISE 8: INTEGRATION OF TECHNICAL MEASURES WITH EACH OTHER AND WITH OTHER TYPES OF EE SOLUTIONS

Let's combine the effects of the installation of RES and technical measure fo r reducing the electrical energy consumption. If we combine the exercises 10.1.2, 10.4.2, 10.5.1 and 10.6.2 would produce:

- simple energy audit,
- purchase of efficient lighting equipment,
- replacement of the lighting equipment,
- installation of RES.

For a building described in 10.5.2 and the roof in 10.4.2 the effects would be:

- reduction of electrical energy consumption by 85kWh per day and
- production of electrical energy **1875kW/year**.

If we presume that the savings in 252 working days (as in 2016) with the replacement of lighting equipment 252*85kWh=21420kWh (85% savings per working day) and the produced electrical energy of PV power plant is 1875kWh per year would mean that we would consume approximately 5% of electrical energy needed for lighting then we used before the applied measure.

EXERCISE 9: INVOLVEMENT OF BUILDING USERS IN THE TECHNICAL EE INTERVENTION

High school has 15 professors and 15 persons as a supporting staff (secretaries, administrators, etc.). Each of the has a computer in the office and there are 3 printers available for all of them.

Unfortunately, most people don't shut down their equipment after they finish their working day and they are not aware that their equipment is still consuming power. The typical standby power for different devices is shown in Annex 1. the standby power for computers is 10W, monitor 5W and printer 15W. Calculate the unnecessary daily consumption of these devices for the high school. Assume that the equipment is in use6 hours a day and 18 hours on standby.

Number of computers is 30 and the number of monitors is 30.

Consumption of computers: after working hours

Standby power for all computers is: P = 15x10W = 150W, for monitors: P = 15x15W = 225W and for printers P = 3x15W = 45W.

Total standby power: P = 150+225+45 = **420W**

Wasted energy per day: W = P*t = 420W*18 = 7560Wh or **7,56kWh per day**.

Cost of wasted energy per day (assumed price is 0,1EUR per kWh) is: C = 7,56*0,1 = 0,756 EUR

This amount may not seem much but it only represents the wasted amount of energy and money per working day so 22 days per month. Lets include the weekends and calculate the loss per month.

4 weekends per month: 4*2*24 = 192hours

Wasted energy on weekends: W = P*t = 4 20W*192 = 80640Wh or 80,64kWh

Wasted energy on all worhing days: W = 7,56kWh*22 days = 166,32kWh

All wasted energy: W = 80,64+166,32 = **246,96kWh**;

Monthly cost: C = 246,96*0,1 = **24,7EUR/month**

ANNEX 1

Stand-by power of **common electric/electronic equipments** and their **typical rating** (in Watts)

Appliances	Typical standby wattages	Typical rating in Watts
Microwave	7	800
Cooker	5	130
TV	5	70-120
Plasma screen TV	1-18	350-700
Video cassette recorder	5	35
Mobile phone charger	6	
Cordless phone	8	
Answering machine	8	
Stereo	10	400
Digital decoder	15	
Washing machine	2	350-500
Personal computer	10	120
Printer	15	
Computer monitor	5	150

Formula for estimating Energy Consumption

You can use this formula to estimate an appliance's energy use:

(Wattage × Hours Used per Day ÷ 1000 = Daily Kilowatt-hour (kWh) consumption

(1 kilowatt (kW) = 1,000 Watts)

Multiply this by the number of days you use the appliance during the year for the annual consumption. You can then calculate the annual cost to run an appliance by multiplying the kWh per year by your local utility's rate per kWh consumed.

Examples: Window fan:

(200 Watts × 4 hours/day × 120 days/year) ÷ 1000 = 96 kWh × 8.5 cents/kWh

= $8.16/year

Personal Computer and Monitor:

(120 + 150 Watts × 4 hours/day × 365 days/year) ÷ 1000 = 394 kWh × 8.5 cents/kWh = $33.51/year

ANNEX 2

Recommended luminance levels according to the premises and uses

Premises	**Luminance** (lumen/m^2 = lux)
General outdoor, rural roads	7-12
Gardens, industrial zones	15-25
Streets, highways	30-50
Entrances, parking	50
Panoramic outdoor, store, reception room, corridors, staircases, washrooms, general tasks	150
Dining rooms, public premises	200
Meeting rooms, laundry, offices, hotel rooms, tasks requiring precision	300
Work stations, large stores, laboratories	500
Reading, drawing, classroom, kitchen, tasks involving detail	750
Shop windows	1000-3000

BIBLIOGRAPHY

- Beggs, C., 2002. *Energy: Management, Supply and Conservation*. Butterworth-Heinemann, Elsevier Science.
- EI-education, 2008. *EI-Education guidebook on energy intelligent retrofitting*. Available at ei-education.aarch.dk, consulted on 12.12.08.
- European Commission, Directorate General XII, (1995). *Energy Management System*.
- EnerBuilding, 2008. *Energy efficiency in households Guide*. Enerbuilding.eu Project, May.
- EU, 2008. *The EU Energy Label*. Available at http://www.energy.eu/#energy-focus, consulted on 9/12/08.
- EU TopTen, 2006. Available at http://www.topten.info/, consulted on 12/12/08.
- GREENBUILDING, 2008. *GreenBuilding Guidelines and Technical Modules*. Available at http://www.eu-greenbuilding.org, consulted on 12/12/08.
- GreenLabelsPurchase, 2006. *GreenLabelsPurchase: making a greener procurement with energy labels*. Available at www.greenlabelspurchase.net, consulted on 12/12/08.
- ISO, 2008. *Building environment design – Guidelines to assess energy efficiency of new buildings – ISO 23045:2008*. International Organization for Standardization, Switzerland.
- Krarti, M., 2000. *Energy Audit of Building Systems – An Engineering Approach*. CRC Press.
- *Annual European Union greenhouse gas inventory 1990–2009 and inventory report 2011*, EEA, Copenhagen, 2011 (citirano 1. 6. 2011). Available at: http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2011.
- *BP Statistical Review of World Energy 2010*, British Petroleum (1. 6. 2011)
- *A Catalogue of "Optimization Scenarios" to enhance decision-making in establishing an efficient energy management programme*, Electronic Version, October 2014".