The way to new energy sources

Fuel cell exhibition

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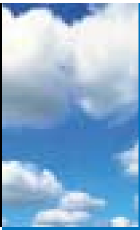


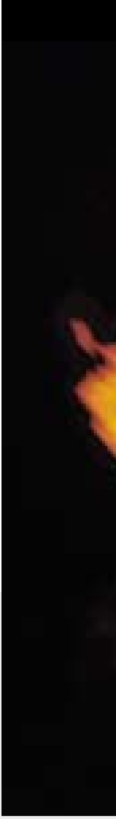
Bewag Aktiengesellschaft ranks among the most efficient electricity and district heat suppliers in Western Europe. Most of its electricity and heat is supplied by plants using the ecofriendly and energy-efficient process of combined heat and power generation. The future will see existing centralized supplies being complemented by locally installed fuel cells. Combined with hydrogen, they may well become a key component of modern energy supply.

The fuel cell demonstration project. Bewag has always been highly innovative, paving the way for new technologies in the energy sector. The Berlin fuel cell project builds on this tradition. For the first time in Europe, the so-called PEM fuel cell technology is being tested here on a pilot scale as part of a joint project with Hamburgische Electricitätswerke AG (HEW), the French energy company Électricité de France, PreussenElektra Aktiengesellschaft (now E.ON Energie AG) and Vereinigte Energiewerke Aktiengesellschaft (VEAG).

The fuel cell exhibition underscores Bewag's commitment as an innovative and conservation-minded company. It illustrates the importance of the fuel cell, addresses current problems in energy supply and shows ways to their solution.

Some 80,000 years ago, man learnt to harness energy

In the beginning there was the Fire.

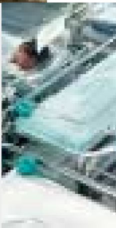


To fully appreciate the importance of future-oriented energy sources such as the fuel cell one has to take a close look at the past.

Our ancestors had been experimenting with naturally occurring fire for a long time before they learnt how to light a fire themselves about 80,000 years ago. Only those who had lasting possession of this element that gave them light and heat were able to survive.

The tribes of prehistoric times formed and grew around these fireplaces. The flames afforded them protection against wild animals and provided heat, which was particularly vital during the freeze of the Ice Age. Man soon discovered that fire could turn indigestible or even inedible produce into palatable food. And last but not least, these fireplaces may well have played a major role in the social development of our ancestors. No doubt, they were focal points of social life where group members gathered to exchange experience and plan further undertakings.

The harnessing of fire must count among the most important technological achievements of all time, and it was a crucial step in the evolution and survival of mankind.



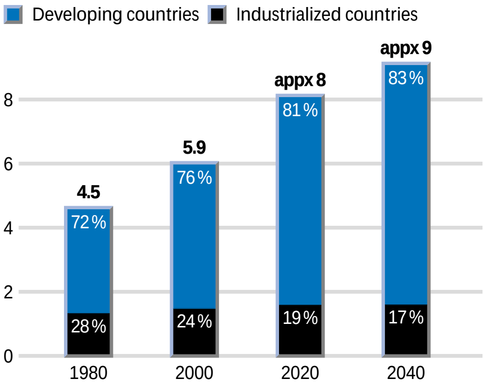
Worldwide resources are finite

The limits of growth.

Never before have so many people inhabited our earth – a development bound to continue most dramatically. While the first billion was marked in 1804, it took only until 12 October 1999 for the world's population to top six billion people. It is uncertain whether the 21st century will see the world's population grow to nine, eleven or even fourteen billion. This will depend on how effective family planning programs prove to be.

