Household visits

Training module

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Learning objectives

- Learn the basic concepts and principles of energy (work, power, voltage and the related units).
- Learn basics about buildings and energy and water use in them.
- Be able to perform simple energy consumption calculations.

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1 Introduction to energy

Forms of energy

- **Fossil fuel energy**: These are energy with limited stocks. They disappear as they are used.
- **Coal** is formed from dead organic plant matter converted into peat. The industrial revolution of the 19th century was made thinks to the coal. This energy is the most commonly used worldwide, for electricity in particular. It’s a highly polluting energy, because it’s mostly composed of carbon, indeed of CO2.
- **Oil** is a liquid carbonaceous rock, composed of organic materials trapped in the rock. Oil provides the majority of liquid energies such as fuel, diesel, petrol or LPG. It is the second most used energy in the world.
- **Natural gas** is an organic gaseous found naturally in porous rocks. Most natural gas is created by two mechanisms: biogenic and thermogenic. Biogenic gas is created by methanogenic organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, thermogenic gas is created from buried organic material. The gas comes in third place among the most worldwide energy used.
- **Uranium** is a radioactive metal present in the depths of the earth and all earth's crust. However, a large majority of these stocks are not usable. This energy is each day more

used for electricity generation although the Fukushima disaster has slowed down this development. It rejects very small amount of CO2, but nuclear waste, formed by depleted uranium that results when the energy drawn are problematic. There is no real way to eliminate radioactivity, and they are buried with no insurance of sustainable security.

- **Renewable energy:** These are energy resources which the stock does not reduce in human scale of time.
  - **Solar photovoltaic**, coming from the conversion of light into electricity using semiconductor materials. Electricity is available either directly or stored in batteries or sent into the grid.
  - **Solar thermal energy**, coming from the conversion of solar radiation into heat. The heat produced can be directly used for heating, or have indirect uses (for example to produce steam for driving generators to produce electricity).
  - **Hydropower** is energy supplied by the movement of water, used either directly with a water mill, or converted into electricity with turbines. Power plants are feed with a dam that keeps water. Once there is enough water, the valves are opened to let water flowing, and operating turbines that will drive an alternator and thus generate electricity.
  - **Geothermal**, or "heat of the Earth," is used while drilling, in order to fetch the heat. The depth of drilling depends on the temperature. With weak drilling depths, the temperature is too low to be used directly for heating, it is necessary to use a heat pump that will increase the temperature of the heat taken.
  - The **wood** energy, which is the oldest energy source known by mankind, can be used for heating, cooking or electricity generation. It is considered a renewable energy as the volume of wood harvested does not exceed the natural increase of the forest.
  - **Wind** energy uses the wind to generate electricity with turbine, feeding a generator that produces electricity. Europe could reach 61% of his global production with wind energy.

The depletion of natural resources

Energy demand is growing in the world, leading to resource depletion. Suppose we reduce the existence of the Earth to 1 calendar year. Homo sapiens would then appear December 31 around 11:15 p.m. And it took only 1, 5 seconds to use up almost half of the resources that the Earth has all year to produce.

In fact, it is very difficult to predict when resources will be depleted for several reasons: new reserves are discovered, the demand is always growing, and numbers of existing reserves are sometimes secret and often under evaluated.

Concept of needs and efficiency

- The concept of energy sobriety: The energy sobriety is an approach aimed to reducing its need by changing behaviour. It is therefore to avoid waste. This is the first action and the easiest way to reduce energy or water consumption.

- The concept of energy efficiency: Energy efficiency goal is to reduce energy or water need firstly by improving the efficiency of equipment. This is a second step towards better energy efficiency and reduced C02 emissions. The third step is to produce energy from renewable sources. Example with a bulb: The first step is to save energy by a rational behaviour, systematically turning off the light when it is not useful. The second step is to replace conventional bulb by a low-energy bulb, which uses at least 5 times less energy. The final step would be run this light with electricity from renewables.

2 Key concepts in energy

Key concepts

- **Energy**: anything that enables to perform a work, that creates heat, or light, that produces a movement. Example: Electricity to light a bulb, petrol to move a car, food vital to human beings, etc
- **Thermal loss**: loss of heat. Example: A cup of tea cools down in contact with the room temperature
- **Thermal comfort**: wellbeing sensation of the human body according to its external environment. Thermal comfort concerns every living being. Example: The ideal room temperature to feel not too hot, not too cold, is 19 degrees Celsius. (We can take as an example the participants' feeling about relative comfort, which is different from a person to another: some are wearing a sweater while others are wearing a T-shirt, in the same room with an equal temperature)
- **Thermal resistance**: is the ability of a material to slow down heat loss between a heated environment and an unheated environment.
- **Thermal insulation**: process that fights heat losses. An insulating material has a strong thermal resistance, and retains better heat within a close interior. Example: A cardigan sweater in winter keeps the body warm because wool is an insulating material with a strong thermal resistance.
- **Temperature (T)**: warm or cool sensation that a body feels in a specific place. Temperature is stated in Celsius degrees (°C). Example: Human body has a temperature of 37 °C.
- **Heat**: is a high body temperature. It can be defined as a sensation produced by a hot thing. Heat always moves from the hottest temperature to the coolest one. Example: A heater blows heat.

Units

- **Power (P)**: is the maximum energy that a system can provide. Power is stated in **Watt (W)**. Example: A vacuum cleaner has a power of 1 600 W – A 1 600 W vacuum cleaner.

- **Kilo Watt (kW)**: 1 kW = 1 000 W. Example: A 1.6 kW vacuum cleaner
- **Consumption (C)**: is the power used in 1 hour. Consumption is stated in **Watt Hour (Wh)**. Example: If my TV has a power of 60W and if I watch it during 1 hour, it will have consumed 60 Wh
- **Kilo Watt Hour (kWh)**: 1 kWh = 1000 Wh. Example: On my electricity bill, it is shown that I have consumed 100 kWh within 2 months.

Consumption of an appliance = Power X Operating time Stated in H Stated in W or in kW Stated in Wh or in kWh

Time and power experience: Let's say that we would like to heat 1 litre of water from a temperature of 20°C to 100°C. Depending on the power of the system used, this process will take more or less time.

- Almost instantaneous: in an industrial oven
- Several hours: with a lighter
- Few minutes: on hot plates

Heat transfer

Heat transfer can happen in several manners:

- Conduction: heat transfer by direct contact between two physical materials. Some materials transfer heat better than others. Example: If the pan handle on the stove is made of copper, it will be warm to touch, because copper is a conductor of heat. If the handle is made of plastic, we won't feel the heat because the plastic is a poor conductor of heat.
- Convection: heat transfer by air movement. Example: when you put your hands over the fire, you feel the heat because the air is heated by the flames
- Thermal radiation: transfer of heat by electromagnetic waves. Materials reflect more or less the thermal radiation they receive. Wood, for example reflects more radiation than marble. This is why a wooden interior is warmer than a marble interior. Example: The sun emits heat radiation. So, when the sun is shining, you feel the heat on the surface of the skin, but when a cloud hides the sun, you no longer feel heat.

3 Comfort factors in housing

Thermal comfort depends on the exchanges of heat between the human body and its environment. These exchanges depend on 6 factors that are classified into 2 families:

Environmental factors	Individual factors
Air temperature Air speed Humidity Wall temperature	One's activity level Clothing's thermal resistance

Comfort and individual factors

The human body is a thermal system which produces an internal heat. Depending on its physical activity, the body does not generate the same amount of heat. The more active we are, the more heat we generate. In that case, we stand more easily lower temperature, than if we were seated or lying down.

Example:

- Lying down, the body gives off 45 Watt per square meter.
- During intensive activity, the body gives off 175 Watt per square meter

The clothes that we are wearing also have an influence on our comfort, because our clothes play a part as insulating material. This is why we wrap up warmly during the winter.
Other factors, such as tiredness, food (which is our energy source), can have an influence on the temperature felt. We are much more sensitive to cold when we are tired or hungry.

Comfort and temperature

Room temperature has an influence on the comfort feeling. Within an accommodation, to feel comfortable, advised temperatures are the following:

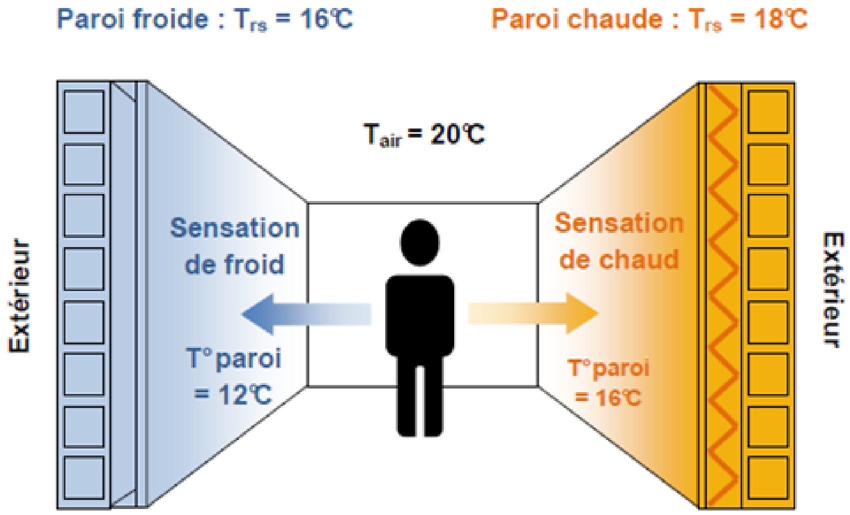
- 17 °C in the bed rooms to sleep well
- 19°C in the lounge, the kitchen and the living rooms
- 22 °C in the bathroom

Nevertheless, the comfort felt varies according to the temperature difference between indoor air and outer wall. A high temperature difference between the outer wall and the indoor air usually means that the thermal resistance of the wall is poor, that is to say that the materials that make up the wall do not enable efficient slowing down of heat loss.

