Basic Information

The Five Forms of Renewable Energy

Energy is the issue of greatest importance to our future. Where will it come from? What alternative forms and sources of energy are available? Beginning in April 2011, the Welios® - Science Center Wels will face the question of what effects alternative energy supply systems will have on our everyday life. What do solar energy, hydroelectric and wind power, geothermal energy and biomass have to offer us? Here's an overview.

Biomass: Humankind's first form of renewable energy

As far back as 790,000 years ago, humanoids used wood to provide heat and to burn bones. Nowadays, we use just about every organic material—things that are alive or once were—as a source of energy. We call it biomass. Water, carbon dioxide and sunlight are the ingredients of photosynthesis that makes plants grow. This is how solar energy is stored in the form of chemical energy in plant matter. In practical terms, this means that energy can be derived from the organic waste of households, restaurants and farms. On one hand, this material can be burned to provide heat. The simplest way to go about it is to burn wood, wood pellets or similar products and use the thermal energy generated thereby.

Another possibility is to apply one of the various techniques to transform biomass into easily usable energy. Via pressing, biological fermentation and chemical conversion, biomass can be used to produce fuels. Biodiesel is derived from canola, sunflowers and other oleaginous plants. The oil pressed out of the seeds is converted by a chemical process. Bioethanol and biogas are produced through fermentation processes (conversion of biological materials by certain cultures or bacteria) working on organic waste or plants like sugarcane and sugar beets cultivated especially for this purpose.

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Thus, it's also possible to produce electricity from bioethanol or biogas with a generator driven by an internal combustion engine. Taking advantage of the heat this gives off – as is done in a thermal power station – is referred to as cogeneration. The use of biomass can be adapted to different needs and, in contrast to energy from wind and solar power, is independent of the weather.

Advantages:

- Biomass is partially available free of charge in the form of organic waste.
- Biomass can be used in very diverse ways since it can be converted into different products: biogas, biodiesel, bioethanol or pellets.
- Fuels derived from biomass can be used just like fossil fuels.
- Biomass is constantly available regardless of wind or weather conditions.
- Plants like rapeseed can be cultivated without undue expense and have a high energy content.
- Fuels produced from biomass can be inventoried and thus serve as energy storage media.

Disadvantages:

- There is direct competition for available land between plants used to derive energy and plants that serve as foodstuffs.
- In some cases, primeval forests are being cleared to obtain land on which to cultivate plants for biomass.
- This competition for available land makes foodstuffs more expensive.
- Cultivating plants to derive biomass is not possible to an unlimited extent.

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Geothermal energy: The only renewable form of energy that is not derived from the Sun

The Earth's core is incredibly hot. Prevailing temperatures there exceed 5,000° Celsius. This is, in part, a remnant of heat generated when the Earth was formed; some of it is the result of radioactive decay in this planet's various subterranean layers. This tremendous heat is enough to melt rock. Fascinating natural spectacles like geysers and volcanic eruptions are manifestations of geothermal energy, whereby temperatures reaching 1,250° C are observed on the Earth's surface, where the ambient temperature normally prevails. The closer you get to the Earth's core, the hotter it gets. Descending through the Earth's crust, the temperature rises by about 3° C per 100 meters of depth. Geothermal energy takes advantage of this heat from the Earth's interior.

This geothermal energy can even be used to power an air conditioning system. Only a few meters below the Earth's surface, the mean temperature is a constant 10° C, and this geothermal energy available close to the surface can be used to heat or cool houses. Geothermal probes or collectors make it possible to transport this warmth to the surface, and heat pumps feed it into the house's heat circulation system.

It is also possible to exploit geothermal energy from much deeper rock strata. The heat has to exceed 100° C for electricity generation to make economic sense. The heat is brought to the surface with the help of a fluid such as water, which is either already present in the layer of rock or is pumped into it. Then the thermal energy is transferred to another fluid that is used to provide heat or generate electricity. Note: The faster temperatures rise with increasing depth, the more favorable are the conditions for the use of geothermal energy.