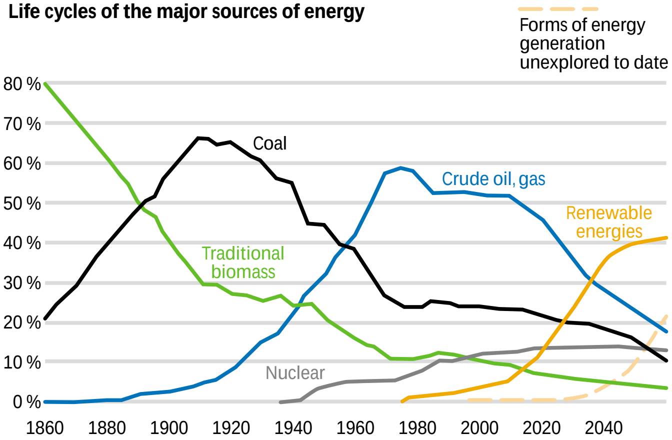
But with every new citizen in the world, energy usage, too, increases, and with it the consumption of fossil fuels (coal, crude oil, natural gas). Managing population growth and global energy supplies is becoming more and more of a key issue for the future of mankind.

Global population breakdown (billion people)



If present usage levels are sustained, fossil energy resources created over several hundred millions of years will be used up within just a few generations. Opening up new deposits requires an ever increasing technological input, becoming more and more expensive. Until 2020, most of the globally rising energy demand is expected to be met by crude oil and natural gas. Any reorientation in energy supplies will depend on whether technologies for generating and storing renewable energies can eventually compete with fossil fuels.

Life cycles of the major sources of energy



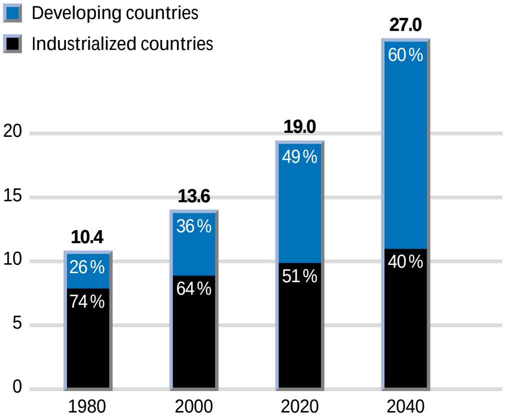
The environment pays a high price for progress

Civilization in an energy frenzy.

Today, we use worldwide twice as much energy as in 1960. By 2050, this amount will again have doubled.

In Europe, the per capita energy usage per year amounts to 5 tonnes of coal equivalent (tce), while North America accounts for up to 13 tce. By contrast, the developing countries use less than 1 tce per person and year. The industrialized world, that contributes only 15 percent to global population, therefore has a special responsibility with a view to meaningful management of the world's energy reserves.

Forecast of global energy consumption in billion tce
(tonnes of coal equivalent)



The carbon dioxide content in the atmosphere is increasing. Although its impact on global climate has not yet been fully explored, provisional computations suggest that the mean air temperature will rise by 1 to 3.5 Kelvin worldwide until 2100. Scientists speak of an artificial greenhouse effect. A drastic rise of the sea level, flooding of coastal areas and the spreading of arid regions are only some of the potential consequences. No immediate solution is in sight. It seems the only way out of this impasse can be provided by new, carbon-free energy sources and entirely different energy conversion techniques.

Bewag's commitment

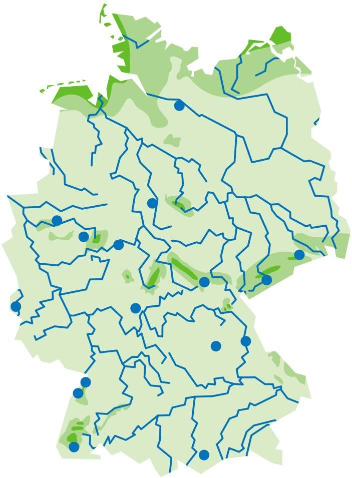
Until coal, oil and gas can be replaced by other energy sources, the technological challenge is to extract as much useful energy as possible from these fuels while markedly relieving the burden on our environment. One of Europe's most modern power plants, Bewag's Mitte thermal power plant, can do both: Combining gas and steam turbine technology and co-generation of electricity and heat, it utilizes up to 90 percent of the fuel energy and makes a significant contribution towards reducing CO_2 greenhouse gas emissions.

