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CO-EMEP

CO-EMEP – Improvement of cooperation for
better energy management and reduction of energy poverty in HU-HR cross-border area

(HUHR/1901/3.1.1/0019)

Guidelines for enhancing energy efficiency in households who face the problem of energy poverty

Project partners

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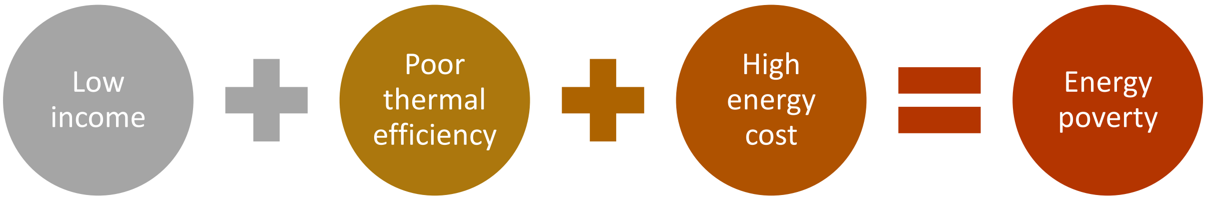
1.Introduction

Energy poverty is often defined as **a situation where individuals or households are not able to adequately heat or provide other required energy services in their homes at affordable cost**. For decades European Union (EU) has been facing an alarming number of Europeans being unable to afford rents or cover basic housing costs. About 34 million Europeans reported an inability to keep their homes adequately warm in 2018, and 6.9% of the EU population have said that they cannot afford to heat their home sufficiently.



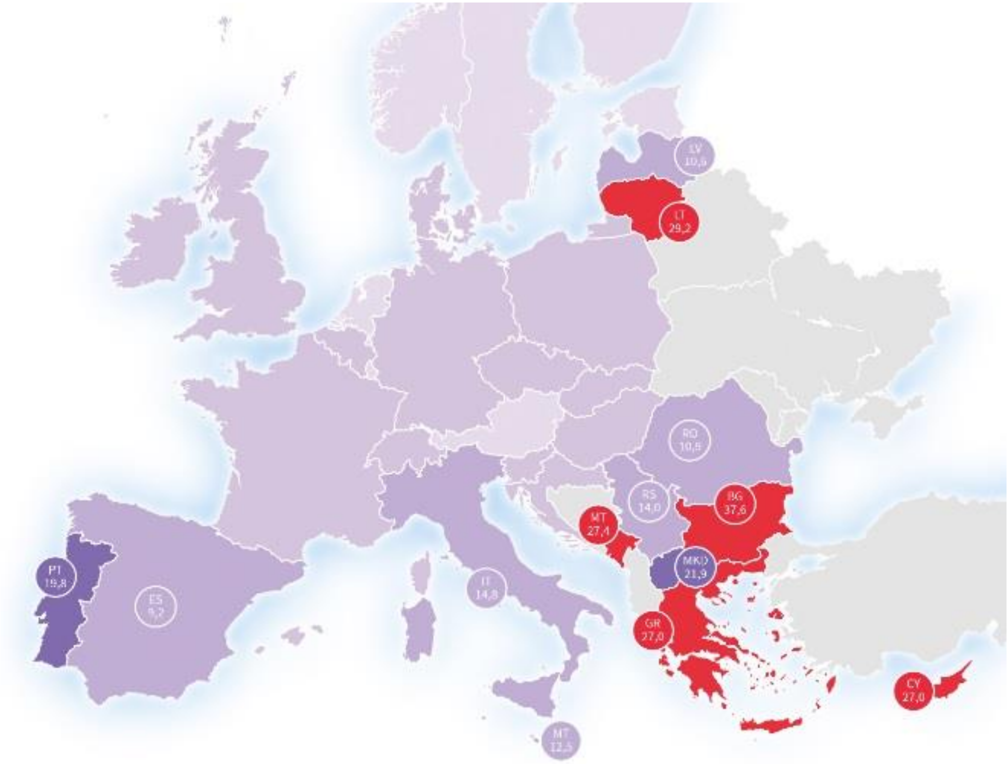
Energy poverty is caused by a combination of **low income**, **poor thermal efficiency** and **high energy cost**. Inadequate comfort and sanitary conditions in housing and work environments, such as inadequate indoor temperatures, deficient air quality and exposure to harmful chemicals and materials, contribute to lower productivity, health problems and higher mortality. This is due to rising energy prices, recessionary impacts on national and regional economies, and poor energy efficient homes.

Based on these indicators, a particularly pervasive problem is highlighted in Central Eastern European and Southern Europe Member States. It is important that Member States recognize and address this problem, as **ensuring basic energy services** is critical to ensure that communities do not suffer negative health impacts, do not become further entrenched in poverty, can maintain a good quality of life, as well as ensuring the financial outlay to assist households that require support does not become too burdensome. While allowing for full competition in energy markets, governments and regulators have a role to protect the most vulnerable communities, and prevent society groups falling into energy poverty. The functioning of energy markets can clearly have an impact on this situation through ensuring consumer protection and safeguards, offering competitive tariffs (and access to them) and assisting in the efficient energy use.

A **common European definition of energy poverty does not exist**, but many Member States acknowledge the scale of this **socio-economic situation** and its **negative impact translated into severe health issues and social isolation**. Different terms are used to describe affected persons: fuel poor, energy poor, vulnerable energy consumers or, to a larger sense, at-risk-of-poverty or low-income people. The multiple causal factors and multiple effects of energy poverty cross policy boundaries can be identified. Therefore, energy poverty is a complex concept that sits between **economic, social and energy policy**. The potential policy responses may reside in energy efficiency and carbon footprint reduction policy, energy market regulation, social policy and wealth redistribution, economic and employment policy, housing standards and public health. Energy poverty is not a new issue in the context of European legislation.

The gas and electricity directives have, since 2009, required that vulnerable customers be defined for the purpose of consumer protection, and this definition 'may refer to energy poverty'.

A key aim of the Clean Energy for All Europeans package was to promote fairness in the clean energy transition. Under the new governance regulation, Member States are required, in their National Energy and Climate Plans (NECPs), to assess the number of households in energy poverty and, if significant numbers are found, to introduce an objective, as well as indicative policies and measures to reduce it.



