# Saving energy

This guideline will provide an overview of the content and didactic context of the media in the media package entitled “Saving energy.”

## 1 Introduction to teaching this topic

### 1.1 Motivation for the topic

At the beginning of the 21st century, energy saving became a subject of global significance in view of the depletion of resources and climate change. Governments throughout the world are planning ways to drastically reduce energy consumption and carbon dioxide emissions. Some well-known examples include the EU Directive on “energy end-use efficiency and energy services” (2006/32/EC) and the Kyoto Protocol. If society fails to slow down the rise in global temperature, it will face drastic consequences in the medium term. The global temperature rise of nearly 1 °C at the end of 2015 is already having major impacts. Due to the melting of glaciers and arctic ice, sea levels are rising such that millions of people who live near coasts or on flat islands are already experiencing problems (for example, Maldives and Bangladesh). The number of hurricanes and tornados is increasing, and large regions of Africa, Australia, and the United States are suffering from abnormally long droughts.

Energy saving should be included under the overarching topic of sustainability and resource conservation. Whether society will now experience problems due to climate change, the dwindling of fossil fuels, or the scarcity of important minerals, or whether the drinking water supply will run out around the world (as is already the case in southern Spain and in California), ultimately all these problems are sustainability issues. Within the context of energy saving, emphasis should be placed on responsibly dealing with our basis for life, the Earth.

In this context, the connection with the topic of “switching to renewable energies” should be pointed out explicitly. Conserving fossil energy sources by using renewable energies not only reduces greenhouse gas emissions, but with enough energy, for instance, sufficient drinking water can be produced from saltwater and contaminated water. Electricity for everyone in Africa could, for example, significantly improve the educational opportunities for children there.

When it comes to this topic, energy should not be saved just for the sake of saving energy. It always depends on what energy is being used for. For example, if a poorly insulated house mainly heats the outdoors or if poor street lighting shines into the sky, saving energy is extremely sensible in this case. In contrast, if as much solar electricity as possible is produced in order to operate water treatment systems, street lighting, and factories, that is not wasted energy (one company today already uses 100 % solar electricity to produce batteries for electric cars).

Political measures alone will not make a difference unless each and every person in society changes his or her energy consumption habits.
The “Humanity Project Energy Saving” therefore begins with each person and is thus a topic with plenty of practical relevance to the everyday lives of students. The students need to recognize that energy saving is one of the mainstays of a reliable energy supply in the future. (The two other mainstays are energy efficiency and renewable energies.)
In order to understand energy saving from a scientific viewpoint, students need a basic knowledge of physics. Students should know the definition of energy itself as well as related quantities and

laws – the conservation of energy, heat, perpetual motion machine, efficiency, electric current, and electrical parameters. Since energy saving has an economic (cost saving) component as well as an ecological (environmental protection) component, the topic is relevant to economics lessons as well as environmental education (possibly cross-curricular). The presentation of modern, energy-saving technologies is an element of technology lessons. For instance, the heat insulation of buildings is particularly relevant to the subject of chemistry (for example, plastics).
A very effective way of working through the topic of energy saving is in the form of a project. In this project work, students practice a structured approach to research, documentation, assessment, and presentation while at the same time strengthening their personal skills and methodology expertise. The school campus itself is a particularly suitable subject for a project. It is important to develop students' awareness of necessary and unnecessary electric power consumption from as early as elementary school.

## 1.2 Ideas for teaching

Why is this topic so important for your students?
Teaching energy saving is educationally relevant to students now and in the future. Energy saving today secures the energy needs of tomorrow (by conserving resources) and simultaneously helps reduce pollution of the environment. The topic is also very interesting because it is a good example that the ecological and economic benefits of saving energy are not mutually exclusive. The students' personal experience related to environmental pollution should be linked with their understanding of accepting responsibility. It can be assumed that most students are already familiar with the topic of energy saving at home from family discussions about high electricity, gas, or fuel prices. When focusing on energy saving, in addition to the theoretical development of the topic, the teacher may select practical references and methods of working. As a result, it will become apparent to the students that they can play an active role and make a contribution to saving energy. The emphasis on the three subitems allows the topic to be developed, starting from the students' familiar environment, which includes their own home and school (or other institutions in the students' vicinity). Subsequently, the perspective can be expanded to include the areas of traffic and transportation as well as industry. In addition, connections between the individual areas can be emphasized. Energy saving can be handled in an interdisciplinary and cross-curricular manner, thus offering a variety of links both to scientific subjects as well as to civics and politics, economics, and ethics.