Wind and water have served us as energy sources from time immemorial

Natural alternatives.

Trade in the ancient world, the discovery of America and the British Empire – without sailing ships driven by wind power, the history of mankind would certainly have taken a different course. Nowadays, modern wind-driven generators symbolize progress and development. With nearly 10,000 wind farms, Germany is number one worldwide. With their total nameplate capacity of currently more than 6,100 Megawatts they meet 2.5 percent of our electricity demand. This share in supply is bound to distinctly increase as a result of the Renewable Energies Act of 1 April 2000. The economic efficiency of these systems, however, will remain limited due to its dependence on the prevailing winds. Many coastal areas offer large wind-energy potentials that can be utilized by installing special offshore systems.

5,500 hydroelectric power plants with a total nameplate capacity of 4,600 Megawatts cover three percent of Germany's electricity needs. However, the use of hydros has only a limited potential for extension due to considerations of nature conservation.



Wind velocities in Germany

- 4–5 m/s
- >5 m/s

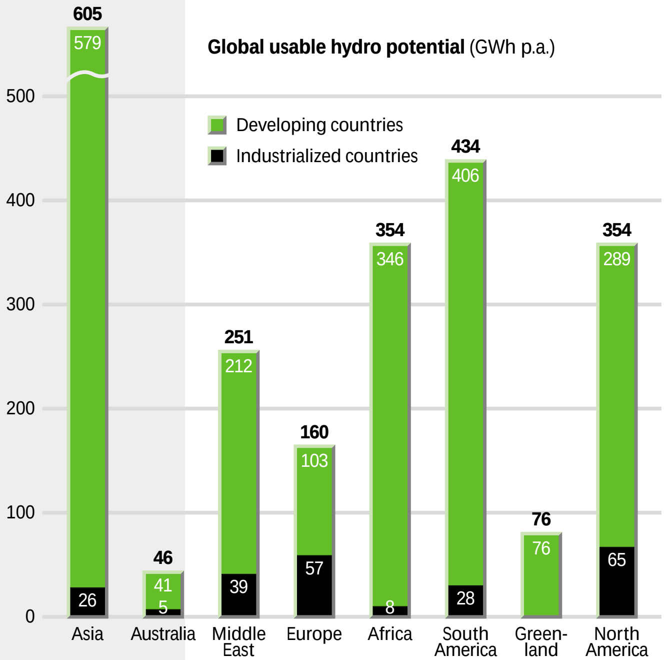
Hydro power plants in Germany

- >10 MW

High time we utilized the assets of the sun

Galactic potential.

Most renewable energy resources can be traced back to solar radiation. The amount of energy the sun radiates to our planet per hour is equivalent to the annual energy consumption of all mankind. The difficulty of technically exploiting renewable energy forms (solar energy, wind energy, hydro power and biomass) on an industrial scale results from our inability to bridge the gap between the temporal and regional energy availability on the one hand and permanent global energy needs on the other. Not until the problems of storage and transportation have been solved, and fossil fuels have become more expensive due to their scarcity, will this change, and only then will the share of renewable energies in world energy usage rise significantly.



Bewag's commitment

For years, Bewag has supported the utilization of renewable energies. Following its own first pilot plants using solar and wind power in the 1980s, activities have been steadily expanded. Since 1997, Bewag has invested DM 40 million as part of its "Energy 2000" program, to promote photovoltaic systems, in particular. In line with market requirements, this commitment is being consistently pursued, for example by offering the "ÖkoPur" eco-electricity product that is generated entirely from renewable resources.

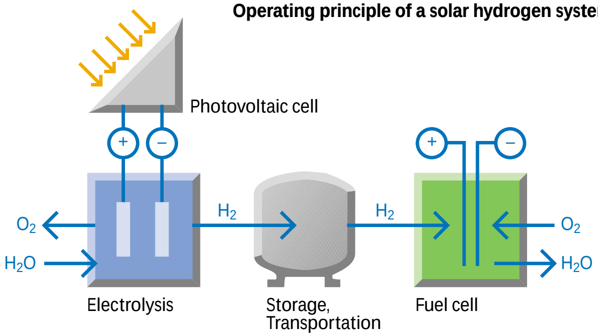
Bewag

Infinite amounts of electricity and heat

The sun shines at night.