Consequences of a high temperature difference:

- Discomfort feelings (shivering)
- Need to increase indoor air temperature by boosting heaters to feel comfortable.

Hot feeling= 18°C
Cold feeling= 16°C
Difference of feelings between a well-insulated wall and a poorly insulated wall.



Outdoor
Outdoor

Cold feeling
Hot feeling

To get a controlled feeling of comfort:

- The temperature difference between indoor air and outdoor wall should not exceed 3°C
- Just as the same, the temperature difference between the head and the feet should not exceed 3°C

Comfort, humidity and ventilation

The air within our accommodation must be constantly renewed, for several reasons:

- Bring new air and ensure our oxygen needs
- Filter out the excess of humidity (water vapor) produced by our activities
- Filter out the air containing odours and pollutants

Ventilation is therefore absolutely necessary to ensure health, security and comfort in any accommodation.
In the past, ventilation was naturally done, by opening the windows, or through the walls which were hardly airtight. In more newly built accommodation, where walls are insulated, ventilation is done through mechanical systems, thanks to air intakes located on the doors and the windows, and extract units, set up in specific rooms, in bathroom and kitchen in particular.

In any case, and in order to secure air exchange, it is important to manually ventilate its accommodation every day, both summer and winter, for about 5 minutes, by opening the windows and by turning off the heat.

Comfort and air speed

Air motion in the accommodation influences the felt air temperature. Thus, the faster is the air motion, the higher room temperature is needed to feel comfortable.

Example:

- For an air motion of 0.15 meters per second (m/ s), the comfort temperature is 21 ° C
- For an air motion of 1 meter per second (m/ s), the comfort temperature is 25 ° C

In old houses, generally not insulated, ventilation is more difficult to control. The air motion is generally larger, generating greater feelings of discomfort.

Comfort and humidity

Indoor air has a humidity level, which impacts our comfort and health. The main sources of humidity in a house are in domestic activity, such as

- showers / bathrooms,
- kitchen,
- breathing,
- cleaning and
- drying clothes.

For example, a person releases an average of 0.5 lifters of water per day, and drying clothes releases up to 1 litre of water per hour as it dries.

Humidity can also be caused by problems in the building:

- Infiltration of rainwater through the roof or deteriorated walls
- Capillary: water rises from moist soil through the walls

Aggravating factors for humidity:

- Over use of water
- Inadequate heating
- Obstruction of entrances or airing
- Poor thermal resistance of walls (the temperature being low, air condenses more easily in contact with these walls)

Humidity in the air is measured in percentage. The ideal humidity should be between 40% and 60%.

Consequences of low humidity (below 30 %)

- Increase of static electricity (small electric discharges when in contact with metal objects)
- Increase of discomfort and irritation to tobacco smoke (odours are more noticeable)
- Increase of the concentration of dust in the air, which can bring bacteria and impact health (respiratory disease)

Consequences of excessive humidity (above 70 %)

- Visible effects in housing: water runoff on and beneath the windows, wall degradation and mould development (unsticking wall papers, moods and fungi in wall corners and in coldest parts), discomfort associated with cold walls, heat over-consumption, moral discomfort, visible damage, dirty appearance
- Visible effects on health: Humidity promotes the emergence of dust mites and cockroaches that like hot and humid places. The presence of fungi and moulds cause allergies (eczema, rhinitis, asthma ...). Babies and children are particularly vulnerable to respiratory problems, because of their weaker lungs.

Fight against humidity can be done in several ways:

- Ventilate the place to remove humidity excess
- Do not block air inlets and outlets, which must be regularly cleaned
- Do not dry your clothes inside the house
- Ventilate especially when cooking, bathing or other activities that release water vapor
- Heat properly: Heating a room allows to control humidity level, by limiting water condensation. Water condensation is defined by the transition from one state of water, vapor (gas) to liquid in contact with a surface or with cold air. The higher the temperature is, the lower the risk of condensation is, and therefore the lower the risk of mould growth is. Heating "dries" the air.

4 The building envelope

Thermal insulation of a wall

Different materials lead to different thermal resistance of a wall:

- Conductive material: a material is conductive if it conducts easily its heat or cold. Example: copper, steel
- Insulating material: a material is insulating if its heat or cold is difficultly transmitted. It is characterized by its ability to trap air and is usually sparse. Example: glass wool, polystyrene

The more the wall is insulated, the less it consumes energy because the heat is better preserved. To avoid heat loss, walls must be made of insulating materials. They thus retain a greater amount of heat inside the housing.

Insulation of windows

The conventional double glazing (two glasses trapping the air) is more efficient than the single-glazed because it reduces the effect of cold wall and it reduces condensation and heat loss through windows.

Example:

Three 100 m² houses, heated with fuel oil and with indoor temperature of 18° C:

House 1	House 2	House 3
uninsulated single glazing	30 cm of insulation recent double glazing	3 cm of insulation old double glazing
Thermal loss: 32 kW Heating consumption: 355 kWh/m² Annual cost: 3400 €	Thermal loss: 10 kW Heating consumption: 147 kWh/m² Annual cost: 1 400 €	Thermal loss: 3 kW Heating consumption: 39 kWh/m² Annual cost: 375 €

Main sources of heat losses in a not insulated building

- The roof: accounts for 25 to 30% of heat loss
- Walls: responsible for 20 to 25% of heat loss
- Ventilation and air leakage: responsible for 20 to 25% of thermal loss
- The windows: account for 10 to 15% of thermal loss
- Soil: accounts for 7 to 10% of heat loss
- Thermal bridges: responsible for 5 to 10% of thermal loss

Thermal bridges correspond to areas less isolated (junction between two walls for example).

Multi-apartment buildings

In collective housing energy consumption is different from an accommodation to another. Why? Each property has an orientation, a specific position in the building. Depending on its position (exposed to the south, surrounded by other heated homes or not), consumption is different. A housing located north and roof downs consumes more than a housing oriented south and surrounded by other neighbours. These differences are even greater if the accommodation is not insulated.

Concept of bioclimate

Bioclimatic architecture consists in finding the adequacy between construction, users' behaviour and climate conditions. It is considering its environment, and the ability to get rid of its external and negative impacts. For instance, vegetation creates a natural protection against cold winds and summer sun. Two factors are of key importance:

- Orientation: Depending on room exposure, natural flows of heat through sun are different. A room facing South will have less needs of heating than a room facing North. For bioclimatic construction, we will choose for instance to place the living rooms like the kitchen to the south, and parts called "buffer" to the north, such as stairs, cellars, garage, closets and entries. For rest rooms, a northeast or southwest exposure is ideal.
- Compacity: Compacity combines the concept of compact and density. The more a building is compact, the less surfaces exposed to thermal loss it gets. For a best thermal

efficiency, it is suitable that the building has a cubic shape.

5 Electricity and electrical appliances

Measuring device for electricity consumption

An electricity measuring device allows the simple measurement of the electricity consumption and the energy consumption of electrical appliances. Electricity measuring devices are available on the market in different designs. For use in the household, as a rule a simple device for the measurement of a maximum of 4 kW is sufficient. The load limit of the measuring device must be observed. Excessive loading can cause fire!

What does one have to consider when purchasing a new measuring device? The measurement range should begin at 0.5 Watt, as otherwise standby losses and losses due to the pseudo-off state can be measured only very inexactly or not at all. Unfortunately, large chain stores frequently offer – altogether inexpensive – measuring devices which fail to fulfil just this criterion! The electricity measuring device should be as exact as possible, feature a clearly visible display and allow simple operation. It should be possible to read the electricity consumption directly in Watts.

Simpler and less expensive devices, which measure less exactly, can be used for the measurement of consumption by the refrigerator. Besides the indication of the current power, a storage function for the long-term measurement of consumption by the refrigerator is absolutely necessary! An internal measuring device measures the time and energy consumption since the installation of the device. Always make certain that the memory is set to zero at the beginning of the measurement. Also, after removing the measuring device it must be possible to read out the stored "time" and "energy consumption" data again.

Most measuring devices also indicate the electricity costs arising from the measured energy consumption. The basic price of electricity is usually pre-set, but can be adapted manually.

Example of a device for the measurement of electricity with a measuring accuracy of 1 Watt for a price of 12 Euros. Source: https://www.mimovrste.com/ampermetri/emos-merilec-porabe-elektricne-energije-p5821

Refrigerator measurements

Measurements are required on refrigerators which are more than 10 years old and/or with defective sealing, doors hanging askew or with a freezer compartment fully covered with ice and for which above-average consumption can therefore be assumed.

Procedure for measuring with a free-standing refrigerator: Install the measuring device. The energy auditor must make certain that the memory of the measuring device is empty. Inform the customer not to touch any of the buttons while the measurement is in progress. The measurement should be performed over a period of around one week and at least 2-3 days.

Long-term measurement entails the problem of how to make the measured data available to the energy auditor in order to take these into account in the analysis. The following variants are possible:

- The customer reads out the data after a few days and informs the energy auditor by telephone. A second visit to the household is arranged to collect the measuring device.
- The customer brings the measuring device personally to the project site before the second visit.
- The customer sends the measuring device by post to the project site before the second visit.
- During the analysis the energy auditor estimates the consumption and presents the report on this basis during the second visit to the household. During the second visit the helper takes the measuring device, reads out the data and enters the results in the Excel tool before storing the data to the database.

