Brokdorf

Information on the Power Plant

e·on | Kernkraft

Brokdorf nuclear power plant

About 10 kilometers northwest of Glückstadt, where glacier masses once pushed their way through today's Elbe River Valley with unfathomable force during the Ice Age, a certain type of energy is produced today, making life in this country quite a bit more pleasant: electric power, generated in the Brokdorf nuclear power plant.

Contents

Nuclear power

Electricity is our lifeblood. Nothing works without it. Power translates into light, heat, energy and communications. Through all walks of life, be it in daily routines, on the job, during leisure time or in the field of healthcare, we depend on electricity to be available without interruption—whenever and wherever needed.

Ensuring its constant and instant availability is the name of our game. Nuclear power plants produce base-load electricity. They are thus responsible for the power that must be available incessantly, around the clock, day and night—to serve homes, industry and commerce.

Politicians decided in the 1960s to make use of nuclear energy for civilian purposes. Their aim was to broaden the primary energy mix, in part to become less dependent on natural resources from regions of political instability, and to generate low-cost electricity in large power station blocks. This decision forms the basis for an energy mix that has proven sensible and efficient for many a decade. It allows each energy source to play to its strengths in establishing its place in the mix. Combined, the agglomeration of energy fuels used—nuclear, coal, gas, hydropower along with the renewables that round them out—guarantees a safe and reliable supply of electricity.

Power stations of E.ON Kernkraft, Europe's largest privately owned nuclear energy company, ranked among the pioneers in Germany. In the early 1970s Würgassen and Stade were the first commercially operated nuclear power plants to be commissioned in Germany. Würgassen, a boiling-water reactor, was decommissioned in 1995, followed by Stade, a pressurized-water reactor, in 2003.

E.ON Kernkraft owns and has stakes in thirteen reactors in Bavaria, Lower Saxony and Schleswig-Holstein, making a decisive contribution to supplying Germany and Europe with electricity—reliably, affordably and in an environmentally friendly manner.

By opting for nuclear power, one scales back the combustion and consumption of other valuable energy sources such as coal, oil and gas, helping to preserve our natural resources.

One of the major challenges of our time is the depletion of greenhouse gases, with carbon dioxide (CO_2) leading the way. To mitigate the risks of global warming arising from the release of gases into the atmosphere, one must stifle the sources of greenhouse gases as much as possible.

Nuclear power plant operations do not emit carbon dioxide, or other pollutants such as carbon monoxide, sulphur dioxide or nitrous oxide. Our facilities thus make a significant contribution to alleviating the environment of its burdens and proactively protecting our climate.

Radioactive radiation has always been part of the natural environment of human beings. We come into contact with it every day, as it emanates from natural sources ubiquitously, be it from outer space, the sun or soil. Progress made in science and research has introduced ways of making use of radioactivity for diagnostic and therapeutic purposes in the field of medicine. Radioactive rays used in civilian applications are no different from those occurring in nature. They are omnipresent to us every day as well, regardless of whether we are sitting in an airplane or in front of the television.

Constant measuring and seamless controls are a fixture in the daily operations of nuclear power stations. Environmentally relevant data is incessantly mined, documented and passed on to independent controlling bodies by every single operator as well as the authorities. Emissions produced by German nuclear installations are considerably lower than required by law. Nuclear power stations account for less than 1 percent of aggregate emissions from civilian applications.

Reducing the burden on the environment and conserving resources

Annual human exposure to radiation	
Natural radiation sources	mSv
Universe	0.3
Food	0.3
Soil	0.4
Building materials	1.4
Civilian radiation	mSv
Nuclear power stations (immediate surroundings)	0.01
Television sets and fluorescent tubes	0.01
Five-hour flight	0.03
Medicine	1.5

mSv millisievert, unit of measurement for ionized radiation.

Safety

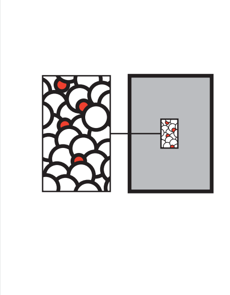
Protecting the general public from radioactive emissions is on top of our list of precautionary measures. To this end, in Germany, the engineering, construction and operation of nuclear installations are subjected to extremely stringent regulations, which have enabled us to achieve the highest safety standards in the world.