As soon as we are able to efficiently store solar energy, we will have infinite amounts of electricity and heat available – even at night. The fluctuations in the availability of renewable energies necessitate a secondary energy carrier. Hydrogen lends itself well to this purpose as its storage behavior is clearly superior to that of a battery. Hydrogen can be extracted from water via electrolysis, and easily transported. The power needed to do this can be generated in an ecofriendly fashion – for example by using a fuel cell to turn hydrogen into electricity and heat at the point of usage. This would allow the uninterrupted utilization of solar and wind-based electricity. Hydrogen generated on a renewable basis makes it possible to meet the electricity demand precisely when it occurs.

Operating principle of a solar hydrogen system



Hydrogen stores renewable energies

The future's name is hydrogen.

Hydrogen occurs in nature only in chemically bound forms, mainly in water, which is available in abundance. Seventy five percent of the surface of our planet is covered by water. To use the hydrogen, though, it has to be separated from its chemical partner. There are a number of technologies to do this. Electrolysis splits water into the gases hydrogen and oxygen. In steam reforming, energy (natural gas) is used to split hydrogen from the water vapor. Other appropriate processes are catalytic high-temperature splitting of water, and the use of hydrogen-producing bacteria.

The generated hydrogen is stored in pressure gas tanks or liquefied gas tanks. Hydrogen turns liquid at –254 °C. Technically, this is achieved by compressing and cooling it with liquid nitrogen. Existing infrastructures such as pipelines or tanker trucks can be used to transport it. Hydrogen is no more hazardous than, for example, natural gas, propane, gasoline and fuel oil.

Bewag's commitment

Bewag

The Berlin fuel cell project provides a demonstration of a future hydrogen-based generation sector in the Berlin borough of Treptow under real-life conditions. The hydrogen is produced in an electrolytic process using electricity generated by photovoltaic cells. The resulting gas is then used in the fuel cell to produce energy.

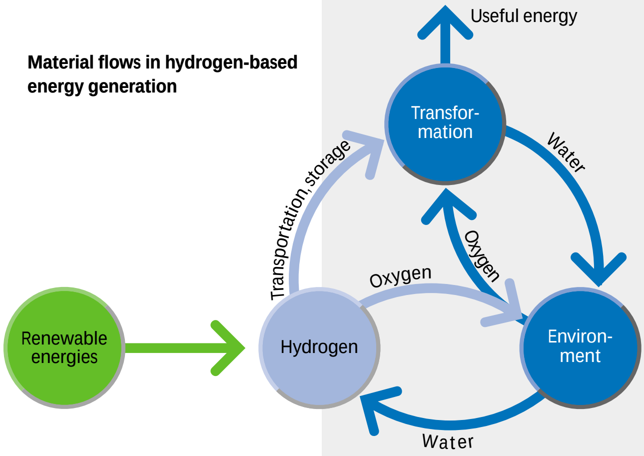
Iceland is the first country worldwide to rely on hydrogen-based generation

For example: Iceland.

It is the objective of Iceland and its European partners to install the world's first hydrogen-based generation sector on this island. This country has no fossil fuel resources, but renewable energies in abundance, especially geothermal and hydroelectric power. Stationary power users are almost exclusively supplied from these sources. In the capital Reykjavik, even the streets are heated. Nevertheless, this country imports about a third of its total energy needs in the form of mineral oil products to keep motor vehicles, buses and fishing boats going. But this is bound to change.

The plan is to replace diesel and gasoline by hydrogen, which will be produced with the help of renewable primary energy resources. In the long run, it is intended to switch all public and private transport as well as the sizeable Icelandic fishing fleet over to fuel cell technology.