Referring to "consumption" in the context of energy is actually incorrect because according to the law of conservation of energy, energy can only be converted. In a closed system, energy is neither lost nor is new energy gained. However, because the term "energy consumption" has found its way into colloquial and commercial language, it is also used here.

### 1.2.1 Learning objectives of the energy saving topic

The general objectives of the topic, that is, higher-level learning objectives, include the following. The students should:

- recognize and understand the importance of saving energy in various areas (home, traffic and transportation, and industry).
- distinguish between ecological and economic objectives and learn to assess their compatibility.
- recognize how energy saving benefits their own future interests.
- recognize energy saving itself as a source of energy.

- develop, plan, and implement their own practical, environmentally sensitive behaviors for saving energy at home and at school.
- gain an overview of their own energy consumption and that at the local, national, international, and global levels.
- determine the energy consumption of individual applications through measurements and calculations.

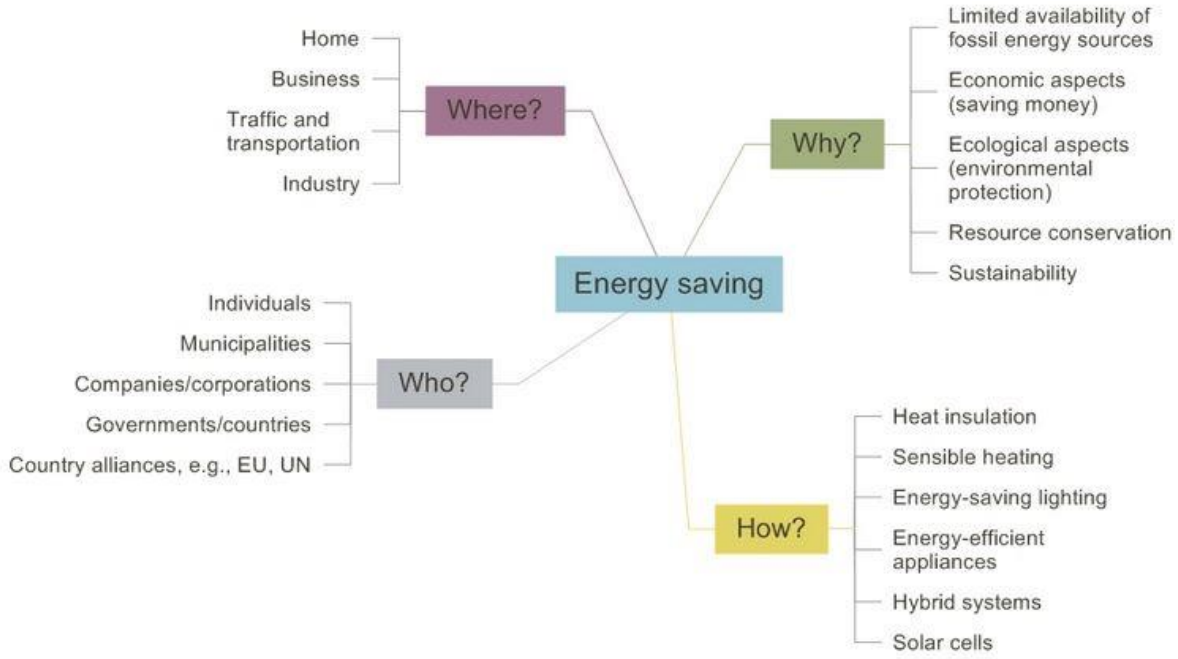
## 1.3 Methodical suggestions and teaching ideas

The topic of energy saving can be introduced with a personal connection to the students' everyday lives. Ideally, this will be followed by an intensive, theoretical, and active discussion of the contents. Lectures by the teacher and class discussions provide basic information, which can then be studied in more detail and reinforced in individual, partner, and group work. Many aspects of energy saving can be developed in an interdisciplinary manner (in scientific subjects such as physics and technology, as well as in civics and politics, economics, and ethics/religion) and offer room for experiments, surveys, group work, and projects.