The plant safety system in use at E.ON's nuclear power stations includes both passive and active safety devices.

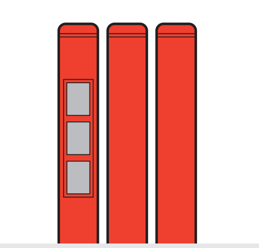
Passive safety features

Passive safety barriers encapsulate the radioactive material contained in the reactor core, regardless of the facility's mode (even in the event of malfunction), thus providing a reliable shield to the surroundings. Passive features run from the interior, consisting of gastight, pressure-resistant casings for fuel assemblies, to the nuclear reactor building's reinforced concrete outer shell.

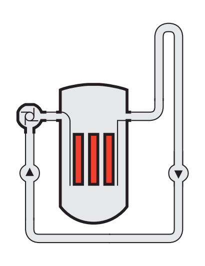
Passive safety features



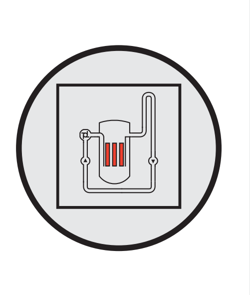
Uranium oxide crystal lattice



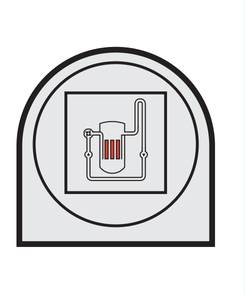
Metal fuel rod cladding tubes



Reactor pressure vessel integrated in the cooling cycle



Steel containment structure

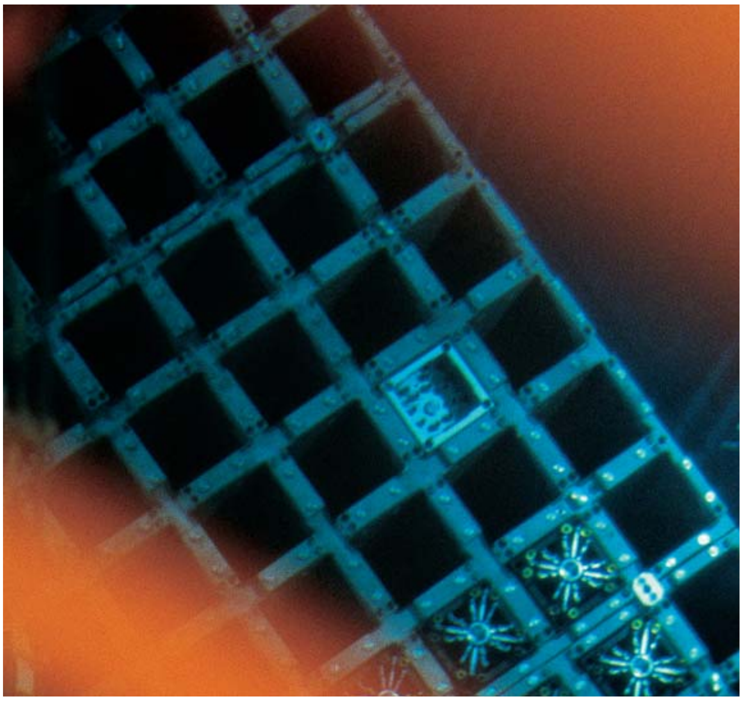


Reinforced concrete outer shell

Active safety features

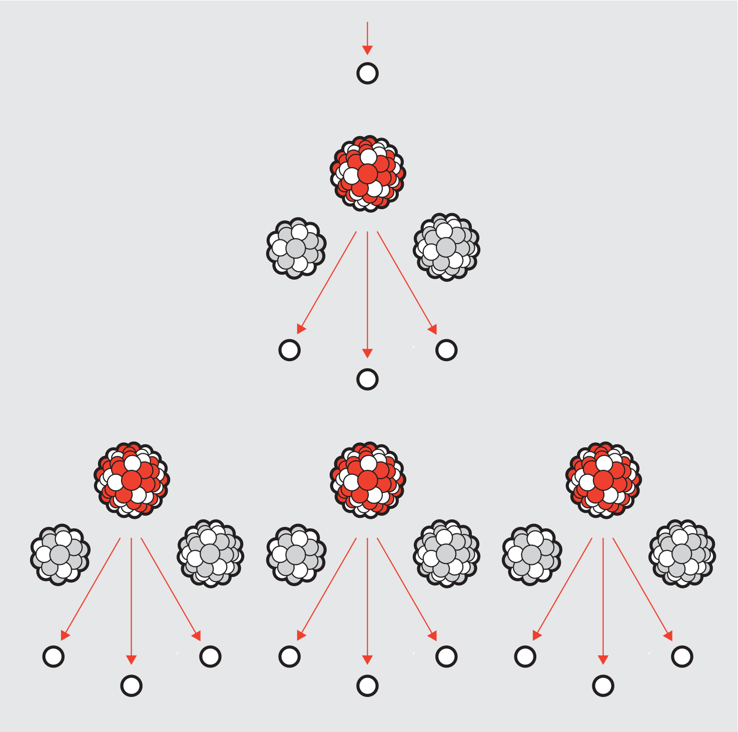
Passive safety features are supplemented by extensive, automated active safety systems. They are extremely reliable since they have multiple redundancies, operate independently of each other, and are physically separated from each other.

This is true for the power station's internal power supply system and, more importantly, for reactor cooling systems, ensuring that heat is reliably dissipated no matter what state the power plant is in. Such systems take over even during events that may appear inconsequential based on human rationale (such as the rupture of a main cooling line). Reactor protection systems are the 'brains' of all active safety measures. They permanently monitor and compare all the plant's key operating parameters. Once threshold values are exceeded, they trigger automatic safety measures without the need for human intervention. Examples of such events are the rapid power-down of a reactor and residual heat removal. Our level of reliability is reflected above all by our nuclear power plants' high degree of availability.