ENERGY POVERTY IN EUROPE % OF THE POPULATION WHO ARE NOT ABLE TO KEEP WARM. EUROSTAT 2015

	COUNTRY	%	CATEGORY	COLOR
NO	NORWAY	0,3	ACCEPTABLE	
LU	LUXEMBOURG	0,8	ACCEPTABLE	
SE	SWEDEN	0,8	ACCEPTABLE	
IS	ICELAND	0,8	ACCEPTABLE	
EE	ESTONIA	1,2	ACCEPTABLE	
FI	FINLAND	1,2	ACCEPTABLE	
NL	NETHERLANDS	1,7	ACCEPTABLE	
AT	AUSTRIA	1,7	ACCEPTABLE	
DK	DENMARK	2,3	DANGEROUS	
DE	GERMANY	3,5	DANGEROUS	
BE	BELGIUM	3,9	DANGEROUS	
SI	SLOVENIA	4,2	DANGEROUS	
CZ	CZECH REPUBLI	4,3	DANGEROUS	
SK	SLOVAKIA	4,6	DANGEROUS	
FR	FRANCE	4,7	DANGEROUS	
UK	UNITED KINGDOM	5,8	DANGEROUS	
PL	POLAND	6,3	DANGEROUS	
IE	IRELAND	6,6	DANGEROUS	
HU	HUNGARY	7,5	DANGEROUS	
HR	CROATIA	7,9	DANGEROUS	
ES	SPAIN	9,2	PRECARIOUS	
LV	LATVIA	10,6	PRECARIOUS	
RO	ROMANIA	10,9	PRECARIOUS	
MT	MALTA	12,5	PRECARIOUS	
RS	SERBIA	14,0	PRECARIOUS	
IT	ITALY	14,8	PRECARIOUS	
PT	PORTUGAL	19,8	EXTREME	
MKD	MACEDONIA	21,9	EXTREME	
GR	GREECE	27,0	VERY EXTREME	
CY	CYPRUS	27,0	VERY EXTREME	
MT	MONTENEGRO*	27,4	VERY EXTREME	
LT	LITHUANIA	29,2	VERY EXTREME	
BG	BULGARIA	37,6	VERY EXTREME	

* Figures of 2013

Figure 1. Energy poverty in Europe[1]

[1] https://www.eapn.eu/wp-content/uploads/2017/05/EAPN-2017-EAPN-EPSU-energypoverty-leaflet-1138.pdf

Furthermore, energy poverty is recognized in the two key EU energy efficiency directives: the **Energy Performance of Buildings Directive** (EPBD) requires that relevant actions to alleviate energy poverty be outlined in the national renovation strategies and the **Energy Efficiency Directive** (EED) requires a share of measures under Article 7 (energy efficiency obligations or alternative measures) to be implemented amongst vulnerable households, including those affected by energy poverty. Finally, the role of renewable energy communities to help fight energy poverty through reduced consumption and lower supply tariffs has been recognized in the revised **Renewable Energy Directive**.

In the last 20 years, energy efficiency has gained increased importance and the number of related policies has increased. While many governments still employ housing and energy subsidies to help, in part, to combat energy poverty issues in the short run, the long-term trend towards energy efficiency contributes to improving the quality of homes and to reducing the energy cost burden to low-income households and the need for subsidies.

The push for renewable energy will be a crucial driver to combat energy poverty when accompanied by household energy efficiency improvements. Renewable energy has become more common as a new household energy source. As renewable energy technology develops and capacity increases, the marginal cost of renewables will continue to fall, making them affordable alternatives to conventional energy sources.

2. Energy consumption and consequences of energy poverty in households

Important indicator for energy poverty in households is **energy consumption per household or capita**. Higher consumption may increase household vulnerability to price increases. However, the drivers of consumption are complex, such as climatic factors, incomes, standard of living and energy efficiency of buildings or appliances. **Type of used energy in household** is also important as it can be indicative of heating systems, applicability of measures for protecting vulnerable consumers and tackling energy poverty.

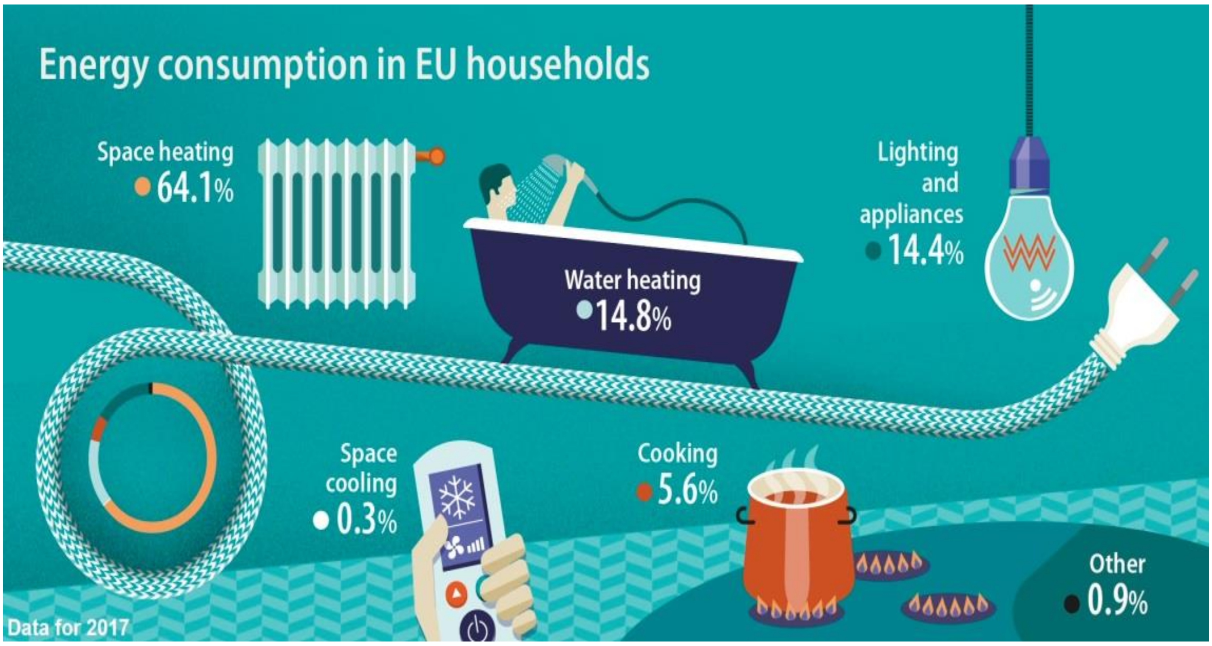


Figure 2. Energy consumption in EU households[2]

On a per capita basis, Scandinavian countries, Luxembourg, Austria and Estonia have the highest consumption levels (between 30 - 42 GJ/capita). Countries such as Malta used the least amount of energy per capita (7.8 GJ/capita), with other low consumers including Portugal, Spain, Bulgaria and Slovakia, where the drivers of this low demand vary from ability to afford to consume to warmer climatic conditions. In terms of the electricity and gas markets, gas provides a high share (>50%) of household consumption in Netherlands, the UK, Italy, Hungary and Slovakia. High electricity shares in the mix (>30%) can be found in Malta, Sweden, Spain, Cyprus, Bulgaria, Finland and Croatia. Regarding the other energy carriers, Latvia, Slovenia, Romania, Lithuania and Austria have the highest dependence on renewables, while Denmark is dependent on derived heat, and Luxembourg, Greece, Ireland and Belgium on petroleum products.