## 1.4 Media selection

This media package is a themed compilation of 29 media files that are available on the media portal of the Siemens Stiftung. They are especially well suited for working through the topic of energy saving with considerable everyday relevance in teaching at secondary schools or vocational schools.
The contents of these media essentially reproduce applications and do not communicate any scientific principles (the media portal of the Siemens Stiftung offers media specifically for this purpose).
The media files in the "Saving energy" media package can be used individually and completely independently of each other by limiting the study to a particular subject.
This guideline suggests a concept whereby the media can be used in an interrelated manner in lessons at secondary schools.

The following mind map visualizes the various facets of energy saving.




Medium: Mind map: “Energy saving”

Answers to the questions “Where?” and “How?” can also be worked out in groups.

Media: Teaching idea: “Energy saving (group work, student instructions)”
Teaching methods: “Energy saving (group work, teacher information)”

The answers to the questions “Why?” “Where?” “How?” and “Who?” can be used as a central theme in the context of energy saving. The focus here is on the students’ everyday environment:

- **Energy saving – why?**
  Develop awareness
  Recognize scarcity of resources

- **Energy saving – where?**
  Home
  Traffic and transportation
  Industry

- **Energy saving – who and how?**
  What can individuals do?
  Industry
  Energy saving in electric power generation and distribution

# 2 Energy saving – why?

## 2.1 Develop awareness

In order to identify approaches to energy saving, students must first have a clear idea of the amount of energy they use every day and what that energy is used for. Their existing knowledge in this respect can be tested with the aid of an interactive matching exercise.

Medium: Matching exercise: “Everyday energy consumption”

Students will then look for further concrete examples of high energy consumption in their everyday life. An example that would have high practical relevance is the consumption of ready-made food products:

Medium: Interactive graphic: “Food production – ‘Energy hog’”

An animated video explains the effects that high meat consumption in Germany has on the whole world. Agriculture and food production now make up 50 percent of global greenhouse gas emissions.

Medium: Video: “Meat and Sustainability”

As a next step, energy consumption can be analyzed more specifically from “global” perspectives. Every single person leaves his or her “ecological footprint” on the Earth every day. This is equivalent to the ground area per human being that is necessary in order to assure production of their food, to provide energy, to break down the waste produced by them and the carbon dioxide ($CO_2$) that they release, and so on, in short, the surface area necessary to allow a human to pursue his or her accustomed life style permanently.
Using vivid illustrations, the video explains Earth Overshoot Day, the global footprint, and biocapacity.
The WWF offers a program with which you can determine your ecological footprint.
The $CO_2$ released through the consumption of energy can also be calculated online.
The links to the video and the programs related to the ecological footprint and $CO_2$ release are included in the link list.

Medium: Link list: “Saving energy”

**Tip (not only for teaching geography)**
An interesting calculation is how much ground area is theoretically available for the ecological footprint of every single inhabitant of Earth. Comparison with their “own” ecological footprint will come as a surprise to many students.

## 2.2 Recognize the scarcity of resources

Fossil energy sources are finite. The point in time when oil and natural gas will be gone can be delayed thanks to new extraction technologies, but not all that long. The estimates vary greatly. The graphic provides an overview of the years of use left for primary energy sources.

Medium: Chart: “How long will our energy sources last”

The information sheet provides data on the available energy sources, how the mix of currently used energy sources came about, and the direction in which it must and will change.
However, some scientists think that not all remaining fossil energy sources should be extracted and consumed due to the need to curb global warming. In their opinion, we have to leave a large portion of the fossil energy sources in the ground if the 2 °C goal is to be met.

Several media packages on the topic of “renewable energies” are available on the media portal of the Siemens Stiftung, for example, the “Electricity from renewable energy sources” content package for interactive whiteboards for elementary school, the “Renewable energies – The future is sunny!” media package, and the “Experimento | 10+: B6 Renewable energies” and “Experimento | 8+: B6 Renewable energies” media packages.

Medium: Information sheet: “An overview of energy sources”

For a complete picture, the global connections and key figures should be viewed. The students will also learn the unit “toe” (tonne of oil equivalent).

Media: Chart: “Global primary energy consumption”
Chart: “Global energy supply – future development”

A comparison between countries related to energy production, total energy consumption, and energy consumption per capita can be used to encourage reflection and discussion.