Material flows in hydrogen-based energy generation



Energy content, relative to volume (kWh/l)

Hard coal	12.0	
Gasoline	9.1	
Liquefied natural gas	5.8	(–162 °C)
Methanol	4.4	
Gaseous natural gas	2.6	(200 bar)
Liquefied hydrogen	2.4	(–253 °C)
Gaseous hydrogen	0.6	(200 bar)
Batteries	up to **0.1**	

Energy content, relative to mass (kWh/kg)

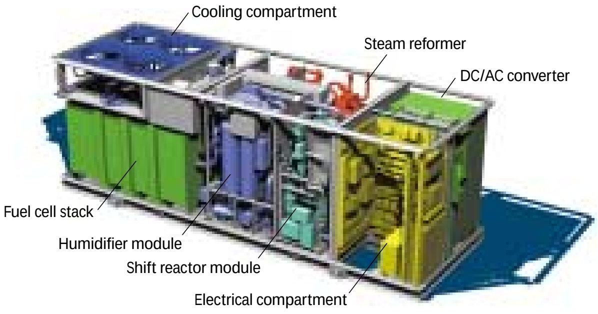
Hydrogen	33.3
Natural gas	13.8
Gasoline	12.0
Hard coal	8.4
Methanol	5.5
Batteries	up to **0.1**

The conversion of chemical energy into electricity

What is a fuel cell?

Fuel cells generate electricity from hydrogen and oxygen – without any harmful emissions and, therefore, in an extremely environmentally friendly way. Heat is produced in varying amounts, and, as a by-product, water. Like batteries and accumulators, fuel cells belong to the group of electrochemical energy converters called voltaic cells. Unlike batteries that store the energy from which the power is generated in the cell, fuel cells rely on a continuous energy supply from the outside. Fuel cells can therefore generate electricity as long as hydrogen and oxygen are supplied.

The Berlin pilot project is the first to use a PEM fuel cell in Europe.

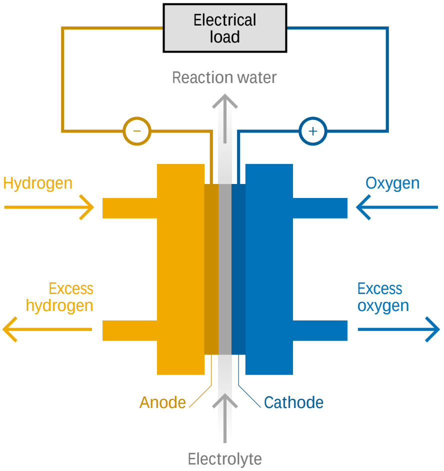


Fuel cells generate direct current

Electrodes and electrolyte.

In principle, all fuel cells consist of two porous surfaces (electrodes) separated from each other by another surface (the electrolyte). Hydrogen is fed to one of the electrodes, oxygen to the other. Without the electrolyte, the two gases would mix. The effect would be a normal combustion, at best, or a detonating gas reaction. The electrolyte, however, causes an electrochemical reaction instead of a normal combustion process: hydrogen ions with a positive charge accumulate at one of the electrodes (anode), and negatively charged oxygen ions at the other electrode (cathode). This creates an electrical voltage between the two electrodes, similar to the one between the poles of a battery. And as in a battery, this voltage can be put to practical use by connecting the electrodes via an exterior circuit.

How a fuel cell works



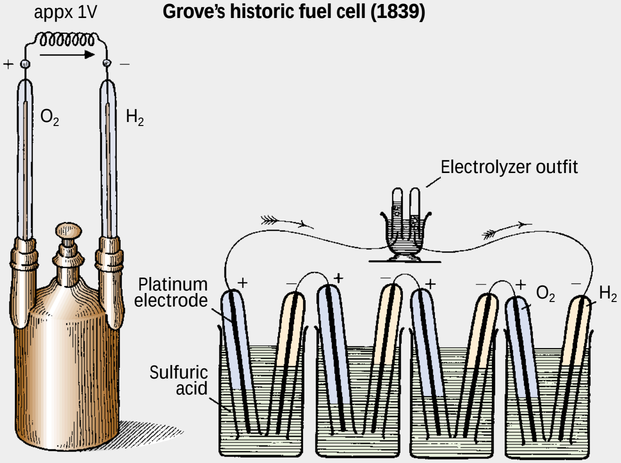
Practical use of fuel cells has so far proved quite difficult

Known for 160 years.