The immediate impact of energy poverty is often indebtedness, as people on low incomes are faced with bills they can't meet. Not using energy isn't really an option. Many households end up prioritizing energy costs, also out of fear of the threat of disconnection, and so neglect other important items, e.g., food, rent, social activities, transport or on children's needs or education.

[2] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190620-1

In the worst cases, energy bills debt can result in cut offs and evictions. Households lose their right to fuel, as energy companies cut off their supply for non-payment leading to untold hardship, increasing difficulties with their housing and risks of housing exclusion. In some Member States, tenants who have faced problems to pay their energy bills are blacklisted, so that when they want to move to a new flat, they cannot get a new rental contract.

On the other hand, an **increasing number of studies demonstrate the severity of the impact of energy poverty on the health** of different groups. Most often this is due to living in cold and bad housing. People on low incomes are often forced to cut back on heating because of cost, or to switch to less healthy energy forms. Poor construction compounds the problems. This result is not only deteriorating health and well-being, but significant indirect impacts. The rate of deaths in winter is strongly linked to the quality of the housing and capacity to heat it adequately. There is a strong relationship between cold temperatures, humidity and cardiovascular and respiratory diseases. Around 40% of Excessive Winter Deaths (EWD) is attributable to cardiovascular diseases and around 33% of EWDs to respiratory diseases. A range of adverse health and well-being outcomes are caused or worsened by cold weather and living in under-heated homes, resulting in extensive costs to society. Furthermore, mortality is most commonly experienced by those in energy poverty and/or with an additional vulnerability.

The **physical health impacts** of cold homes are often experienced long after exposure, with a time lag of two weeks and more. There are also indirect negative health impacts including the risk of carbon monoxide poisoning if boilers, cooking, and heating appliances are poorly maintained or poorly ventilated. Cold-related mortality/morbidity established that many disease outcomes show seasonal increases during winter and have clear exposure-response relationships with low outdoor temperatures. Those unable to heat their homes in periods of cold weather, therefore experience a health risk. The strongest direct associations with cold are for cardio-respiratory.

The relationship between a **cold home and mental health operates in two ways**. Having a mental illness, like other vulnerable groups, can make people more vulnerable to cold related harm for the reasons outlined earlier. However, energy poverty and being cold at home can also increase risk of having a diagnosable clinical mental health condition such as anxiety and depression, and can also lead to impaired mental wellbeing through increased stress and worry about debt and balancing household finances.

From the information and evidence presented so far, it is easy to understand how important social relations and networks are to ameliorating the negative health impacts of a cold home. Someone who is well integrated in society, but energy vulnerable, is more likely to be supported practically, financially and in terms of advice, information and signposting to help. Again, the case studies illustrate how someone can incrementally become lost to society because of the burden of living in a cold home, or because of shame and embarrassment of the consequences. For people who are ill, mentally and/or physically, the effort of surviving day-to-day means they lose the ability to socialize. The consequent loneliness further compromises health. It also means others will not notice if someone slips from struggling to crisis. Living in cold home and experiencing energy poverty is associated with a broad range of physical, psychological, and social health morbidity impacts, although the precise nature of these relationships is dependent on individual circumstances, and will vary in intensity depending on pre-existing conditions and levels of social support.

3. Proper thermal protection of the building envelope

To fully understand the energy consumption of a building, it is necessary to know and understand the basic concepts and quantities required for its determination and analysis. Namely, the **energy consumption** in a building depends on the characteristics of the building itself (shape and construction materials), characteristics of energy systems in it (heating systems, electrical appliances and lighting, etc.), but also on climatic conditions of the climate in which the building is located.

The **energy balance of a building includes all energy losses and gains of that building**. Heat balance of the building is an indicator on how much energy is needed to meet the thermal needs of the building. It is important to remember that there is a need for thermal energy is always closely related to the heat loss of the building. As long as the thermal energy gains are sufficient to cover heat losses, the desired thermal conditions will be maintained in the building benefits. For reducing heating costs, which make up to 3/4 of the energy costs in overhead costs.

3.1. Recommended energy efficiency measures

Installing or increase the thickness of the thermal insulation, especially to family houses without a facade and those that are without thermal insulation is very important. **Thermal insulation** not only reduces losses in the winter, but also allows house not to overheat in the summer.

Stone or glass wool and polystyrene (styrofoam) are most often used as insulation materials for thermal insulation. By installing thermal insulation on the outside of the wall, also can be solved the problems with steam condensation (from cooking, showering, drying clothes) that occurs due to the low temperature of the wall and the formation of fungi and mold.

Thermal insulation also protects the building from harmful external influences and their consequences (moisture, freezing, overheating) thus extending its lifespan.

3.1.1. Exterior walls and thermal bridges

In the last few decades, people have strived to better insulate the buildings in which they live, and they have achieved the same by building thicker walls or insulating them. The outer walls of the building are exposed to different conditions (different external and internal temperature, wind, precipitation), which is why it is necessary to achieve their good insulation.

Figure 3. Thermal insulation of exterior wall[3]

Through the outer walls buildings lose up to 25% of the energy needed to heat the space. Thermal insulation of the outer wall, should be performed by adding a thermal insulation layer on the outside of the wall, and exceptionally on the inside wall. The design of thermal insulation on the inside of the wall is unfavorable with construction standpoint, and is often more expensive due to the need for additional solving the problem of water vapor diffusion, stricter safety requirements against fire, loss of useful space, etc. Installation of thermal insulation on the inside of the wall is physically worse, because although we achieve improvement insulation values of the wall, we significantly change the heat flux in the wall and the base the load-bearing wall becomes colder. Therefore, special attention should be paid to performance steam dams to avoid condensation and mold. Also, part of the partitions that connect to the outside should be thermally insulated wall. Refurbishment of the existing external wall by performing insulation on the inside, it is performed when changes are to be avoided the exterior of the building because of its historical value.

In order for the repair of external walls to be effective, it is recommended to **install thermal insulation of the outer wall** performed by adding a thermal insulation layer on the outside. Depending on the type of thermal insulation, according to the latest regulations, it is recommended to install insulation 12-14 centimeters thick. The material for installing thermal insulation costs around EUR 40/m^2, and depending on the quality of the insulation, possible energy savings amount to 20 to 40%.

Insulation materials most commonly used to insulate the outer shell of a house are **rock wool and polymeric insulation materials** (styrofoam or expanded polystyrene). Styrofoam insulation 10 cm thick has a heat transfer coefficient of 0.385 W/m^{2}K, while rock wool insulation has 0.35 W/m^{2}K. Rock wool has far less resistance to water vapor diffusion than styrofoam, but is also more favorable in case of fire (preserves properties up to a temperature of 900°C and prevents the spread of fire, although styrofoam is a highly flammable material). There are many other types of insulation materials of different properties such as sheep wool, straw, expanded cork, wood wool, polyurethane (PUR) foam, expanded perlite, porofen, airgel, but their application is somewhat rarer.