Medium: Matching exercise: “Energy consumption – comparison between countries”

# 3 Energy saving – where?

## 3.1 Home

Energy saving in the household area starts with an analysis of consumption of primary and secondary energy sources in the form of useful energy. The next step is to ask what this energy is used for in the home and how much energy is used. These analyses reveal the potential energy savings of a household, allowing energy-saving measures to be developed. It is assumed that a modern household in an industrialized country is equipped with a large number of electrically operated appliances and devices. In addition to household appliances, communications devices, lamps, and air conditioners, electrical devices such as electric motors in heating systems are not as obvious but must also be taken into account. A substantial number of electronic controllers in modern devices as well as all the consumer electronics should also be considered. However, in households, the largest portion of energy is used for heating the living areas and water. Primarily the energy sources heating oil and natural gas are used for this.

The students can read the consumption values from the charts. However, they can also take consumption measurements themselves in the experiment and calculate household consumption using their measured values.

Media: Chart: “What do private households use energy for?”
Experimentation instructions: “Tracking down ‘energy hogs’ (student instructions)”
Chart: “Energy consumption of household appliances”
Teaching methods: “Tracking down ‘energy hogs’ (teacher information)”
Answer sheet: “Tracking down ‘energy hogs’ (answer sheet)”

The students will likely be very interested in knowing their personal everyday energy demand. They should list in the table all heated rooms where they spend time (for example, the living room) and that thus contribute to their energy consumption.

Medium: Inquiry task: “My everyday energy demand (inquiry task)”

For the students, their smartphones most likely top the list of electronic devices that require energy every day. People often think only of the electricity that is needed to charge the device. The interactive graphic shows that even more factors must be considered. Not to be forgotten is also the fact that production of a smartphone is extremely energy intensive. Disposal also uses a lot of energy. The students should be aware of this if, for example, they get a new smartphone every year.

Medium: Interactive graphic: “Communication costs energy”

## 3.2 Traffic and transportation

Around the world, traffic has developed into a major problem in terms of environmental pollution. It is not only the emissions of the greenhouse gas $CO_2$ (and hydrofluorocarbons from air conditioners), but also the pollution of the environment from nitric oxides and particulate matter. These nitric oxides increasingly jeopardize human health, especially in densely populated areas such as large cities, intensified by the formation of smog. In the end, this smog is a combination of ozone, nitric oxides, and their secondary photochemical products in reaction with hydrocarbons and particulate matter. It results in ailments including asthma and cardiovascular problems. Moreover, nitric oxides cause serious harm to vegetation, primarily through damage to deciduous trees.

Particulate matter, especially soot but also dust from tires and brakes, also affects human health and leads to ailments such as cardiovascular problems and lung cancer.

Additionally, most means of transportation that rely on oil-based fuels (gasoline, diesel, kerosene) perform rather poorly in terms of climate footprint.
For instance, in a car with a combustion engine, only approx. 10–15 percent of the energy content of the fuel is converted to propulsion, while a state-of-the-art electric vehicle already reaches up to 70 percent. When the energy balance is considered over the complete life cycle (extraction of raw materials, production, operation, recycling, disposal), an electric vehicle at 410 GJ performed significantly better compared with a car with a combustion engine at 550 GJ in late 2014 (presentation by Prof. Ulrich Wagner, German Aerospace Center (DLR) and the Research Center for Energy Economics (FfE) at the ENERGY university day in September 2014). This information is still based on a power mix with 23 percent electricity from renewable energies. As the proportion of renewable electricity increases in the power mix, the energy balance for electric vehicles will become even

better, while the combustion engine has very little potential for improvement. (This is determined by the law of nature; while an electric motor already achieves over 95 percent efficiency today, a combustion engine cannot rise much above 50 percent according to the second law of thermodynamics).

Energy saving in traffic and transportation can simultaneously improve the environment and human health by contributing to ecology and sustainability. The students can research and discuss a whole range of examples related to practical everyday life.

One example is energy-saving forms of transportation, such as “rail instead of road” for freight transport. Other examples are topics that directly affect the students and their parents, such as forming car pools, car sharing, traveling by train instead of by air, and limiting long-distance travel.

A very hot topic would be researching (for example, through surveys among classmates) and discussing a trend that is disturbing to the auto industry – the fact that the majority of adolescents (especially in urban areas) do not even want their own car.

Another example would be the following work assignment:
Based on the values provided for a high-speed train, the students will estimate the $CO_2$ emissions and energy demand of other means of transport and enter the values in a table. After doing research in group work or individually at home, they will then enter the actual values in the table and compare them with the estimated values.