Advantages:

- Geothermal energy can be used throughout the year regardless of the weather or the time of day.
- Near-surface geothermal energy is available everywhere.
- Geothermal energy requires little space because most of the infrastructure is situated below ground.

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- Heat pump technology has been fully perfected, so it is very cost-efficient to extract geothermal energy from just below the Earth's surface.
- Exploiting geothermal energy produces no CO_2.
- The amount of energy extracted can be regulated and thus precisely adjusted to needs.

Disadvantages:

- Deep-lying geothermal energy requires extensive drilling, which means high costs.
- Deep-lying geothermal energy cannot be used everywhere in a cost-effective way.
- Drilling and pumping water into geological formations can cause them to shift or collapse.
- The water bringing deep-lying geothermal energy to the surface may also contain poison gasses and salts.

Solar energy: The Sun is a practically inexhaustible power plant

Our Sun constantly radiates inexhaustible quantities of energy out into the universe, and scientists estimate that it will continue to do so for the next five billion years. This energy is produced by nuclear fusion in the Sun's core, whereby hydrogen is converted into helium and energy is released as radiation. A portion of this energy reaches the Earth in the form of sunbeams.

We notice just how loaded with energy this radiation is when, for example, we get a sunburn. The Sun is the driving force of life on Earth and of our planet's climate. The sum of all the solar energy that reaches Earth is enough to cover humankind's energy needs 5,000 times over. The big technical challenge is to concentrate the energy contained in these rays of sunlight distributed all over the surface of the Earth.

We use solar radiation to produce heat and electricity. But is it also possible to use the warmth of the Sun to heat directly? When the Sun shines on objects, they heat up. We quickly become aware of this when we, for example, walk barefoot across hot sand. Passive heating of buildings takes advantage of this effect—large windows and well-insulated walls make conventional heating almost

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unnecessary. Solar panels, on the other hand, use this energy actively. A carrier medium such as water is heated up, transports the warmth and feeds it into the building's heating system.

Solar thermal power plants generate electricity by using giant mirrors to concentrate the Sun's rays. This results in such high temperatures that it produces steam that can drive a generator and, in turn, produce electric current. Photovoltaic plants, on the other hand, transform sunlight with the help of semiconductor materials like silicon directly into electrical energy. Since photovoltaic energy equipment needs a lot of space, it is ideal for small, individual energy consumers—for instance, on the roof of a house.

Advantages:

- The Sun's radiation is present almost everywhere.
- The use of solar energy is possible even on a very small scale; the infrastructure can be decentralized.
- Solar energy can be used to produce warm water and electricity.
- Photovoltaic equipment converts sunlight directly into electricity.
- Photovoltaic energy production does not result in the emission of CO_2 or toxic substances.
- The technology for producing warm water in small-scale plants is proven and reliable, which means it is economically viable.

Disadvantages:

- Because the energy density is low, a tremendous amount of space is necessary to produce electricity on a large scale.
- The yield fluctuates to a great extent because of its dependency on weather conditions.
- Since no energy can be produced at night, additional storage systems are necessary.
- The production of the photovoltaic cells themselves emits toxic materials such as cadmium and CO_2.
- The efficiency of solar cells diminishes over their productive life by 1% per annum on average.

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- The efficiency of solar cells diminishes when the temperature exceeds 25° C by 0.3% for each additional degree Celsius.

Hydroelectric power: The Sun empowers enormous quantities of water

71% of the Earth's surface is covered by water, of which the largest quantity is in the oceans. On their surface, water is warmed by the Sun and evaporates. As this water vapor rises up into the atmosphere, it cools. This leads to the formation of clouds and then water droplets or ice crystals, which fall to Earth as rain or snow. The average altitude of this planet's continents is 800 meters. The Sun thus imparts potential energy to water. This energy is utilized by hydroelectric power plants.