[3] https://www.kamenavuna.com/izvodjenje-fasade-u-10-koraka/

Furthermore, in the absence of insulation of the balcony, it is necessary to cover the balcony with insulating material or to thermally separate the balcony from the rest of the building.

The thermal bridge is a smaller area in the envelope of the heated part of the building through which is the heat flux increased due to a change in material, thickness or geometry construction part. Due to the reduced resistance to thermal permeability in the ratio on a typical cross-section of the structure, the temperature of the inner surface of the barrier on the thermal bridge is lower than on the rest of the surface, which increases the risk of condensation of water vapor. Depending on the cause of the increased thermal permeability, there are two types of thermal bridges:

- **structural thermal bridges** – occur in combinations of different type of material;
- **geometric thermal bridges** – occur due to a change in shape structures, e.g., building corners.

In practice, combinations of these types of thermal bridges are very common. The consequences of thermal bridges are changes in heat losses and changes in internal surface temperature. Due to the lower resistance to thermal permeability than the typical cross section of the barrier, the temperature of the inner surface of the bulkhead on the thermal bridge is less than on the remaining surface, which increases the potential risk of condensation water vapor in these places. The best way to avoid thermal bridges is the installation of thermal insulation on the outside of the entire outer shell, without interrupts the good sealing of joints and joints. Thermographic imaging of the building typical thermal bridges can be seen very nicely.

3.1.2. Roof, floor and ceiling

Although the share of the roof is represented by only about 10-20% in the total thermal losses in the house, the roof plays a particularly important role in quality and standard housing. It protects the house from rain, snow, cold and heat. The most common form the roof on family and smaller residential buildings is a sloping roof. Very often the space under the sloping roof is intended for housing, although it is not adequate thermally insulated. In such situations, large heat losses occur in winter, but also an even bigger problem of overheating in summer. If the roof is not thermally insulated, through 30% of the heat can pass through it. Subsequent thermal insulation of the roof is simple and economically very profitable, because the period of investment return is from 1 to 5 years. Non-flammable should be used for thermal insulation of pitched roofs and vapor-permeable thermal insulation materials, such as rock wool. The detail of the joint insulation of the external wall and roof should be solved without thermal bridges. If the space under the sloping roof is not heated, thermal insulation should be placed on the ceiling of the last floor according to unheated attic. The recommended thickness of thermal insulation on a pitched roof is at least 16 to 20 cm. The insulation should be laid in two layers; one layer between the horns, and one layer under the horns to prevent thermal bridges. Thermal insulation with the lower sides is usually closed with plasterboards or wood.

Figure 4. Thermal insulation of roof[4]

Flat roofs are the most exposed to the weather than any exterior elements of the building. That is why it is important to insulate them well with both thermal and waterproofing, and properly address stormwater drainage. A flat roof can be resolved as passable, impassable or so-called green roof.

Another place where moisture and cold air usually accumulate is the basement. It is usually a cold and humid room where mold, fungi and bacteria are formed. Heat losses through the floor make 10 – 15% of the total heat losses of the building. Moisture and cool air not only remain in the basement and attic, but is spread throughout the structure of the house. Therefore, attic and basement insulation can be of great importance, and is applicable with the least initial investment.

If the attic and the basement are not planned to be used or heated on a daily basis, it is sufficient to insulate the ceiling slab (ceiling) in the basement towards the upper floors, and in the attic the roof or floor slab (floor) towards the lower floors. As the construction of the floor on the ground differs from the floor constructions according to the unheated space, in existing buildings the measure of installing thermal insulation of the floor on the ground is economically unprofitable due to the larger construction works required. Therefore, thermal insulation of the floor structure towards the unheated basement is recommended. The thickness of the insulation depends on the temperature of the cold room, and is 8 – 14 cm^2.

3.1.3. Windows and doors

The window is the most dynamic part of the building's exterior, which operates at the same time as a receiver that lets solar energy into the space and as protection from external influences and heat losses. Losses through windows are divided **into transmission losses and losses by ventilation**. If include the transmission heat losses through the windows and the losses by ventilation, total heat losses through windows represent more than 50 percent of the heat building losses.

[4] https://stacbond.com/en/thermal-insulation/

Losses through windows are usually ten or more times greater than those through the walls, so it is clear how important the energy efficiency of windows plays in the total energy needs of buildings.

Window and door frames on the building must have good sealing, break the thermal bridge in the profile, simple and easy opening and closing, and low heat transfer coefficient. Glass can be insulating, two-layer or three-layer, with different filling (gas) and coatings that improve thermal characteristics.

In accordance with the technical regulation, the heat transfer coefficient for windows and balcony doors can amount to a maximum of U=1.80 W/m^{2}K, while on old buildings the coefficient of window ranges around 3.00 – 3.50 W/m^{2}K and more (heat losses through such a window amount to an average of 240 – 280 kWh/m^2 per year), European legislation prescribes lower values and they are most often in the range from 1.40 to 1.80 W/m^{2}K. On modern low-energy and passive houses this coefficient ranges between 0.80 – 1.40 W/m^{2}K. Recommendation for efficient building is to use windows with a coefficient U < 1.40 W/m^{2}K.

If existing carpentry is worn out and has visible damage, it is recommended to **replace the carpentry**. When replacing the exterior carpentry, it is necessary to ensure the correct installation of the window, which will ensure **strong external conduits and a hermetically sealed connection between the window and the wall**. In order for the measure to result in high savings, it is recommended to install windows with double or triple insulated glass with a low-e coating on the inside of the inner glass which prevents heat loss by reflecting it back into the space.

The quality of exterior carpentry also depends on the material from which it is made, and most often **wood, PVC, aluminum** or a **combination of wood and aluminum** is used as a material in its production. Wooden carpentry is the most environmentally friendly. Its disadvantage is complex maintenance, high cost and high sensitivity to external influences. PVC joinery has found wide application due to a more favorable price compared to wood and aluminum, practical maintenance and low sensitivity to external influences.

Aluminum is very resistant to external influences and does not require much maintenance, but it is a poor insulator. Glass and window profiles participate in the total heat loss of windows. Window profiles, regardless of the type of material from which they are made, must provide: good sealing, broken thermal bridge in profile, easy opening and low heat transfer coefficient. Today, glass is made as insulation glass, two-layer or three-layer, with different gaseous fillings or coatings which improve thermal characteristics.

3.2. Tips for quick savings

- Visual inspection of the outer shell once a year facilitates the detection of cracks, impact damage and local changes in the color of the outer layer of the shell.
- Repairing cracks or impact damage to walls with appropriate materials (e.g. PUR foam) prevents water from entering the crack.
- Regular and proper ventilation of basements and attics reduces the risk of fungus, mold and odors that can spread throughout the building.
- Laying any thickness or type of insulation layer on the ceiling of the house, if the attic is not used for living, even without proper construction is better than leaving the ceiling (under the attic) completely uninsulated
- By insulating windows and doors by installing insulating sealing tape airflow through the cracks around windows and doors is prevented.
- Closing windows and doors tightly prevents uncontrolled air penetration into the room in both winter and summer months.
- Special insulation of roller shutter boxes prevents uncontrolled penetration of cold air.

