Water as an energy source

The history of using water as an energy source goes back far into the past. Great river cultures centered on the Nile, Euphrates and Tigris, and along the Yellow River and the Indus, used water to drive a wide variety of work machines. In the Middle Ages in Europe, the most important centers of trade sprung up where the rivers were. And the rapid progress of industrialization and the standard of living achieved in the 19th century is due in large part to hydropower. In light of declining supplies of fossil energy sources and the anthropogenic strengthening of the greenhouse effect, water is a more attractive energy source than ever. After all, water covers more of the Earth's surface (approx. 70%) than land.

Various power plant technologies now make it possible to generate useful energy from water's energy forms. Water can carry the following forms of energy:

- Rivers and ocean waves possess mechanical energy (potential and kinetic energy).
- Hot water or steam (created in a boiler or drawn from the depths of the Earth) possesses thermal energy.
- The decomposition of water as a chemical compound of hydrogen (H_2) and oxygen (O_2) can be used as a chemical energy store.

Water as a carrier of mechanical energy

The mechanical energy of water is generally called "hydropower" or "hydroenergy". It is a renewable energy. The ultimate source of this energy is the same as for other renewable energy sources (including biomass, wind energy, and solar energy) – the sun. By human standards, hydropower, like the sun itself, is considered a nearly inexhaustible energy source.

How is hydropower created?

First, water evaporates, primarily over the oceans, and rises into the atmosphere. If the evaporated water encounters colder air layers, it cools and condenses to create clouds. The wind carries the clouds over land. The moist air inside the clouds may cool further – if it rises over a mountain, for example – and if the clouds become supersaturated, the condensed water falls back to Earth as precipitation (rain, snow, hail). From these high elevations, the precipitation flows in the form of streams and rivers back toward sea level; appropriate technology (dams, hydroelectric plants, etc.) then enables us to "generate" power from the water. The process of harnessing hydropower from ocean waves is similar: wind (for which the sun is also the "engine") sets the water in motion.

How is hydropower used?

Prior to the industrial age, water was used as an energy source to directly drive technical devices. The potential energy (height difference) and kinetic energy (speed of flow) in the flowing water was converted to mechanical rotational energy (kinetic energy) using a waterwheel and used to operate tools such as mills, sawmills, and hammer mills. Since electrification, hydropower has been used indirectly in power plants with the help of turbines to drive generators that in turn generate electrical energy.
The moving and flowing water masses in our oceans also contain enormous amounts of energy that we are trying to utilize with mechanical (for example, tidal power plants and marine current power plants) and thermal technologies (utilization of the temperature difference between the sur-

face and the depths of tropical oceans with ocean thermal gradient power plants). However, the commercial use of ocean waves and currents is still in its infancy.

Place of hydropower in energy "generation"

Hydropower is currently the only renewable source of energy that is making a significant contribution to supplying energy to the world's population. Hydroelectric plants provide about 17 % of the world's electricity supply. This is almost exactly the amount of energy generated using nuclear power. Other renewable energies such as solar, wind, geothermal, and biomass only contribute a total of about 2.1 %.
Natural and geographic factors play an important role in hydropower – for example, it is helpful to have many bodies of water with the necessary fall in elevation. Particularly in developing countries, hydropower provides about 45 % of total electricity supplies. It is the most important source of electric power, even more important than oil, and should be significantly expanded. Particularly in the countries of Asia, Africa, and Latin America, appropriate hydropower reserves are available. The largest hydroelectric plant in the world, which provides up to 14,000 MW of power, is currently (2008) the "Itaipu" plant in Brazil, South America. The Three Gorges Dam and its hydroelectric plant in China will provide more than 18,000 MW of power when its last phase is completed (2009).

Country	TWh[1]	Share[2] (%)	Country	TWh[1]	Share[2] (%)
Norway	132	96	**France**	56	10
Brazil	369	84	**India**	124	15
Austria	37	55	**Japan**	83	8
Canada	369	58	**USA**	275	6
Sweden	72	45	**Germany**	24	4
Russia	179	18			
China	422	13	**World**	**3,110**	**16**

[1] Power generation from hydropower, [2] Share of national power generation. These values are for 2007 and were calculated on the basis of values from 2005-2006 IEA statistics (current as of July 2008).

Water as a source of thermal energy

How is "hot" water created?

Water is heated in a boiler by adding energy, for example, by burning a fossil energy source. Under normal pressure, water turns to steam at 100 °C. Geothermal heat is a special case: at depths of 1,000 to 2,500 meters below the surface of the Earth, there are layers of rock through which thermal water flows at temperatures of 50 °C to 60 °C. The water is heated by the heat from the molten core of the Earth.

How is the water's heat put to use?

In the early years of industrialization, steam engines used steam energy to generate mechanical energy to drive vehicles and mechanical machines. Today, steam is used at power plants as a working medium for steam turbines: the hot steam drives the blades of the turbine, which then

power a generator. The final product is electrical energy. In households, the energy of hot water is used to feed boilers and process water circuits (for example radiators, solar collectors).
At geologically suitable locations such as active volcanoes or Molasse Basins, hot water can be collected using heat pumps. It is also possible to use thermal energy from tunnels (for example tunnel water exiting the Gotthard Basin tunnel at temperatures of 34 °C) and mines (temperatures from 60° to 120 °C, depending on the depth).

Heat-carrying water as a climate regulator

Water plays a very special role as a carrier of heat for the Earth's climate. The water cycle controls the transport and release of heat energy into the atmosphere. The circulation of cold and warm ocean currents also helps regulate the climate: For example, the Gulf Stream in the Atlantic transports warm water, acting like a large heater for parts of Northern and Western Europe.

Water as a heat carrier of chemical energy

During the oxidation of hydrogen (H_2) with oxygen (O_2), water (H_2O) is created, and energy is released in the process.

Hydrogen: Decomposition of water as a chemical energy store

If water (H_2O) is separated into H_2 and O_2, the same amount of energy must be used that will be "generated" later during combustion. The hydrogen gained in this way is thus a chemical store for other forms of energy.
In principle, H_2O can undergo thermal ("thermolysis") or electrical ("electrolysis") decomposition. Both are technologically proven processes. If the energy for decomposition comes from the wind or from the sun, the H_2 collected is a carbon-neutral energy source. H_2 can then be burned directly to "generate" heat energy. Even more efficient is "cold combustion" in fuel cells, where the reaction energy is converted to electricity rather than heat. This technology is environmentally neutral when it uses hydrogen generated using renewable resources. The end product of hot and cold combustion is always environmentally friendly H_2O.
Currently, H_2 is being tested as an energy source for fuel cell systems for various automotive and marine applications and as a portable power supply for electrical devices. In the chemical industry, H_2 can also be used as an elementary raw material. Since the supply of wind and solar energy can fluctuate strongly, many experts see the environmentally friendly H_2 as an ideal energy store for renewable energy "generation."