Due to oceanic currents, the tides and waves, enormous quantities of water move about in the oceans. Human beings are also attempting to harness the kinetic energy of this water. Hydroelectric power thus takes advantage of both the potential and kinetic energy of water. Currently, the focus of R&D efforts is on wave power plants. After all, any form of water in motion can be utilized to generate energy. In mountainous regions, water's energy is exploited by hydroelectric power plants. Here, water is stored in large reservoirs and then piped through long downspouts into a turbine. Its rotary motion drives a generator that produces electricity. The same principle is used on rivers or in the seas.

Reservoirs can hold tremendous amounts of water. Thus, hydroelectric power is very important for the storage of energy. Whereas energy production with sunlight and wind is dependent on the weather and seasonal factors, hydroelectric power is independent of them. Energy produced by other means is used to pump water to high-altitude reservoirs. Then, at times when the Sun does not shine and there is no wind, energy requirements can be covered by hydroelectric power.

Advantages:

- Hydroelectric power generation has been going on for decades; thus, the technology is proven and reliable.

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- The operation of hydroelectric power plants produces no harmful emissions.
- State-of-the-art technology delivers a high degree of efficiency.
- Pumped-storage power plants can also be used for energy storage purposes.
- As a rule, hydroelectric power is available continuously.
- Waves and oceanic currents represent a potentially enormous source of energy.
- Hydroelectric power projects often include flood prevention measures.
- Hydroelectric power plants often have a very long productive life—up to 100 years.

Disadvantages:

- Building hydroelectric power plants and the reservoirs to feed them necessarily entails a radical intervention in the natural environment.
- Large-scale hydroelectric power plants can be built only at certain locations and the electricity often has to be transported over long distances.
- Hydroelectric power plants are extremely expensive to build.
- Most of the very attractive locations are already being used for this purpose; thus, a significant expansion of conventional hydroelectric power generation is hardly possible.
- Hydroelectric power plants have an impact on the ecosystems of local waterways.

Wind power: It all begins with the Sun

Wind power is one of the oldest forms of renewable energy. It is the result of pressure differences in the atmosphere, which is why it is constantly dependent on the weather. Wind is the outcome of differential warming of the Earth's surface by the Sun. For example, the poles warm less than the equator, the oceans slower than landmasses, and mountains differently than valleys. This differential warming leads to pressure differences in the atmosphere. Winds equalize these air pressure differences. So, as long as the Sun shines, winds will blow across the face of the Earth, and this is why wind is a form of renewable energy. Wind power is usually converted into electricity. Nowadays,

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there are few remaining windmills that directly use the mechanical energy of the wind—for instance, to grind grain into flour.

Wind has energy due to its speed. Human beings have taken advantage of this energy—for example, by constructing sailboats for wind-driven transportation. In windmills, the power of the wind turns a wheel and thus produces mechanical motion. Modern wind power plants utilize this principle. They exploit the force of the wind to turn rotor blades that, in turn, power a generator to produce electricity. The output of such wind power plants fluctuates greatly in accordance with wind velocity. Since it is constantly windy in coastal areas, they offer the most favorable conditions for the operation of wind power plants. At present, large offshore windparks are being built out at sea where there is nothing to impede the wind. Wind power plants are built above all in regions with constant wind. The Province of Lower Austria has a favorable topographical situation. There are few usable locations in Upper Austria.

Advantages:

- The technology of wind power plants is proven and reliable; they thus deliver electricity at a relatively low price.
- The cost of a wind turbine is recaptured after only six months in operation producing energy.
- Wind power requires relatively little space – for example, in comparison to photovoltaic infrastructure.
- Adjacent lands can continue to be used for agricultural purposes.
- There is tremendous potential for expansion of wind energy – first and foremost in the form of offshore parks.
- Particularly during the cold half of the year, there is sufficient wind available, which thus provides a good supplement to solar energy.
- Wind power generating equipment can also be decentralized, which avoids energy loss through transportation.

Disadvantages:

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- The output of wind power plants fluctuates dramatically with changing weather conditions.
- For continuous usage, storage systems are necessary.
- Erecting wind turbines has a high-profile negative impact on the landscape. The turbines' rotating blades cast moving shadows onto adjacent real estate.

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