4. The use of proper heating and DHW preparation systems

Heating systems are an indispensable part of installation in households. Which system to choose depends on the available energy sources. Renewable energy sources are used to achieve and maintain thermal comfort throughout the house and the recommendation is to install a **central heating system**. As the price of energy, especially heating oil, rises, consider using renewable energy sources such as solar collectors and biomass or heat pumps to reduce heating costs while also helping to preserve the environment. Heating costs in the coldest winter months represent ¾ of energy costs. That is the reason, not only when choosing energy-efficient devices, but also to maintain those devices well. The boiler should have the highest possible degree of efficiency. The most energy efficient is condensing boiler.

On the preparation of **domestic hot water** (DHW) in the average household accounts for approximately 20% of total annual heat consumption energy, while the rest is spent on space heating (~ 73%) and cooking (~ 7%). The average citizen consumes about 200-300 liters of drinking water per day, which in average accounts for 40-70 liters of waste hot water temperature of 45°C which is mainly used for maintaining personal hygiene and washing dishes. In season when there is no heating preparation, DHW represents individually the largest expenditure for the energy of one household, regardless of which energy source is used. Effective preparation and use of DHW can therefore have a significant impact on reducing overall household energy costs.

4.1. Recommended energy efficiency measures

In case the costs of heating and cooling energy are high, the first thing that is recommended is to consult experts regarding the **replacement of the existing heating and cooling system in the household with an energy efficient system and combine it with renewable energy sources** (wood and biomass, heat pumps, solar collectors etc.).

Replacing an old electric water heater with a new one, of identical volume and power (2 kW) which has a built-in "timer" which turns on the water heater in the period of low electricity tariffs, you can save up to 100 EUR per year. It is assumed that this is a family of four, and the daily consumption of domestic hot water is 60 liters per person. Replacement of electric boiler for hot water consumption with solar system using electricity for heating for a family house with four members that heated water with an old electric boiler, it is recommended to install a solar system with two collectors (effective area 3.6 m^2) and a tank of 200 liters. With an investment in the entire system of around 4.000 EUR, it can be saved around 425 EUR per year.

4.1.1. Heating system

The task of heating is to provide appropriate conditions in the room in order to achieved a thermal balance between the human body and its environment thus achieved a sense of comfort.

Factors that affect comfort are in addition to clothing and physical activity, air temperature, wall temperature, humidity, speed air flow and its quality.

Room heating can only be affected on two of the above factors and these are air temperature and wall temperature.

Basic requirements for heating systems mean room air temperature (sensory temperature) and the temperature of the walls must be uniform throughout the space, in in the range of 20 °C to 22 °C (± 1 °C), whereby a permanent equilibrium is established between the body heat generated by metabolic processes and that devoted to the environment. The **heating system is required to be able to regulate the temperature in certain limits and with a certain reaction rate**. The heating system must be such that does not affect the air quality and comfort conditions in the premises (harmful gases, dust, noise, draft).

The boiler should have the highest possible degree of efficiency. The most energy efficient is condensing boiler. By installing a condensing boiler, savings of 10-15% are achieved compared to other new boilers, and up to 25% compared to boilers older than 30 years. If boiler is older than 15 years, it should be considered to replace it with a new boiler whose efficiency can be up to 15% higher. Replacing an old fuel oil boiler with natural gas condensing boiler results in 73% savings in energy costs, and the investment can pay for itself in less than three years.

Biomass is a renewable energy source that includes firewood, wood waste from forests, sawdust, bark and other residues from the wood industry as well as straw, corn, sunflower stalks, animal feces and residues from livestock, municipal and industrial waste. For application in heating systems, as a rule, firewood or various products obtained by processing wood, wood residues and waste are used. Replacing an old wood stove with a more efficient new stove or wood boiler can save up to 50% on firewood. Replacing an old fuel oil boiler with a biomass boiler results savings in energy costs, although the efficiency of a biomass boiler is not significantly higher than that of a fuel oil boiler. The price of biomass is 2.2 times cheaper than the price of heating oil. If there is no option in installing a heating system with biomass or solar collectors or gas central heating and electricity is the only available energy source, it is recommended to install a heat pump. A heat pump consumes approximately 2.5-4 times less electricity than electric radiators or stoves. Oversized equipment can reduce the thermal atmosphere and increase noise in the room.

4.1.2. DHW preparation system

The choice of hot water preparation method mainly depends on the number of people in the household, consumption and energy selection. Depending on the needs of the household, the following types of devices are used:

- **Instantaneous gas or electric water heater** (<2 persons),
- **Accumulation gas or electric boiler** (<4-5 persons),
- **Combined gas boiler for DHW and space heating-flow or accumulative** (<4-5 persons),
- **Boiler with indirectly heated tank for central heating water preparation** (> 4-5 persons),
- **Solar collectors with tank** (> 3 persons),
- **Heat pump** (> 3 people).

Electric water heaters are usually used in bathrooms to prepare water with quantities up to 12 lit/min (at 45 °C). With newer devices there is a stepwise possibility of power regulation and water temperature. The advantage of such devices is low cost, high efficiency in operation, small heat losses in short pipelines, short heating time. The disadvantages are the relatively large connected power (12-27 kW), and depending on the tariff (1.7-3.2) × higher water treatment costs compared to gas boilers.

Gas water heaters use natural or liquefied petroleum gas for heating domestic hot water passing through a tubular heat exchanger in which water takes part of the heat from the hot products of gas combustion (flue gases) on the burner, which are then discharged into the atmosphere. Burner turns on when the water outlet (tap) is opened and shuts off when closed. The largest flow capacity of the boiler is up to 11 l/min of water at a temperature of 45 °C with the corresponding power of 26 kW. Due to the relatively small available flow, the number of discharge points is limited to 2 to 3, which should be located nearby the boiler itself to avoid excessive cooling of the water in the supply pipelines. Gas instantaneous water heaters are characterized by high efficiency (~ 90%), low operating costs, the possibility of regulating the burner power, i.e., water flow and temperature. The disadvantage is the need for installation chimney (or drain to the facade), more frequent burning of the burner compared to storage boilers, greater temperature variation in the immediate period after igniting the burner. Major problems in operation arise due to deposition of limescale in the pipes and thus caused poorer heat dissipation, when it can the exchanger tube also burns due to limescale deposition.