Procedure for measuring with a built-in refrigerator or when the main plug is not accessible

For the case that it is not possible to measure the electricity consumption because the mains plug is concealed and therefore not accessible record the data from the nameplate (usually inside, in the lower left corner), in particular the manufacturer, product name, year of manufacture and volume of the fresh food section and freezer compartment. The measurement of the refrigerator temperature (in both the fresh food section and the freezer compartment) can provide additional information.

Do not forget refrigerators and deep freeze cabinets in the cellar! In this case it is then necessary to install two measuring devices on site. For refrigerators and deep freeze cabinets in the cellar, determine whether the electricity consumed is measured by the main electricity meter. You can test this by opening the door of the unit and observing the electricity meter.

When the household has both an old refrigerator and an old deep freeze cabinet, ask the customer to consider purchasing one new unit and disposing of both old units. From the standpoint of fresh food and freezer compartment volumes, two units are often not required. A quick look inside the refrigerator is sufficient to determine this. As different cities and regions subsidize highly efficient refrigerators and freezers, refrigerator measurements are in any case meaningful. Replacing is necessary when the electricity consumption of the household can be reduced by more 200 kWh per year.

Electricity bill

As a rule, electricity consumption is measured and calculated separately for each flat. Theoretically, it should then be possible to find the respective bill in each separate household.

The electricity costs are divided into two cost components, the basic price and the consumption price. The basic price reflects the costs of the electricity supplier for the installation of the meter, maintenance, read-out and administrative tasks. This price is determined annually or monthly and does not depend upon the amount of electricity consumed.

The consumption price defines the costs per kilowatt hour consumed and is comprised of different cost components which, depending upon the supplier, may also be individually listed. This can cause problems in reading the electricity bill, as the actual consumption price is not always apparent at first glance.

Electricity, water and heating bills for households can exist in different forms: as a rule, electricity bills are issued separately for each flat, however water and heating bills can be issued separately for each flat, for the entire building, or within the scope of ancillary house costs. The differences are explained below.

In 2019 the mean price for electricity for EU (28 countries) was around 0.2147 EUR/kWh.

For the countries concerned (data for 2019): Albania: 0.0844 EUR/kWh (in 2017), Croatia: 0.1321 EUR/kWh; Slovenia: 0.1634 EUR/kWh, Spain: 0.2403 EUR7kWh, Italy: 0.2301 EUR/kWh, Germany: 0.3088 EUR/kWh, France: 0.1765 EUR/kW[1]. Besides the consumption for the year billed and the corresponding costs, as a rule the electricity supplier also gives the consumption for the previous year. This information is important for the household, as it offers a straightforward control of whether the electricity consumption has changed and, if so, in which direction.

Allocation of electricity consumption

After the energy auditor has taken the information of interest from the electricity bill he should state whether the household is using electricity sparingly or, compared with other households, is consuming more electricity than necessary.

The level of consumption depends above all upon the number of persons in the household. The specific consumption per person is less for a household with a greater number of persons, as – for example – the electricity consumption of a cooling unit is of the same order of magnitude for a household with one person or with two persons.

Another important influencing factor is the question of whether hot water is produced electrically or by the central heating system. In the first case, the electricity consumption is considerably higher than in households of the same size without electrical water heating.

In single-family dwellings it must be considered that the electricity consumption of the heating system – in particular that of the heating pump – is included in the overall consumption. The level of additional consumption depends upon the power draw and, in general, can be assumed to be around 300 - 500 kWh per year.

Persons cooking with a gas stove save electricity compared with the average household having an electric stove.

Changing the electricity supplier

In the course of an advisory discussion the question frequently arises, which electricity supplier offers the lowest rates. The energy auditor should refer the customer to consumer information centres which can offer advice on this topic or to the Internet.

6 Water

Water flow measurement

There are two possibilities for measuring the flow of water through water tap or a shower head.

- Flow measuring cup: The flow measuring cup measures the water level in the cup and

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[1] Source:
https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=ten00117&plugin=1

allows the read-out of the flow rate from a scale. The disadvantage is the relatively high purchase price of around 30 - 40 Euros.

- Measuring cup and stopwatch: Alternatively, you can use a simple household cup and a stopwatch. Measure the amount of water filled to the cup over a time interval of, for example, 15 seconds. Multiply this amount by four to determine the water flow per minute.

It is often helpful to ask a member of the household to open the water tap as usual and then measure the flow rate under these conditions. The reason is that, in many cases, the water pressure is so high that the water tap is in fact never fully opened.

Water bill

The analysis of the water bill requires a thorough understanding of the different cases which can occur. In principle, one must distinguish between three main variants:

- The household to be analysed is in a single-family or two-family home
- The household rents in a multi-occupancy home with central hot water heating or
- The household rents in a multi-occupancy home with central flat hot water heating.

In single- and two-family homes the household is billed individually by the communal water supplier on the basis of the amount of water consumption measured by the main water meter. As a rule, no further water meters are installed, so that it is not possible to determine the amount of cold water heated and consumed as hot water.

On the other hand, in multi-occupancy homes the house owner or the house manager is billed by the water supplier on the basis of the main water meter. In the ideal case each tenant has his own separate sub-meter for the individual measurement of cold and hot water consumption. The read-out of the sub-meter is often performed by an external service provider, establishing the basis for the allocation of water costs to the different tenants. Multi-occupancy homes frequently have only cold water or only hot water meters and, in rare cases, no sub-meters.

It is important to differentiate whether hot water production takes place via a common central heating system or the respective flat has its own gas flow heater for hot water production, for example. In the latter case the water meter measures the entire water quantity consumed by the flat. Furthermore, the gas or power bill is then billed directly to the flat, so that the power price can be read out.

In general: Either the overall water consumption must be measured by a main water meter or the sum of cold-water consumption and hot water consumption must be determined from two separate water meters.

Water prices

The costs of water are divided into the fresh drinking water component, the drainage of waste water, and the basic price. The amount of water in cubic meters measured by the water meter represents the basis for the calculation of drinking water and waste water costs. Water prices can vary considerably according to region.

Allocation of water consumption

The actual water consumption (and therefore also water savings potential) of a household cannot be determined unless there is a separate meter for each household. Frequently, water bills are therefore sent to the house owner and not to the tenant. The house owner then distributes the overall costs over the individual flats according to a certain scale (e.g. per person or per m^2 living space).

Even if the billing of the ancillary costs shows a consumption in m^3 it is necessary to control exactly whether this consumption is actually measured by the water meter or calculated according to a scale for distributing the consumption over all tenants in the house. In the latter case, an allocation of water consumption of course makes no sense. If both cold water and hot water meters are installed, the two values must be added for allocation in the tables.

7 Heat

Heating bill

The energy content must be calculated for the amount of fuel consumed according to the type of fuel used. For example, oil consumption is given in litres and households using wood are frequently able to state the amounts consumed in cubic metres. The following table lists the usual conversion factors.

For all other types of flats the billing for heat energy is by way of the ancillary costs. The distribution takes place according to a certain dimensionless scale. The bill does not allow reading out the amount of energy consumed.

Of the many types of fuels, only gas and district heating are billed by the energy supplier. As for electricity, the costs are divided into two components, the basic price and the consumption price. The basic price reflects the costs of the electricity supplier for the installation of the meter, maintenance, read-out and administrative tasks. This price is determined annually or monthly and does not depend upon the amount of energy consumed.

Allocation of heating costs

In single-family homes the residents are mostly billed in the form of a single bill for the required fuels. In multi-occupancy homes with central heating or district heating, as a rule the heat energy consumption is measured by heat cost allocators on the radiators. Here, the house owner or house manager bills the ancillary costs to the respective household. For self-contained gas heating, electrical heating or individual decentralised furnaces the energy supplier bills the household directly according to the amount of energy consumed.

According to energy supplier, the consumption is converted to the unit kilowatt hour, using conversion factors. The consumption must be evaluated in relation to the building conditions.

Billing of ancillary costs

In most cases, the house owner or a billing company send the households a bill for ancillary costs annually, in which the costs of water and heating are listed.

Measurement of consumption

Different methods of measurement are possible to allow the allocation of energy and water consumption to the different tenants in a rented building. As a rule, evaporation heat cost allocators and, more recently, digital devices are installed on radiators.

In many flats water meters measure both cold water and hot water consumption in cubic metres. In the case of energy and hot water so-called heat meters measure the heat energy consumption in kilowatt hours. These meters would allow a far more just distribution of costs, however they are costly and are therefore not widely used up to now.

8 Lighting

In the average household lighting represents around 10 per cent of the electricity consumption. However, the savings potential with lighting is very high. Using LED lamps, a consumption of, for example, 300 kWh per year can be reduced to less than 100 kWh with no loss of comfort.

Efficient lighting is far more than merely a matter of replacing light bulbs by energy-saving lamps. The goal of efficient lighting is to achieve the required lighting level with minimum energy expenditure over an area or a room. A number of techniques and measures are available in order to achieve the required results.

Luminous flux

Luminous flux refers to the amount of light which a lamp produces. Luminous flux is measured in lumens (lm). The higher the number of lumens produced by a lamp, the brighter the lamp.
Because bulbs vary in their efficiency, it is best to compare bulbs based on their light output (lumens) rather than their wattage (amount of energy used).