Media: Worksheet: “Energy comparison of means of transport (worksheet)”
Teaching methods: “Energy comparison of means of transport (teacher information)”

## 3.3 Industry

Industrial plants have relatively high energy requirements, depending on their type and size. A great deal of electricity is used, especially in the chemical industry, in iron and metalworking, and in wood and paper production. Some companies in the chemical industry operate their own power plants to cover their energy needs. Energy is also used for the lighting and air conditioning of shopping malls and large office buildings.

In industry, energy is required for the following areas:

- the operation of machinery, control systems, and computers and servers (the latter usually interruption-free)
- lighting
- heating and air conditioning
- the cooling of systems, machinery, and servers

# 4 Energy saving – who and how?

## 4.1 What can individuals do?

Three pictures, one of them a negative example, provide an introduction to measures that certainly can be named immediately.

Media: Photo: “Waste of energy”
Photo: “Energy efficiency class”
Photo collage: “Everyday energy-saving lighting”

There are three possibilities for saving energy, that is, electricity, natural gas, and oil, in a household:

- The development and use of efficient appliances and highly efficient lighting (for example, energy-saving light bulbs)
- The conscious handling of energy by each individual (for example, avoiding stand-by operation and the constant heating of unused rooms)
- Expansion in the use of renewable energy sources, such as solar thermal energy and photovoltaic systems

In the interactive task, the students can match specific energy-saving tips to the energy-saving areas “electricity,” “heating,” and “hot water.”

Medium: Matching exercise: “How can you save energy at home?”

So-called passive houses that do without a conventional heating system are becoming increasingly popular. The heat needed for heating the house is extracted entirely from the environment (solar irradiation, ambient air, waste heat dissipated by appliances, etc.).

Medium: Labeled graphic (interactive): “The passive house”

**Tip for physics and chemistry lessons (for secondary schools)**
The refrigerator is a popular example in connection with energy, heat, and cyclic processes. It is a particularly good model for illustrating the second law of thermodynamics (heat can of its own accord flow only from hot to cold, not in the other direction). (For basic physics, there are separate media available on the media portal of the Siemens Stiftung.) However, energy-saving technologies can also be demonstrated using, for instance, the example of the heat insulation of a refrigerator of energy efficiency class A.

The government has already taken steps to regulate lighting. The EU has adopted a gradual ban on the production and distribution of incandescent lamps. It is evident from the comparison of an incandescent lamp, energy-saving light bulb, and LED lamp that this action is expedient.

Medium: Graphic: “Means of lighting in comparison”

## 4.2 Industry

Primary energy sources are saved as resources for industrial companies primarily by means of increasing efficiency, which is achieved by increasing the efficiency of plants and machinery. An-

other energy-saving aspect in industry is the further use of resulting process heat, for example, for the production of steam or hot water.
Possible energy-saving measures include the following:

- Sensor-activated or computer-controlled lighting
- Use of energy-saving light bulbs
- Use of modern building technology (for example, for central control of ventilation and air-conditioning systems)
- Separate control of the heating circuits
- Use of process heat
- Structural measures, such as heat insulation
- Use of efficient machines
- Use of renewable energies
- Energy-saving heating, ventilation, and air-conditioning systems

It may be helpful to establish an energy strategy to determine sensible energy-saving measures for each respective industrial company. After the energy demand has been analyzed and potential energy savings have been identified, the strategy provides binding energy-saving measures. Although the implementation of energy-saving measures in industry is predominantly associated with investments, for example, retrofitting a plant with efficient machinery or structural measures, this pays off economically in the long term and simultaneously helps protect the environment.

## 4.3 Energy saving in electric power generation and distribution

In view of declining resources, energy saving itself is often referred to as an “energy source.” This seems to be a contradiction because how can savings serve as the source for something new? To resolve this apparent contradiction, the teacher can show the students the following graphic.

Medium: Schematic diagram: “Energy saving as an energy source”

**Tip for technology lessons (for secondary schools)**
New energy-saving technologies are constantly being developed, particularly in connection with a sustainable electric power supply for humanity – starting with the conversion of primary energy sources to electrical energy in power plants up to and including the distribution of electric power to consumers. Keywords for modern technologies of this kind are “combined cycle power plants” (CC) and “high-voltage direct-current transmission” (HVDCT). Numerous related media are available on the media portal of the Siemens Stiftung.