4.2. Tips for quick savings

- By calling a service technician before the start of the heating season, it is possible to check the correctness of the heating and burner installations because a dirty burner causes insufficient energy combustion.
- Insulating hot water pipes leading from the boiler to the hot water tank, water tank and pipes passing through unheated spaces prevents heat loss.
- Shielding radiators with curtains, furniture and clothing reduces their thermal effect.
- Regular cleaning of the radiator from dirt will ensure a quality heat transfer.
- Regular venting of the radiator and the entire installation prevents a reduction in the capacity of the heating system at the beginning of the heating season caused by air that may enter the installation.
- By using radiator valves that can manually regulate the room temperature or thermostatic valves that help to regulate the temperature automatically, it is possible to lower excessive air temperatures in the rooms without the need to open windows.
- By adjusting the room temperature according to the residence time, heat loss can be prevented and at the same time thermal comfort is protected (recommended temperatures that ensure thermal comfort: 14-17 °C, bedroom and kitchen 18 °C, workshops 17-21 °C, living room 20 °C, bathroom 23 °C).
- If the windows are open for a long time, the heating and cooling system must be switched off.
- In households where electricity is used to heat water on a two-tariff meter, it is recommended to heat water at night when the price of electricity is lower.
- Regular cleaning of fans, external openings and nap filters reduces the use of electricity, as dirty filters or clogged external openings make it more difficult for air to pass through and thus increase energy consumption.

5. The use of proper ventilation and cooling systems

The main task of ventilation in buildings is **ensuring continuous replacement of polluted air from premises, with fresh air from the free atmosphere** to maintain the hygienic conditions necessary for a healthy and comfortable stay. The role of ventilation is also heating the air if necessary, removing excess moisture and harmful gases from space, and cooling the air in the summer.

5.1. Recommended energy efficiency measures

Ventilation is essential to ensure a comfortable stay in the room. Room ventilation can be **natural and mechanical**. Term natural ventilation means the exchange of air in a room which is a consequence of different air temperatures inside and outside the room, and currents due to wind. Natural ventilation is achieved through windows, controlled openings on the facades of the buildings or ventilation ducts, and to a lesser extent through walls. Mechanical ventilation is the forced exchange of air in a room assisted by the action of the fan or additional mechanical energy.

Refrigeration units used in residential areas are the most common compression cooling systems for air cooling which cool the condenser air. The left-hand cooling process mediates the heat transfer between the heat source, air that cools on the evaporator and thermal abyss. Environment air increased by energy compression receive heat taken away from the space which is being cooled.

5.2. Tips for quick savings

- In case it is not possible to use natural ventilation, occasional use of a room fan that will increase the air flow and promote heat exchange between the body and the air in the room will create a feeling of cooling.
- Using blinds on windows will prevent the ingress of solar radiation (in summer, outdoor blinds can reduce the room temperature by up to 8 °C).
- Cooling the room to low temperatures in the summer is not desirable, so it is suggested to set the temperature on the controller to 25-26 °C
- Effective ventilation is ensured by eliminating unnecessary heat sources in the room (lighting and household appliances) and closing windows during air conditioning operation.
- Regular maintenance of the air conditioner by authorized persons and cleaning of the outdoor and indoor unit before the cooling season or heating it is possible to prevent failures and additional energy consumption (it is recommended to clean the filter once a month).

6. Use of renewable energy sources and energy efficient domestic appliances

Given today's problems related to increased warming of the atmosphere, environmental pollution, accelerated growth of fossil fuel prices and predictions about their disappearing in the near future, the world is increasingly turning to upliftment energy efficiency of energy production and consumption and in particular the use of renewable energy sources. The **largest renewable energy source is the sun** and other forms of renewable energies are **wind energy, hydropower, biomass, wave energy**. Solar radiation is by far the largest source of energy on Earth, which is why the irradiated energy is 15,000 times higher than the total world energy need. Today, the energy of the sun is directly used with the help of the solar collectors for DHW heating and space heating, with the help of photovoltaic cells for the production of electricity or passively in buildings using architectural measures for the purpose of heating and lighting the space.

6.1. Recommended energy efficiency measures

Energy sources used in households could be divided into the following two main groups: **fossil fuels and renewable energy sources**, which include both conventional biomass and modern sources such as solar, wind and geothermal energy. Solar photovoltaic (PV) and solar thermal, micro wind, heat pumps and small-scale biomass heating technologies can be distinguished as the main renewable energy technologies in households.

From a household perspective, **the use of renewable energy technologies offers a considerable number of benefits**. It improves living conditions by using energy more productively, contributes to sustainable spatial planning and architecture, helps to protect the quality of the environment, and distributes energy in a balanced way and thus gives financial autonomy.

Figure 5. Renewable energy sources[5]

[5] http://www.velkaton.ba/bez-plastike-ne-bi-bilo-ni-obnovljive-energije/Renewable energy sources

Solar radiation is the largest source of renewable energy on Earth while other forms of renewable energy include wind energy, hydropower, biomass, wave energy, energy of sea currents, ocean heat energy, geothermal energy, etc. Geothermal energy is the source of the thermal capacity of the earth's core and chemical and nuclear reactions in the layers deep below the earth 's surface and tidal energy that has its source in orbital motion and gravitational forces between the Earth, the Moon and the Sun.

The basic difference between renewable and energy obtained from fossil fuels is manifested through the principle of renewable energy. Renewable energy is only “diverted” from its natural renewable flow and returned to it again, with the total increase in energy in the environment equal to zero. Energy from fossil fuels was obtained from a static source, where it was stored for millions of years, and in a short time was released into the environment by human beings. The total increase in energy in the environment is equal to the energy released from the fuel.

Solar energy is used directly by **solar collectors to heat water and space**, **concentrating collectors for electricity production** and **photovoltaic cells for direct electricity production**. Passive utilization of solar radiation energy includes various architectural measures with the aim of maximizing the absorption and accumulation of irradiated energy in buildings for space heating. Typical values of the efficiency of conversion of solar into useful energy are about 50% for hot water collectors (plate and vacuum), 20% for concentrating collectors, 10% for photovoltaic cells, while in solar sorption cooling systems ratio of cooling efficiency and driving energy of solar radiation SPCF <0.15. Nominal power systems for direct utilization of solar energy range from 1 kW for systems with hot water collectors or from 50 W for photovoltaic systems, up to several MW in solar power plants with parabolic collectors or photovoltaic cells.

Biomass is an organic material created during the process of photosynthesis, i.e., the fusion of CO_2 and water under the action of photons from solar radiation, which produces the carbohydrates oxygen and water, and as such actually represents the accumulated energy of the solar radiation in the total amount of about 90 TW (together with the produced O_2). In a reversible reaction of coupling with oxygen during combustion and natural metabolic processes (e.g., decomposition, fermentation), heat energy is released in the amount of 16 MJ/kg (dry matter) and CO_2 and water.