As early as in 1839, an Englishman, Sir William Robert Grove (1811–1896), constructed the first fuel cell. Yet, its further sophistication proved such an arduous task that Grove's concept was left untouched for nearly 100 years, and was on the point of sinking into oblivion. His fuel cells featured electrodes made of platinum which were sitting in a glass tube and reached, with their lower end, into dilute sulfuric acid as an electrolyte, while the upper part was exposed to hydrogen and oxygen inside the tube. This was sufficient to produce a voltage of about 1 Volt.

Sir William Grove (1811–1896) constructed the first fuel cell.

Grove's historic fuel cell (1839)



To turn the fuel cell into a really efficient source of power, some further substantial technical efforts had to be made. A major contribution towards understanding the electrochemical processes that caused the energy transformation in electrolysis and the reverse process in the fuel cell, was made by the English physicist Michael Faraday (1791–1867) who coined such fundamental terms as ions, electrolyte, electrodes, cathode and anode.

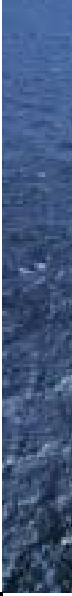
Michael Faraday (1791–1867) explained how ions conduct current in water.

The works of the German physicist Rudolf Clausius (1822–1888), the Swedish scientist Svante Arrhenius (1859–1927) and the German physicist Walther Kossel (1888–1956) were further milestones on the way to understanding the fuel cell.

Svante Arrhenius (1859–1927) formulated the ion theory in 1887.

Hydrogen lends itself to a variety of uses – power, light and heat

One solution for all.



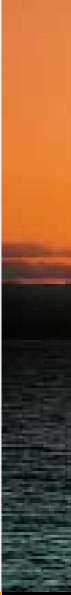
The first practically usable fuel cells were developed for use in submarines and spacecraft. During the moon-landings of the Apollo program, fuel cells were meeting the spacecraft's power needs while producing potable water for the astronauts. Today's efforts are focussed on using fuel cells, e.g. as power plants for electricity generation, as energy sources for electric vehicles, or as battery replacements for cell phones and notebooks. In the future, fuel cells can be employed for on-site combined heat and power generation to supply both industrial and housing estates. Using small-scale, virtually networked fuel cell systems the owners of small family homes may be able to generate their own power and heat in the near future.

One of the presently most popular applications of this technology is Necar 4, a car jointly developed by DaimlerChrysler, Ford and the Canadian company Ballard Power Systems Inc. With a tank filling of 40 l of methanol, it can cover a range of 400 km, using a reformer to produce a hydrogen-rich synthesis gas for the fuel cell. All the hardware needed is on board the car. Unlike combustion-engined cars, Necar is nearly emission-free and noiseless. And what does come out of the exhaust? Water vapor!

Bewag's commitment

Bewag

During several years of trial operation, the pilot project is expected to yield findings concerning an economically efficient use of fuel cells in order to develop their market potential sooner rather than later. Project costs for planning and construction totaled DM 7.5 million. As part of its THERMIE program, the European Commission in Brussels has part-financed 40 percent of the plant. The remaining 60 percent have been contributed by Bewag and its partners.



Bewag Aktiengesellschaft
Puschkinallee 52
12435 Berlin
E-Mail **bewag@bewag.com**
Internet **www.bewag.de**

Fuel cell exhibition
Eichenstraße 7/corner of Puschkinallee
12435 Berlin-Treptow
S-Bahn station: Treptower Park
Subway station: Schlesisches Tor/Bus 265
Open Mondays through Fridays
10:00 to 18:00 hours,
Saturdays and Sundays
13:00 to 17:00 hours

Information:
Phone +49 30-267-1 11 38
Fax +49 30-267-1 03 13
E-mail Innovationspark@bewag.com
Internet www.fuelcellpark.com

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