Illuminance

The basic parameter for the planning of lighting systems is the required illuminance. The illuminance expresses the amount of light falling on a surface. It is measured in lux (lx).

Lux = lumen per square metre

For the workplace, different minimum illuminances are specified according to application. These vary from 50 lux in corridors and 200 to 500 lux in typical working areas to 1500 lux in Quality Control. An illuminance between 20,000 and 100,000 lux is required on the surface of an operating room table.

Luminous efficiency

The so-called luminous efficiency of a lamp describes the amount of light produced in relation to the required energy input. it is calculated as the ratio of the luminous flux (lumens) to the electrical power input (Watts).

Luminous efficiency = Lumens per Watt

The higher the "lumens per Watt value" (lm/W) of a lamp, the better the energy efficiency. This value is therefore a measure of the lamp's efficiency.

Luminous colour

The luminous colour results from the spectral composition of the light emitted by a light source. The luminous colour can be made up of either discrete individual colours of certain wavelengths, a mixture of several wavelengths, or wavelength regions of a certain spectral region.

Candles, incandescent lamps and the sun are our important light sources and have one feature in: the luminous colour depends upon the temperature.
The luminous temperature is expressed in Kelvin (K). For sunlight in Germany in the month of July, for example, a colour temperature of 5850 Kelvin has been measured.

Scale of different colour temperatures

The different colour temperatures affect our sense of well-being and our performance capabilities. It is therefore meaningful to have different colour temperatures in living areas, according to requirement.

In light therapy, cold light is introduced to counter winter depressions. Furthermore, it improves 3D vision and eye-hand coordination and also enhances contrasts. Colder light (4,000 K to 8,000 K) is therefore well suited for the workplace, while warm light (≈ 2.700 K) is better suited for living rooms and, above all, for bedrooms.

Colour choices of lamps. Source: https://www.efficiencymaine.com/at-home/lighting-

Warm White, Soft White The standard color of incandescent bulbs	**Cool White, Neutral, Bright White** Good for kitchens and work spaces	**Neutral or Daylight** Good for reading
2700K 3000K	3500K 4100K	5000K 6500K

solutions/

Lamp types

Light bulb types. Source: https://www.angieslist.com/articles/guide-light-bulb-types.htm

Incandescent lamps

The incandescent lamp was invented and patented by Thomas Edison more than 125 years ago (1879), at that time with charred bamboo or carbon filaments). A wound tungsten wire is electrically heated to white heat, emitting – among other things – visible light, but unfortunately also heat. 95% of the power input is converted to heat.

Halogen lamps

Halogen lamps are a further development of incandescent lamps in which a halogen gas surrounds the filament. They are around 20 to 30% more efficient than incandescent lamps.

Fluorescent lamps

The structure of a fluorescent lamp is comprised of a gas-filled glass tube with an electrode at each end. It is commonly referred to as a neon tube, although it utilizes mercury vapor and, as inert gas, the far more common and less expensive argon and not neon.

Light-emitting diodes (LEDs)

The light-emitting diode (abbreviated LED) is a semiconductor electronic component. When current flows in the conducting direction it radiates light according to the material. This light is virtually monochromatic (that is, of only a single colour). In order to obtain white light either individual diodes of different colours are mixed or the LED is combined with a photo-luminescent material, similar to a fluorescent lamp.

Lamp base types

Light bulb shapes and base types. Source: http://hafele-vietnam.co/light-bulb-base-sizes/

Efficiency classes of lamps

The efficiency classification is defined according to the power and the luminous flux. Common incandescent lamps belong to efficiency classes D, E, F and G. Low-voltage halogen lamps, typically operated from a 12 Volt supply, are often in efficiency classes B and C. High-voltage halogen lamps, directly operated from a 230 Volt supply, are only more compact, but often no brighter or energy-saving than normal incandescent lamps. This is reflected in their allocation to efficiency classes between D and F.

Example of cost savings with energy-saving lamps

A 60-Watt incandescent lamp is replaced by an 11-Watt energy-saving lamp. A typical lifetime of 1,000 hours can be assumed for the incandescent lamp and a typical lifetime of 10,000 hours for the energy-saving lamp. For a burning life of 10,000 hours the following energy consumption is found:

Energy-saving lamp: 11 Watts x 10,000 h = 110,000 Wh = 110 kWh
Incandescent lamp: 60 Watts x 10,000 h = 600,000 Wh = 600 kWh
Assuming a price of 20 Euro-cents per kilowatt hour for electricity, the savings in the cost off electricity after this time are:

(600 kWh - 110 kWh) x 0.2 Euros / kWh = 98 Euros

The purchase price of the energy-saving lamp is around 6.50 Euros and the purchase price of an incandescent lamp around 75 Euro-cents. For a burning life of 10,000 hours, however, it is necessary to purchase 10 incandescent lamps. The following investment costs result for the two lamp types:

Incandescent lamp: (10,000 h / 1,000 h) x 0.75 Euros = 7.50 Euros
Energy-saving lamp: 6.50 Euros

The cost savings over the entire lifetime with the energy-saving lamp are therefore:

Savings: (7.50 Euros – 6.50 Euros) + 98 Euros = 99 Euros

9 Stand-by losses

Standby losses describe the energy consumption of technical systems and devices in the standby mode of operation (including servicing mode). As a rule, the devices are only temporarily deactivated and can be activated again at any time without undue waiting times. Compared with the consumption under normal operating conditions this is in fact much lower, but over a period of time adds up to a significant amount if the standby mode is in effect much longer than the normal operating mode.

Standby losses occur with electrical devices above all in the following operating modes:

- Standby (state of readiness for remote control operation), such as for televisions, video players and DVD players
- Pseudo-off (the devices require energy, although they appear to be switched off, for example low-voltage lamps with power supplies which are switched off from the low-voltage side but not unplugged from the mains).

Operating modes of electrical devices

No-load operation refers to the period in which the device is switched on but not in operation. There are four different operating modes, each of which entails a different level of energy consumption:

- Some devices are in a continuous state of operational readiness as soon as they are switched on and therefore consume just as much electricity as during normal operation.
- The standby mode is known above all in connection with televisions. The device is in a continuous state of readiness in order to allow switching on and off and selecting

programmes via remote control. With older televisions the picture tube is simultaneously preheated, resulting in a mean power input of three to eight Watts.

- Some devices automatically switch to the sleep mode after a certain time not in use (this function is found particularly with computers and their monitor screens).
- Standby losses also include pseudo-off losses in the so-called off mode. The device appears to be switched off and does not execute any function, but still consumes electricity. Printers, scanners, computers, halogen lamps, loudspeaker boxes, CD players, satellite receivers and a number of other devices belong to this group of devices. With these devices the power supply is still active, because the off switch is installed on the low-voltage side. This saves the manufacturer a few cents in production costs, but over a longer period causes pseudo-off costs for electricity which one would not expect, because the device is switched to "off" and no lamps or LED are lit up.

Only unplugging the device from the mains or switching off the power connection to the mains guarantees that the device no longer consumes electricity.

EU regulations for electrical and electronic household and office devices demand that a maximum value of 0.5 – 2 Watts for the consumption of electricity by all relevant household appliances in the standby mode and the off mode, to be reduced stepwise. This is valid for all new electrical devices.

Standby losses

See standby losses: If a lamp or an LED is still lit up or any information is displayed on the device, this is a visible indication that the device is still connected to the mains and is therefore causing avoidable standby losses.
Feel standby losses: Devices consuming electricity (and also their power supplies – also known as voltage converters) can be recognised by the fact that they are still warm to the touch after switching off devices connected to these. Simply lay your hand on them and feel whether the device is producing heat.
Hear standby losses: If the transformer and power supply continue to "hum" after switching off, they are consuming electricity.
Measure standby losses: Even devices with no visible, felt or audible indications of standby losses may still have standby losses. If there are no indications of actions on the device, if standby losses are suspected it is necessary to measure with an ammeter. Make certain to use a suitable ammeter, as not all measuring instruments have the required accuracy at low power levels.

Assuming that a television is used four hours per day and is otherwise in standby mode until switched on again, during this waiting time the device consumes around 70 kWh per year at a cost of around 14 Euros.

In our households there are many other devices which secretly consume electricity in standby mode, such as printers, halogen lamps with voltage converters upstream from the on/off switch, audio equipment, handy power packs, and many more.

	Standby power (Watts)	Mean standby time per day	Costs (rounded off)
TV LCD, 80 – 94 cm	1	20	1 €
Old TV DVB-T receiver	6	20	8 €
DVD recorder with hard disc	10	20	14 €
Hifi system	8	22	12 €
Radio	2	20	2 €
PC with monitor and printer	10	20	13 €
DSL modem + router	7	20	10 €
Cordless telephone	2	23	3 €
Answering machine	3	24	5 €
Game console	3	22	5 €
Coffee vending machine	3	23	5 €

The costs of devices with standby losses can be estimated according to the following considerations: One year has 8,760 hours. For each Watt input power, a device therefore consumes 8,760 Watt hours (Wh) or 8.76 kilowatt hours (kWh) of electrical energy per Watt. For a cost of 20 Euro-cents per kilowatt hour electricity, this gives 1.75 Euros electricity costs per year (assuming the device is used continuously over the entire year). Rule of thumb: A connected load of 1 Watt causes electricity costs of around 2 Euros per year (assuming the device is used continuously over the entire year)).

Typical standby losses also occur in these areas:

- Coffee vending machines are an amenity. However, they can cause considerable standby losses, as the devices are also in a state of readiness while coffee is being brewed. Here also the use of time-delay switches is in the interest of saving electricity costs.