Today, **wind turbines** with a horizontal axis of nominal power are most commonly used to convert wind energy into electricity with an average of up to 1 MW and a rotor diameter of up to 60 m, with one, two or three blades. Such wind turbines are usually included in the operation at wind speeds of 5 m/s and achieve their maximum power at speeds of 12-14 m/s, which is then maintained by regulation constant up to speeds of 30 m/s when the rotor is stopped to prevent damage. For these reasons it is not possible use all the energy potential of wind.

Today, **geothermal energy** is most often used in the world for electricity production and for heating needs in buildings or production processes. Electric production energy is economical only if geothermal energy is available at temperatures >150 °C and which in practice are not more than 300°C. Wells are used to bring heated water from natural reservoirs present at depths of up to 30 km steam (usually 180-185 ° C, 8-9 bar) to drive a turbine connected to electric generator with plant efficiency <30%.

6.1.1. Energy efficient domestic appliances and lightning

Household appliances occupy a central place in electricity consumption in every household. By encouraging **responsible behavior** on occasion use of household appliances, significant savings can be achieved. Very often the user is focused on the activity he performs with particular household appliances (for example cooking dinner or washing pants before an important meeting) and don't take into account the electricity consumed to perform that activity. Just due to this insensitivity of the user to the energy usage, ordinary household activities result in significantly higher energy consumption than it should. By increasing the energy efficiency of the device for the same or higher level of service less energy is consumed and in that way energy and money are saved. Of course, energy savings are directly related to **reducing the emissions of harmful gases** because it also reduces the combustion of fossil fuels for producing electricity.

Energy labels inform the customer about energy consumption, price and impact on the environment of the device he intends to purchase. The standardization of energy labels and independent testing of the device is introduced as an additional protection mechanism.

A **refrigerator/freezer** is a household appliance that retains inside lower temperature than ambient temperature. It achieves this by taking heat from its own interior draws into the environment. When buying a new device certainly do not overdo the size because if the device is oversized, it certainly consumes more energy and therefore money. When placing the refrigerator/freezer in the space, it shouldn't be place near to a heat source or directly exposed to the sun because it will only increase the operating time of the compressor needed to achieve the set temperature.

A **stove** is a basic household appliance that is intended for food preparation. It basically consists of a hotplate and an oven. Today it is a growing trend to buy heating plates and ovens separately, which are then installed separately in the kitchen furniture. Particularly popular is the glass-ceramic heating plate that has about 20 to 25% lower electricity consumption compared to conventional heater plates. Of course, it must be emphasized that the utilization of input energy (up to 92%) is best with gas cookers. If production losses are added to this, transmission and distribution of electricity, then gas stoves are multiple more cost effective than electric.

Today, the **microwave oven** is an increasingly common device in households. It is used for defrost, reheat or even cook smaller amounts of food. In combined microwave ovens (have a built-in infrared heater) food can also be cooked. The main advantage of using microwave ovens lies in the speed of food preparation and in connection with that less energy consumption. Especially in young households, the microwave is a favorite appliance because of the possibility of fast reheating of baby food. When installing a microwave oven, it is required to make sure that there is enough space around it for air circulation.

The same rule applies to **washing machines and dryers** as to all other electric devices, i.e., proper choice (energy efficiency) and rational use are the basic prerequisites for achieving savings while using the device. Most of the energy, even up to 90%, consumed by one washing machine goes to heating the water needed for washing. The average washing machine consumes about 100 liters water, while larger washing machines consume up to 160 liters of water per wash cycle.

Dishwashers are a very useful household appliance that is becoming almost unavoidable especially in younger households. With the correct and rational behavior of the dishes washed in the dishwasher is hygienically cleaner than in hand washing and also in the washing process itself consumes less energy and water. As with a washing machine, it is very important that the dishwasher is adequately full and that the dishes are properly stacked. This way the washing machine will be most productive in doing your job.

Furthermore, the implementation of a **complete replacement of lighting fixtures** is recommended. Since ordinary incandescent bulbs predominate in older households, it is recommended to switch to energy-saving light bulbs or to a more modern lighting system based on LED technology. By replacing ordinary incandescent bulbs, fluorescent (energy saving) bulbs and bulbs based on LED technology for the same level of illumination, five to ten times higher electricity savings can be achieved.

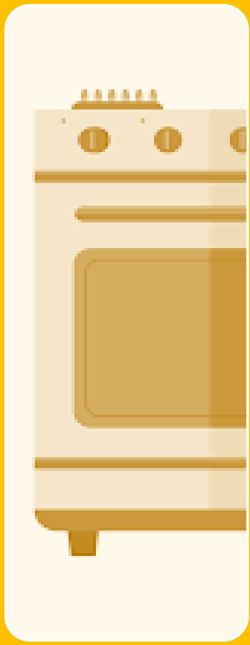
6.2. Tips for quick savings

REFRIGERATORS AND FREEZERS

- It is desirable to maintain a suitable temperature in the refrigerator and freezer (in the freezer the temperature should be between -15 and -32 °C, and in the refrigerator between 3 and 5 °C because reaching a temperature lower than necessary consumes up to 25% more energy).
- It is necessary to place the refrigerator and freezer in cooler places in the house (it is not recommended to keep them near heat-generating devices, but also in places where the temperature is lower than 0 °C) and not to expose them to sunlight.
- Leave about 10 cm between the back part and wall for ventilation because these devices work on the principle of heat exchange, so in the rear of the exchanger it is necessary to ensure sufficient air circulation to allow proper operation of the device and reduced electricity consumption.
- Periodic cleaning of the back of the refrigerator where heat is exchanged is recommended because dirty pipes make it difficult to transfer heat and increase electricity consumption.
- It is advisable to keep the refrigerator and freezer doors open as short as possible (before opening, consider what is necessary) and check that they are tightly closed after use, as this increases the temperature in the appliances and the energy consumption required for cooling.
- It is necessary to check the strength of the door seals and whether they adhere well (to check, put a piece of paper - if the paper does not fall, the door seals are in good condition).
- Timely defrosting of the refrigerator and freezer saves energy and prolongs the service life of the device. Since the ice layer prevents efficient cooling, defrosting is necessary when the ice thickness reaches 3 to 5 mm.

OVENS AND STOVES

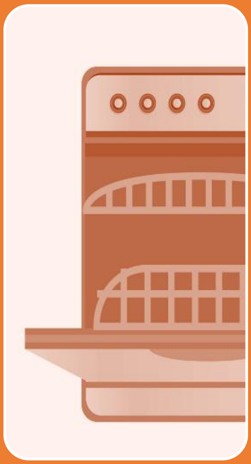
- Using the size of the most suitable stove heating circuit for the selected pan will prevent energy loss because every unnecessary inch of empty surface of the hob is leaking 10% of the energy needed to heat the pan.
- By adjusting the size of the pan to the amount of food being cooked, savings will be achieved because preparing a smaller amount of food in a large pan increases energy loss.
- Turning off the heater on the electric stove a few minutes before the food is ready will save energy, while the heater will maintain a high temperature sufficient for the food to be cooked.
- By placing the lids on the cooking pots, the heat will stay in the pot longer, which can save up to 20% of cooking energy.
- By opening the oven door unnecessarily, 20% of the heat will be lost, and by switching off the oven 10 minutes before the end of baking, the food will continue to bake because the oven retains heat longer.
- Regular cleaning of the oven will reduce electricity consumption.



WASHING MACHINES AND DRYERS

- Lowering the washing temperature will reduce energy consumption by as much as 90% and achieve the same washing effect as at higher temperatures (modern laundry detergents are already so advanced that they no longer require high temperatures for clean washed clothes - instead of 60˚C it can be washed at 40˚C or instead of 40˚C at 30˚C).
- The washing machine is most efficient to use when the drum is filled according to the technical characteristics of the washing machine (it is unprofitable to turn on a half-loaded washing machine to run the whole process twice for the same amount of laundry, while a crowded washing machine consumes more electricity with worse washing results).
- Air drying of laundry is more efficient than drying in a washing machine.
- Regular cleaning of the filter ensures the efficiency of the tumble dryer.

DISHWASHERS



- Regularly checking the filter and the salt level in the washing machine, which softens the water and prevents the formation of scale on the heating surfaces.
- Cleaning the inside of the washing machine increases the washing efficiency and reduces energy consumption. Also, it is recommended to avoid washing at higher temperatures because today's dishwashing detergents are effective even at lower temperatures (50 - 55 °C).
- It is advisable to connect the washing machine to the hot water supply because most of the energy is used to heat the water.

LIGHTING

- It is recommended to make maximum use of daylight wherever possible, and for even lighting of the room, regularly clean the windows without placing dark curtains or too many plants in front of the window.
- Switching off lighting in rooms where no one stays most of the time and reducing the use of decorative lighting, which does not contribute significantly to increasing the brightness of the room, brings a reduction in unnecessary electricity costs.
- Directing outdoor lighting to desired areas reduces unwanted light scattering and light pollution.

OTHER HOUSEHOLD APPLIANCES

- By avoiding the operation of electrical devices in "stand by" mode, it is possible to save up to 6% of electricity in the household.
- By using a microwave oven instead of an ordinary oven, savings of up to 50% are possible due to the shorter cooking time.
- Using electric water heaters will ensure savings in electricity consumption because heating water is faster and more efficient than heating water in a pot on an electric stove.
- Disconnecting mobile phone chargers, laptops and digital cameras from the sockets after charging saves energy because the primary circuit of the small transformers inside the adapter still consumes energy even though no consumer is connected to the secondary.

7. Recommendations and conclusions

Energy is one of the most important resources in modern society. Its availability is prerequisite for many activities in business and at home. Today's energy consumption is significantly different from the habits common a few decades ago. **Consumption is influenced by** several important factors, such as **rising incomes**, **globalization of the economy**, **technological developments** (e.g., internet and mobile phones), **decrease of the household size**, and **population aging**, among others.

Households have several ways to save energy by **changing their consumption habits**. Since people do not easily change their habits, the increasing energy costs have definitely the biggest impact on people's energy consumption. In order to save energy, people should first find out how much energy they consume and how much it costs. More than 60% of households monitor their energy consumption constantly. 25% of them monitor their energy consumption from time to time and the remaining households do not monitor it at all. If we look at energy-saving behaviour based on a household's income, it appears that the higher the income, the more likely it is that the household does not monitor energy expenditure very often. The lower the household's income, the more likely household monitors energy costs. As a rule, energy savings are based on measuring the volume of consumption. Consequently, households tend to monitor the consumption of those types of energy that they can measure themselves. Electricity consumption is definitely the easiest to monitor – more than 85% of households monitored their electricity use. Natural gas consumption was monitored by only a little over 12% of households, even though all households using natural gas are connected to the gas grid and can easily measure their gas use. About a quarter of households monitor their monthly heat consumption. The main energy-saving measures of households are related to heat and electricity consumption. The most common method is the thermal insulation of buildings, since more than 60% of households have improved the thermal performance of their homes. The most common improvements include the replacement of windows and the additional insulation of the building envelope (roof and outer walls), whereas getting new windows is the most popular method for improving the thermal insulation of houses. Nearly 40% of households have not taken any measures to improve the thermal insulation of their households. Half of these households cited lack of money as the reason. More than half of the households who had not undertaken thermal insulation did also not plan to do it in the near future. Still, almost 20% of households plan to improve the thermal insulation, and about the same share of households had postponed these improvements for at least three years. In order to achieve savings, it is advisable to make an **energy certificate**.

Energy certificate is a document that presents the energy performance of a building and is prepared by authorized persons for energy certification – energy certifiers. **The document contains general data of the building, energy class of the building, validity of the certificate, data on the person who issued and produced the energy certificate, data on persons who participated in the energy certificate, energy certificate label, data on thermo-technical systems, energy needs of the building, data on the use of renewable energy sources and proposed measures**. The energy class is expressed for reference climate data and the indicator is specific annual required heat energy for heating which in residential buildings includes energy for heating, domestic hot water preparation and ventilation/air conditioning.

Residential and non-residential buildings are classified into eight energy classes according to the energy scale from A+ to G, with A+ denoting the most energy-efficient and G the most energy unfavorable class.

Building energy audit is performed by authorized persons, each in a part of their profession, based on **the methodology of conducting energy audit of buildings** (a set of actions and procedures for conducting energy inspection of buildings, which also contains an algorithm for calculating energy performance of the buildings).

With the aim of **increasing energy efficiency in the building sector**, which consumes **40% of total energy**, **energy refurbishment of all levels must be more encouraging**. Governments must provide co-financing mechanisms for implementation of energy efficient measures to increase energy efficiency in households, building and construction of energy efficient residential buildings or multi-apartment buildings, etc.

The energy costs of households increase from year to year. Energy consumption habits are formed by many factors, with the general attitude, income and cost of energy being the most important. **Energy prices have risen in the recent years and will rise in the future**. Consumption of heat, electricity and motor fuels constitutes a large part of the household budget. The dwelling stock is relatively old and requires a lot of energy for heating. Motor fuels hold the biggest part in the household energy budget – especially in rural areas where there is often no other option but to use their own car due to the poor public transport options and long distances. Households usually monitor their energy costs, but this has probably more to do with the household income than any concern for the environment. **As the income level increases, households pay much less attention to optimizing the energy expenditure.** In order to change or influence consumption habits, a person needs to have a specific reason for changing the habits. On the individual level, the main reason is cost minimization; on the wider scale, the motivation is environmental sustainability. In the foreseeable future, energy will not get cheaper. Thus, the only solution is to use the energy resources more efficiently.

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Project CO-EMEP – Improvement of cooperation for better energy management and reduction of energy poverty in HU-HR cross-border area (HUHR/1901/3.1.1/0019)

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