- Most fax machines are in a continuous state of readiness. In order to reduce the consumption of electricity there are "intelligent" power saver devices (available for around 45 Euros from office mail order companies) which immediately respond for sending and receiving faxes. At all other times the special power saver ensures that the fax machine consumes virtually no electricity but switches on at the latest every 12 hours in order that no data are lost in the fax machine.
- For the operational readiness of a computer one distinguishes between several steps of deactivation, each with its own level of electricity consumption:
  - Reduction of system resources (lower processor clock frequency, reduced brightness of LCD monitor screens, switch-off of hard discs during longer times between access)
  - Switching off the monitor
  - Standby mode
  - Sleep mode (quiescent sate)

  These steps can be set by the energy manager of the operating system. If the computer is connected to the mains, the activation of the quiescent state in the energy-saving settings has no effect. The PC is permanently able to send and receive data via the mains and, in spite of non-use, does not switch to the quiescent state. In this case it is better to switch off the PC when not in use.

Avoiding standby losses

In principle, devices should be completely unplugged from the mains when not in use and do not depend upon a permanent power supply. It is therefore necessary to control that the mains contact is in fact interrupted. The safest way is simply to pull the plug. This completely isolates the load from the mains voltage.

A switchable multi-socket outlet achieves the same effect. Such multi-sockets are available in different designs. The simplest have an off switch which can be actuated by finger pressure. The switch is usually coupled with a glow lamp, so that the operating state of the outlet is easy to recognize. The glow lamp consumes a negligible energy of around 0.1 Watts.

For the case that devices are connected to a multi-socket outlet not easily accessed by hand, there are also multi-socket outlets with pushbutton switches attached to a cable and which can be operated, for example, with the foot. In addition, there are switchable remote control operated wireless sockets which are also well suited for use in inaccessible corners. Furthermore, there are also so-called standby interrupters which greatly reduce standby losses while maintaining the state of readiness of the device. The devices are simply connected between the plug outlet and the load and can be operated by remote control. The consumption of electricity of these ballasts is less than one Watt and is therefore well below the standby consumption of televisions or radios.

For office workplaces or situations in which several devices are used simultaneously (for example, computers, monitors, printers, power supplies for desk lamps, handy charging devices, etc.) so-called master-slave socket outlets offer an alternative. All (slave) devices are automatically switched off when the main device (master), such as the computer, is switched off.

Multi-socket outlets offering overvoltage protection also exist. This has the advantage that, for example, televisions or radios connected are protected against lightning strikes which cause overvoltage in the public mains.

Unavoidable standby losses

With some devices, such as answering machines or programmed DVD or VHS recorders or satellite receivers, the settings cannot be stored without power, as data would otherwise be lost (such as clock times or programmed recording times). When it is not possible to dispense with these settings, only the use of newer models helps to avoid standby losses. As a rule, modern devices have much lower standby losses. And intelligently built devices contain stored information about the receiver channel, date, time of day, etc. thanks to different buffer techniques, such as a "backup accumulator". This makes it possible to switch off these devices entirely when they are not in use over a longer period of time.
Please note that some ink-jet printers require a complicated re-initialisation and self-cleaning procedure, frequently consuming a large amount of ink, following complete isolation from the mains and re-starting. They should therefore not be switched off and then on again very often.

Some devices in the sphere of the household cannot be switched off at all. These include, for example, network telephones and in some cases answering machines and fax machines. When purchasing such devices, it is therefore necessary to determine which devices have favourable consumption values in standby mode.

In some cases, the continuous readiness of a device is desirable or unavoidable (such as with video or DVD recorders). In such cases it is important when purchasing to examine the consumption during standby mode. An efficient device requires around 20 Watts during operation and less than one Watt in standby mode. Since the introduction of the EU Directive only devices with a standby consumption of less than 1-2 Watts may be sold in the (see Section 3.7). In German households, on the average video recorders are used only around one hour per day. During the remaining 23 hours the device is in a state of readiness. Viewed overall, an older video player consumes far more electricity in the state of readiness than during its actual time in use.

The programming of set-top boxes, decoders and DVD players can be lost when the device is unplugged and the memory is not battery or accumulator buffered. It is therefore necessary to purchase only devices which do not lose their usefulness when completely disconnected.

10 Appliances

Refrigerators and Deep Freeze Cabinets

Refrigerators and deep freeze cabinets belong to the household appliances. As they are continuously operated, they are usually the largest consumers of electricity in the household. Although the power draw of modern refrigerators is hardly more than that of an incandescent lamp, they consume significant amounts of electricity, as they are in operation many hours in the course of a year. At the same time, there are considerable potential savings here when an old appliance is replaced by a highly efficient new appliance of class A++. In particular, refrigerators and deep freeze cabinets more than 10 years old can be veritable power gluttons. However, intelligent operation also contributes to savings. Refrigerators belong to the most widespread household appliances and are therefore found in virtually every household.

Refrigerators are essentially spaces insulated against heat, with a heat exchanger (usually with compression systems) for the removal of heat. In the household the refrigerator is operated nearly without exception from electrical power. An excessively high consumption of electricity can be due to the following causes:

Reason for high power consumption	Cause
Poor thermal insulation	Old appliance
Inefficient heat exchanger	Old appliance
Unsealed door	Wear

High ambient temperature	Wrong location (sunlight, stove…)
Cooling temperature too low	Incorrect setting
Poor heat dissipation	Insufficient ventilation, no ventilation slits
Refrigerator iced over	Insufficient maintenance

The typical operating temperature of the interior is usually between 2°C and 8°C. Lowering the temperature increases the amount of energy required per degree Celsius by six per cent! The setting of the appliance should therefore ensure that the temperature of the interior is not less than 7° C. This saves around 30 per cent of the electricity consumption compared with a setting of 2° C.

In the last 10 years the energy efficiency of new refrigerators has considerably improved. The thermal insulation is better, and they also have more efficient heat exchangers and better regulation. The energy-saving appliances of today require only half as much electricity as the best energy-saving appliances of 10 years ago.

As a rule, a four-person household with an old refrigerator or refrigerator-deep freeze chest will consume up to 700 kWh per year for the cooling appliances alone. By comparison, a new particularly energy-saving combined refrigerator-deep freeze with a refrigerator volume of more than 190 litres and a freezer section of 92 litres requires only around 200 kWh per year. Deciding in favour of purchasing energy-saving appliances thus saves round two thirds of the electricity required for the refrigerator and deep freeze.

On the average, before replacing the older appliances households require 720 kWh for refrigeration and deep-freeze purposes. Following the purchase of new appliances, the mean electricity consumption of these households for refrigeration and deep freeze was only 160 kWh per year.

Before purchasing, a requirement analysis is required: Is it worth purchasing a freezer or deep freeze chest or would a refrigerator with freezer compartment or perhaps a refrigerator-freezer combination be sufficient?

In the case that the old refrigerator or freezer is too small, it is better to purchase a larger appliance and take the old one out of service than to purchase a second appliance. A refrigerator with double the useful volume consumes far less energy than two appliances. When an inefficient old appliance is also replaced, in spite of the larger useful volume the energy savings can be more than 50%.

In the case that two appliances are in fact required, if possible a colder location should be found for the freezer unit. And the refrigerator in the kitchen should not be exposed to direct sunlight or located next to radiators or the stove (an unheated pantry is an ideal location).

If a freezer is already present, as a rule a refrigerator without a freezer compartment is adequate. Refrigerators without a freezer compartment requires far less electricity than one with a freezer compartment or four-star freezer compartment.

Frost-free appliances, today mostly called "no-frost units" on the market, should not be considered. These appliances have the apparent advantage that the unpleasant task of defrosting is eliminated, as no frost forms on the inner walls and frozen goods. However, as a rule these units consume between 10 and nearly 20 per cent more electricity than the usual "low-frost units".

One should carefully consider whether a freezer or a deep freeze chest should be purchased. The preparation of deep-frozen products is in fact fast and simple, however the preparation of fresh groceries from the weekly market or directly from the producer is recommended for climate protection reasons. Furthermore. deep-frozen products entail considerable energy expenditure for storage and transport. When purchasing fresh groceries, give priority to those identified as regional products.

Refrigerators used in the household function according to the compressor principle. The CFC-based coolants used for a long time as the coolant are ecologically very questionable, as they contribute heavily to the degradation of ozone and are therefore damaging to the climate. A refrigerator may therefore be disposed of only professionally via the hazardous waste collection stations or via the dealer. During removal it is necessary to ensure that the cooling lines are not damaged. Since the mid-1990s newer refrigerators mostly have other coolants, such as butane or R134a. In the meantime, CFCs are banned throughout the EU.

Washing machines

Around 5 % of the electricity consumed in the household is required for washing laundry.

The greatest part of this is for heating the water. A washing machine requires a small part of the energy input (10 to 20%, according to the wash program) for the rotation of the washing, while the greatest part serves the heat the soapy water.

The energy requirements for a washing cycle increase with the amount of water and the washing temperature. The amount of water required for a washing cycle depends upon the machine, but also upon the selected wash program. In earlier times more than 100 litres of water flowed through the machine for a standard 60 °C wash program. Today, only somewhat less than 40 to 50 litres are required for five or even six kilogrammes of laundry. This has been made possible, because today the laundry, so to say, "showers" and no longer "bathes".

The electricity consumption of a conventional old washing machine does not depend upon the filling level; that is, when only half loaded with the normal wash program the washing machine requires the same amount of electricity as with a completely filled drum.

If washing with an only partially loaded washing machine is unavoidable in your household, the most economical washing machines are those which adapt the amount of water to the amount of laundry. In new washing machines this so-called automatic capacity regulation is already standard. However, a half-full washing machine still requires considerably more electricity per kilogram of laundry than a small, but full washing machine.

The energy consumption per washing cycle depends strongly on the washing temperature.

Washing temperature	**Required electricity for each use**	**Cost per use**
30-degree wash	0.35 kWh	0.84 €
40-degree wash	0.50 kWh	1.20 €
60-degree wash	0.95 kWh	2.28 €
95-degree wash	1.7 kWh	4.08 €

Consumption and costs per washing cycle according to washing temperature with 0.24 Euro-cents /kWh electricity

The selection of the best suited wash program according to the type of textile and the level of soiling determine the consumption. As a rule, even for heavily soiled textiles no pre-washing is required. At 95 degrees without pre-washing one saves around 40% of the energy consumed with pre-washing. In view of the washing effectiveness of today's washing machines the 60° program is sufficient for white laundry (underwear, hand towels). The 95°C program requires nearly double the energy of the 60° program.

The different extra programs, such as the short program, energy-saving program or the optimisation of the spin speed, can save energy. With energy-saving programs longer soaking times are used in place of high washing temperatures. Examine the times required for the respective wash programs in the user's manual. The so-called energy-saving program sometimes turns out to be more energy-intensive than, for example, the short program for slightly soiled laundry.

New appliances frequently require only half as much electricity and two thirds less water! Tips for purchasing a new appliance:

- Check the size (3 kg for a single person household, otherwise 5 kg filling capacity)
- Purchase only efficiency appliances in the category A+ with low water and electricity consumption
- Ensure a high spin speed when a dryer is used.
- Purchase and use appliances for shared use.
- Washer-driers (combinations of washing machine and drier) consume far more electricity and should therefore not be purchased.
- If the appliance has standby consumption, dispense with automatic time control, etc.
- Ensure that the instructions are easy to read. The selector switch and the buttons must be easy to operate and reliable.

Laundry dryers

Electrical laundry dryers require considerable electricity. In any case, drying laundry in fresh air or in the laundry room is less expensive. In winter also, laundry can be dried with little energy consumption in the laundry room, in the cellar or in another suitable room on the laundry stand, if necessary with a 25-Watt fan (cost of purchase around 10 Euros) oriented so that the air is blown between the laundry items and causes them to move in the air stream. Laundry dried in fresh air delivers water to the air flowing past. With this trick well spin-dried laundry is dry after one day or already after a few hours. Pleasant side effect: The continuous motion of the laundry renders it soft and smooth, as in a laundry drier.

Laundry driers are available in three basically different designs:

- Ventilation driers introduce ambient air, heat the air and blow it through the laundry, so that it takes up moisture. The moist hot air is then expelled to the outside. This requires a well-ventilated room and an exhaust air pipe to the outside in order that the air intake is relatively dry and not moist and no damage occurs to the building structure due to moist air. Gas-heated ventilation driers have around only half the low primary consumption of electrically heated ventilation driers.

- Condensation driers are more widespread than ventilation driers and require only a single connection to power. Moist hot air is cooled in a section of the appliance, whereby the moisture condenses and is collected in a reservoir or immediately passed to the waste water. The drier air dried and cooled in this manner is heated again and blown through the laundry. Usually the room air is pumped in a duct through the hot air of the drier, heated and again expelled to the room in order to heat the drier environment. Alternatively, there are also water-cooling systems. According to design, these appliances require around 10 per cent more energy than ventilation driers to achieve the same effect. Condensation driers with heat pump function at low hot air temperatures as standard condensation driers. The heat from the drying process is recovered. With these driers one can save as much as 50% of the electricity consumption, depending upon the appliance compared. Cabinet driers, which dry using cold air, have the lowest energy consumption of all but require very long drying times.
- A special form of drier is the washer-drier. These appliances are washing machines which can also dry laundry. The standard models can e.g. wash 5 kg of laundry and dry 2.5 kg of laundry per wash cycle. That is, after washing it is necessary to remove half of the laundry and dry the amount remaining. If this is dry, one then dries the second portion. For the appliances described here drying takes by a water condensation technique. The heated dry air is led past a water-cooled surface onto which the water vapour condenses and flows off as water. For drying these appliances also required (cooling) water. Washer-driers are intended for small households in which a separate drier cannot be installed and where there is also no possibility to hang laundry on a clothes line to dry.

Decisive for the time and energy consumption required for drying is how much water is admitted to the laundry. If the laundry is spin-dried at 1,400 instead of 800 rpm, the electricity consumption of the condensation or ventilation drier is reduced by around 30 %. Driers too function best when completely filled.

	Washer-drier	**Ventilation drier (electric)**	**Condensation drier (without heat pump)**	**Clothes line**
Inefficient appliance	750 €	660 €	675 €	0 €

New efficient appliance	380 €	400 €	510 €	0 €
Savings	370 €	250 €	165 €	0 €
Savings in electricity costs per year	75 €	50 €	30 €	0 €

Table xx: Operating costs for washer-driers in a four-person household (150 usages per year, cost of electricity 20 Euro-cents/kWh). Author's calculations.

Tips for purchasing a new drier:

- There are really no energy-saving appliances except for very expensive special models, such as gas-heated ventilation driers
- Choose capacities suitable for the washing machine.
- Condensation driers are more suitable for flats than ventilation driers, because the moisture produced during drying must be passed through an exhaust air hose directly to the outside. However, they have a high electricity consumption.
- Drying according to moisture has many advantages compared with drying according to time.
- Can the lint trap be easily cleaned? For condensation driers: Can the condensate be easily removed?

Dishwashers

Dishwashers require electricity above all for heating the water and dishes. This fraction constitutes around two thirds of the consumption per washing cycle. Reducing the temperature of the dishwasher from 60 degrees to 50 degrees consumes around 30% less electricity. When fully loaded, large dishwashers with space for 10 to 14 place settings are more economical in terms of electricity consumption than smaller dishwashers with space for seven to nine place settings.

There are usually programs for different degrees of food residues, which differ according to temperature (40 – 70 °C), washing time (approximately 30 – 120 minutes) and also required energy. However, nearly every dishwasher has special program settings and the program times can be very different.

The energy-saving programs of these appliances equally good results are obtained with longer washing times at lower temperatures, with less energy consumption than with shorter washing times at higher temperatures.

Temperature	Description	Electricity consumption	Program time	Water consumption
35 degrees	"fast"	0.7 kWh	approx. 30 min.	10 l
40 degrees	"mild"	0.9 kWh	approx. 75 min.	15 l
50 degrees	"eco"	1.05 kWh	approx.140 min.	15 l
65 degrees	"normal"	1.6 kWh	approx.140 min.	19 l
70 degrees	"intensive"	1.7 kWh	approx.150 min.	20 l

Examples of electricity and water consumption with a modern dishwasher (12 place settings, full)

Stoves

The average power of an electric stove is 1000 to 1500 Watts (small hot plate), up to 2200 Watts (large hot plate) per hot plate in use. The oven has a power of around 2 kW. Thus, cooking one hour with the large hot plate consumes between 2 and 2.2 kWh of electricity. In terms of energy consumed, gas is more favourable for cooking, as the entire chain leading to conversion of energy (e.g. coal) to electricity is no longer required. As the price of gas is also less than that of electricity (6 to 8 Euro-cents/kWh compared with 19 to 21 Euro-cents/kWh) the price advantage is more than 30 %.

Household size	Annual electricity consumption for cooking
1 person	200 kWh
2 persons	390 kWh
3 persons	450 kWh
4 persons	580 kWh

Mean consumption values for an electric stove. Source: VDEW

Different efficiencies are found according to the type of cooking hob. The higher the efficiency, the greater the amount of heat directly supplied to the food being cooked in the cooking vessel and not only to the hot plate itself. Heating to the required temperature consumes between 70 and 80% of the electricity consumed, leaving only 20 to 30% for further cooking, particularly when the hot plate step is reduced in due time.

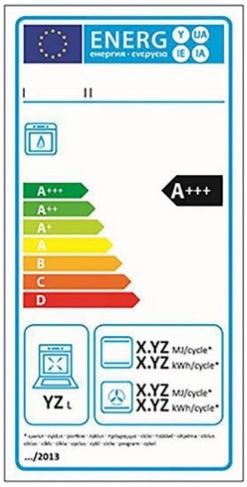
Tips for saving electricity when purchasing a new stove

- For the purchase of a new stove, gas is in any case preferable to electricity. While the amounts of energy consumed are roughly the same, the energy losses with an electric stove are considerably higher. Gas is also less expensive and the residual heat losses are far less.

- If it is not possible to install a gas stove, it is also possible to save energy with your new electric stove. New technology, such as improved thermal insulation or glass-ceramic hot plates reduce the energy consumption of electric stoves.

Labels for Energy Consumption

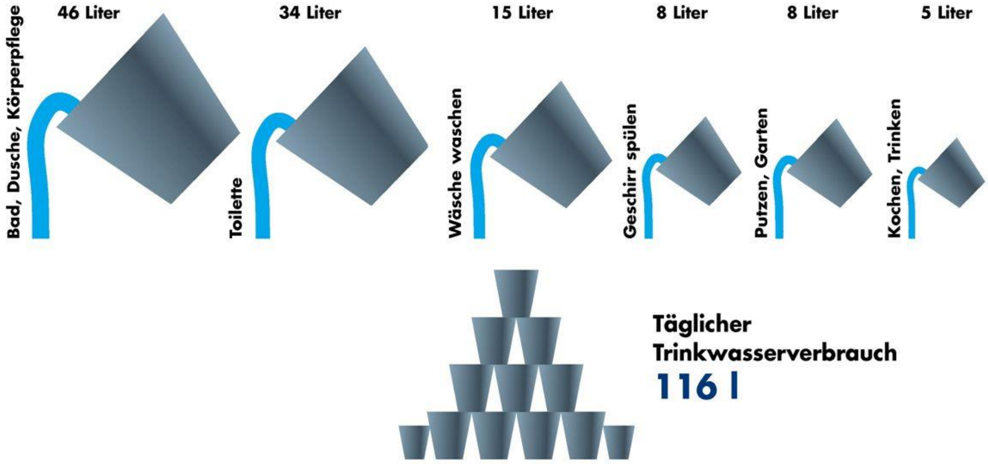
The European Union specifies an energy consumption label for all large household appliances ("white goods"), the so-called EU uniform energy label (EU label). The advantage of this label is that one can assess the relative energy consumption of the new appliance at a glance.



The EU label classifies the different appliances according to energy efficiency classes from A+++ (very low consumption) to G (high consumption). Thus, when purchasing one of these appliances you should ensure that the appliance belongs to the best energy efficiency class.

11 Water

An average three-person household consumes approximately 360 litres of water per day. The mean consumption per person is therefore around 120 litres per day, or 40 cubic metres per year. Nearly half of the water consumption in the household is required for bathing, showering and flushing toilets. Around one fourth of the water consumption is required for washing laundry and dishwashers. Only a small part – approximately 5% - is used for cooking and drinking.



Water consumption per person. Source: Energy Agency of North Rhine – Westphalia

A significant part of the water consumption is unnecessary; that is, the same level of usage could be achieved with a smaller amount of water. Dealing more consumption-consciously with water and a few smaller investments are sufficient to reduce the consumption of water by around 30%. In respect of hot water, this amounts to double savings: here the energy costs for heating the water can also be reduced.

A similar double benefit due to savings of hot water also applies for washing machines and dishwashers: Low water consumption leads to less consumption of electricity for heating the water in the respective appliance.

Example of a calculation: Saving the costs of water in the household
For a water consumption of around 120 litres per person per day, a family of four consumes 480 litres per day, equivalent to around 175,000 litres or 175 cubic metres per year. How high are the costs of water alone (without considering the energy for the preparation of hot water)? For an assumed total price of 4 Euros per cubic metre (including the cost of waste water) a family of four then has annual water costs of 700 Euros. Dealing more consumption-consciously with water allows savings of 30% per person, so that a family of four can save a total of 210 Euros each year.

A number of different water-saving articles can be installed as immediate aids within the scope of the power-saving check, leading to considerable cost savings. The installation of low-flow shower heads and flow limiters on the water tap results in double savings: savings in hot water costs and in heating costs. The installation of a low-flow shower head in a two-person household, for example, leads on the average to savings of around 52 Euros in water costs and 24 Euros in heating costs annually. If water is heated electrically, on the

average savings of 60 Euros result for the costs of electricity. The installation of a WC flow limiter leads to considerable savings of cold water.
Electrical water storage heaters used seldom but in a continuous state of readiness cause very large heat losses. It is therefore advisable to switch off electrical water storage heaters used only seldom when not in use (in the evening, when on holiday, etc.), turn down the temperature set point, or with infrequent but repeated use at particular times of day to install a time switch or a thermostop

	Savings of water	Savings of energy (fraction of hot water for overall water consumption)
Low-flow shower head	Yes	yes (approx. 90% hot water)
Shower with flow limiter	Yes	yes (approx. 90% hot water)
Water stream regulator on water tap	Yes	yes (approx. one third hot water, depending upon tapping point)
WC flow limiter	Yes	no

Table 5: Savings potentials of the different immediate aids

12 Heating and ventilation

One frequently hears the opinion that heat consumption is determined by the thermal insulation of the walls, well insulated windows and the efficiency of the heating system, while the tenant has practically no influence on consumption. Correct is that the quality of thermal insulation, the windows and the heating technology are the most important factors for heat consumption. Nevertheless, the tenant's behaviour has a considerable influence on the heat energy consumption.

In an average building housing flats the energy consumption for heating purposes is around 225 kilowatt hours (kWh) per square metre of living space per year. If the tenant knows how to deal efficiently with energy, it is possible to reduce the energy consumption by nearly one fourth; that is, by around 50 kWh per square metre per year. Compared with a household which behaves incorrectly and thus wastes energy, this tenant can even save more than half of the energy, namely around 140 kWh per square metre per year.

For a flat having a living space of 70 square metres and a price of 0.07 Euro per kWh for heat energy the difference between an "efficient user" and a "wasteful user", the difference in cost over a year's time is nearly 700 Euros!

The correct room temperature setting is one of the major influences on the heat energy consumption of a flat. Recommended room temperatures:

	Recommended room temperature
Living rooms	20 °C
Kitchen	18° C
Bedrooms	16 °C
Hallways	15 °C

The human perception of warmth or cold is very different. Older or sick persons and persons with low blood pressure freeze much faster than others. It is therefore advisable to regularly control the room temperature with the help of a thermometer.

In order to deal economically with heat energy, it is meaningful to reduce the temperature in rooms which are not used by turning down the heat. Reducing the room temperature saves far more energy than the required "reheating" of the rooms. It is important to close the doors between the heated and unheated rooms- Even when leaving the flat, as well as evenings and nights, the room temperature should be lowered. Each degree of temperature reduction saves around 6% heat energy.

In order that flats do not cool down excessively overnight even with poorly insulated windows, during cold nights roller shutters should be lowered and window shutters closed. Heavy curtains and so-called draught excluders placed before doors and windows can help to reduce heat losses.

Thermostat valves

In most flats the room temperature is set via so-called thermostat valves on the radiators.

With normal central heating the heat is transported by the heating pipes to the radiators. Without a valve to reduce and regulate the incoming heat the room would be overheated. The valve regulates the flow of heating water and therefore the temperature in the room.
Thermostat valves are mechanical temperature regulators which regulate the flow of heating water so that the temperature in the room remains constant. The thermostat valve has a temperature sensor which measures the room temperature. If the temperature in the room increases an expansion element is stretched and this motion is transferred to the valve, which reduces the incoming flow. A pull-back spring opens the valve when the expansion element shrinks due to a drop in temperature.

Design of a classical thermostat valve

The temperature of the room air is pre-selected by rotating the adjusting knob. As a rule, the adjusting knob has a scale of values from one to five. The setting "3" gives a room temperature of around 20 °C. Changing the setting by one number upwards or downwards causes a change in temperature of around 4 °C.

A frost protection mark "*" on the adjusting ring indicates the frost protection setting. This prevents the room temperature from falling below 6 °C and thus offers protection against freezing and the resulting frost damage to the heating system.

Thermostat valves must be unobstructed and surrounded by the room air. If the thermostat valve is, for example, covered by a curtain or concealed beneath a deep window sill this can result in the accumulation of heat and can interfere with the functioning of the thermostat valve. In such cases remote sensors which transfer the thermal expansion to the thermostat valve via a capillary tube are helpful.

Programmable thermostat valves can be set so that the incoming heat to the radiator is controlled by a time program. Such programmable thermostat valves are of interest particularly for those users who are regularly absent from the flat on certain days or at certain times. The programmable thermostat valve reduces the heat to the thermostat valve at the time set (for example, half an hour before leaving the flat) and opens it again at a later time (such as half an hour before the planned time of) so that the flat is already slightly heated when the user returns.

Important: Explain to people that they should set the thermostat valve to the temperature step which they wish. A higher setting (e.g. step 5) does not cause faster heating of the room to the desired room temperature of 20 °C, but only overheats the room.

Tips for correctly heating:

- Reducing the heat by 1°C saves around 6% heat energy.
- The healthiest room temperature is between 18 and 20°C, with a relative humidity of 40 to 60%. For a pleasant room climate 20°C is sufficient in the living and children's rooms, 18°C in the kitchen and 15°C in the hallways.
- During longer absences turn down the thermostat valve. If the heating does not have automatic overnight reduction it is also meaningful to turn back the thermostat valves overnight. When lowering the room temperature overnight in a rather humid room (greater than 60% relative humidity) you should ventilate the room first in order to leave dry air in the room.
- Always set the thermostat valve to the desired temperature step. A higher setting (e.g. step 5) does not cause faster heating of the room to the desired room temperature of 20 °C, but only overheats the room.
- Keep inner doors between differently heated rooms closed day and night. Do not heat the bedroom from the living room. "Leaving the unheated bedroom slightly heated" allows warm, i.e. moist air, to flow from the living room into the bedroom, where the humidity condenses when cooled by the cold environment (e.g. outer walls). It is therefore better to temper colder rooms with the radiators in these rooms.
- During cold nights roller shutters should be lowered and window shutters closed.
- Furniture and curtains may not be placed directly before the heating! Furniture placed before the heating or curtains hanging over the heating inhibit the transport of heat into the room. The thermostat valve must be opened wider in order to obtain the desired room temperature. This in turn increases the temperature of the wall behind the radiator and therefore the heat losses to the outside.
- Do not heat from the wall socket! Decentralised electric heaters are only for absolute emergencies. Electrically produced heat is roughly three times as expensive as heat from the heating system.

Tips for minor structural measures

The building owner is obligated to uphold certain technical standards relating to heating systems. This includes, for example, the obligation to install temperature regulation in the different rooms (as a rule in the form of thermostat valves) and the thermal insulation of all pipelines not passing through heated rooms. If the house owner does not comply with these regulations, the tenant can demand their implementation.

However, some standards cannot be demanded by the tenant. In such cases, it may be meaningful for the tenant to reduce the costs of heating by relatively simple steps entailing only low costs. The measures described below entail only relatively low investment costs.

- A considerable part of heat losses in a flat result from radiator recesses, as the walls are usually thinner there and at the same time the wall temperature, and therefore the heat losses, are greatest. If there is sufficient space between the radiator and the wall the user can affix radiator insulation plates to the wall behind the radiator. These insulation plates (e.g. aluminium-coated styrene plates or flexible insulation films) are available in thicknesses from 2 to 10 cm. For a three-room flat the expected costs are around 25 to 50 Euros. A clever house owner will be happy to reimburse the tenant for these costs.
- When the distribution lines from the boiler to the living spaces and flats pass through unheated rooms and are not thermally insulated, this causes heat losses. In this case thermal insulation should be installed, particularly as this is required by the valid energy-saving act. In these cases, the tenant should speak with the house owner.
- Sealing of draughty cracks in windows and doors with self-sticking insulation strips. As a rule, these can be obtained in hardware stores, are not expensive and can be easily affixed even by lay persons. This measure not only saves energy, but also improves the sense of well-being in the respective room.
- The outer walls are also usually much thinner before the shutter boxes. One can Insulate the interior of the shutter boxes by wrapping the shutter with flexible insulation plates and sealing the. However, this should be agreed with the house owner in advance.
- A somewhat more expensive measure, which can however be very effective for households in which the tenants are regularly absent, is the use of programmable radiator thermostats (available for around 35 Euros in hardware stores). This is simply attached by screws in place of normal thermostat valves. Programmable thermostat valves allow the automatic reduction of room temperature at pre-defined timed during day or night. With the help of these devices an increase or decrease of the room temperature can be individually programmed for any day of the week.

Ventilating Correctly

Particularly during summer fungal spores are present in the ambient air. In dry, hot weather above all black mould releases large amounts of spores to the air. The spores in the ambient air are then regularly found in interior rooms. For intact living space constructions these normal spores have no chance to survive. Under unfavourable conditions in the interior rooms, however, the fungal spores thrive and cause both damage to the building structure and impair the health of the tenants.

For their growth mould spores require high relative humidity (65 - 85%). In interior rooms they therefore preferentially infest cellars, bathrooms, window frames, air conditioning units, air humidifiers and cold wall areas, where condensation can occur. Cold wall areas are found above all in connection with "heat bridges". Heat bridges arise where there are significant heat flows to the outside, such as junctions to balconies with continuous concrete slab, in the vicinity of windows or in building corners and of course wherever thermal insulation is defective or lacking. In particular, mould can grow where cold wall areas are blocked by cabinets or book shelves and no air exchange can take place.

An average household supplies around ten litres of water to the air every day. Most of this results from showering, bathing and cooking. However, respiration and perspiring also increase the water content of the air. Another source of humidity is plants within the room. The Irrigation water is also eventually passed to the room air. Furthermore, uncovered aquariums and water fountains in the room can increase the humidity. Sources of harmful substances are, for example, construction materials, floor coverings, furniture and chemical cleaning agents.

In flats with old windows, as a rule considerable exchange of air takes place with the outside, as the windows are not airtight. In winter cold and relatively dry air then penetrates the cracks. This is bad for the consumption of energy; however, it leads to relatively low room humidity.

New windows and airtight joints prevent the exchange of air. Humidity resulting from showering, cooking or respiration is supplied to the room air, resulting in increased humidity in the room and condensation on cold surfaces, where mould spores find Ideal conditions for growth. Correct ventilation is therefore very important in order to prevent mould growth (see section Ventilating Correctly).

High humidity also favours the living conditions for mildew, found for example preferentially in upholstery or mattresses. Particularly for persons with allergies mildew represents a serious health problem.

Should you encounter mould problems in the course of your power-saving check or requested to investigate mould problems, you should explain the facts and refer the customer to the local consumer advice centre. This subject is so complex that – beyond pointing out the need for correct ventilation – you should not attempt to discuss this at greater length and certainly not offer any recommendations.

Ventilation losses represent a large part of the overall heat losses in a home. In old buildings this is around 40% and in low-energy buildings this can be as much as 60%. Not infrequently half of the room heat energy is "thrown out the window" due to improper ventilation.

Nevertheless, to conclude that one should no longer ventilate or ventilate only as infrequently as possible would be false. The outer walls of buildings are not only nearly impermeable to air and water. Walls do not breathe! One must therefore ensure healthy room air by reasonably ventilating. At the same time, the water vapour and the odours and harmful substances accumulating in the flat must be expelled by ventilating.
The art of ventilating correctly then consists of ventilating as much as necessary, but no more. In passive houses (see Chapter 7) this is ensured by a ventilation system with heat exchanger or in some houses, without optimised energy consumption, by an exhaust air system (without heat recovery). In most flats, however, the tenants must understand how to ventilate correctly.

In principle the rule that the humidity accumulating in a flat should be expelled as efficiently as possible without loss of the entire heat stored in the walls and without "cooling down" the flat applies. During the heating period this should not be done by the permanent open tilting of windows, but by cross-ventilation or brief intensive ventilation, with the windows wide open, however only for a few minutes.

The better the ventilation of the flat the shorter the required ventilation time. With "thermal ventilation" (also called free ventilation) the temperature difference between inside and outside causes cold air to flow into the room and expels warm air to the outside. However, this ventilation process functions rather slowly. In particular, if the window is relatively small and the temperature difference between inside and outside is very small free ventilation is very poor. Cross-ventilation is then vastly more efficient. Here two windows (or other openings) are opened on opposite sides of the building. The pressure differences which arise result in the rapid exchange of air, so that the entire amount of air is refreshed after only a few minutes.

A very good tip for effective ventilation is the use of a so-called hygrometer. This measures the relative humidity of the air, which one can estimate only with difficulty in relation to the temperature. When the hygrometer indicates a value of more than 60% relative humidity, ventilating briefly and intensively is recommended.

Air always contains water or moisture. A measure of its level is the relative humidity. 0% relative humidity means there is no water vapour in the air. 100% relative humidity means the air is saturated with water vapour and can no longer take up additional water. This case occurs, for example, with fog, when virtual drops of water appear to fall from the air. The capacity of the air to take up water vapour depends very strongly upon the temperature. Cold air has a very limited capacity for taking up water, while warm, dry air has a very high capacity. This is the reason why ventilation is so important in order to expel the accumulated humidity from rooms: The cold air, which contains very little water vapour, is heated in the flat. In the absence of sources of humidity in the flat, this would lead to very dry air with low relative humidity. When sources of humidity are present, the heated dry air can take up this water vapour without problem. One cubic metre of air can take up around 17 grams of water vapour before the air becomes saturated. However, it must be considered that a relative humidity of much higher than 60% should not be exceeded, as this value is considered to be the limit value for a healthy room climate.

Tips for ventilating correctly

- Avoid the "permanent open tilting" of windows! Windows tilted open cause the highest heat losses, which are also not noticeable. The tenant can save as much as 200 Euros per heating season by simply avoiding permanently open window tilting. This also prevents the peripheral walls and furniture from cooling down.
- Ventilating correctly means: Opening the windows wide for a short time (five minutes is normally sufficient) (brief intensive ventilation). The best way is to carry out a complete exchange of room air mornings. If possible, this should create a draught. Otherwise, open the windows side in every room. The most efficient method is the brief intensive ventilation of the flat.
- Ventilating once per day is not sufficient. Ventilation should take place in rooms where persons were present in the morning and again in the afternoon. Carry out a complete exchange of air evenings, including bedrooms. This improves the room climate and prevents mould growth.
- Before ventilating turn down the thermostat valves!

Tips to prevent mould growth:

- Use a thermo-hygrometer: This indicates the temperature and the relative humidity.

With the help of this instrument you can control the room climate.

- In rooms in which a large amount of humidity can accumulate over a short time (such as the kitchen or bathroom) the humidity should be immediately expelled by ventilating. Thus, for example, one should immediately ventilate the moisture arising from cooking to the outside. Closing the door to the kitchen prevents the water vapour form entering other rooms of the flat.
- For bathrooms inside the flat without windows expel the moist air by the shortest possible path through another room. Keep the other doors closed so that the water vapour cannot accumulate uniformly throughout the flat.
- When necessary to dry laundry in the flat, because no laundry room is available, the room should be ventilated frequently. The doors to the room should be kept closed.
- Ventilate during rainy weather also, provided that the rain does not enter through the window. Even in rainy weather cold outside air is "drier" than warm room air. The reason is that the capacity of the air to take up water vapour depends very strongly upon the temperature. Thus, for example, one cubic metre of air at a temperature of 0°C can take up 4.4 g of humidity (water vapour). By comparison, at a temperature of 20°C water is saturated only after taking up 17.3 g of water vapour. The cold, moist air therefore contains less water vapour than saturated air at room temperature. This means that the cold, moist air has a relative humidity of only around 25% when heated to room temperature – and is therefore very dry – and able to take up additional moisture.

Literature

This document is based on Potthoff, M. and Dünnhoff, E. 2012. Curriculum for Specialised Training Saving Energy and Water. Energy-savings Checks for Low-income Households. Caritasverband Frankfurt e.V. The mentioned document and its related materials have been adjusted for the needs of EmpowerMed project.

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