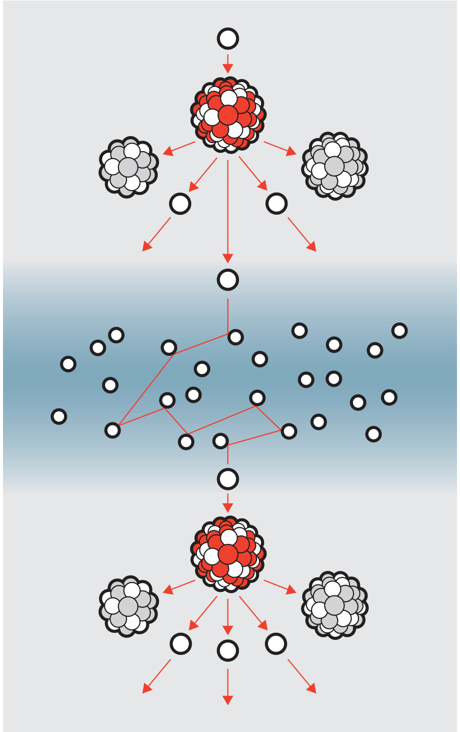
Controlled chain reaction

Nuclear fission



Whereas heat is generated through combustion in coal, gas and oil-fired power stations, in nuclear power plants, heat is produced from a controlled chain reaction. In the reactor, atomic cores are split using neutrons. This sets free kinetic energy, which results in heat.

How water works as moderator



High-speed neutrons: no new nuclear fission

Water molecules slow down the neutrons

Low-speed neutrons: nuclear fission possible

To split a 235-grade uranium core, one must ’bombard’ the atomic core with neutrons. Nuclear fission occurs whenever a neutron is absorbed or captured by a uranium core and the neutron transfers enough energy to make the core vibrate so much that it splits in two.

Extremely dynamic forces

The fission products fly in opposite directions at high speed. This releases thermal energy. The uranium’s nuclear fission sets free another two to three additional neutrons that fly off fast enough to enable them to split yet another uranium core. This triggers a chain reaction.

The moderator as decelerator

It is quite difficult for the high-speed neutrons to hit the 235-grade uranium cores. Therefore, in order to ensure further nuclear fission (i.e. trigger a chain reaction), one must 'decelerate' the neutrons, which is done through a process referred to as 'moderation.' Once the fast fission neutrons hit the atoms of the moderator (e.g. hydrogen), they lose speed, and although an absorption process takes place, hardly any neutrons are lost.

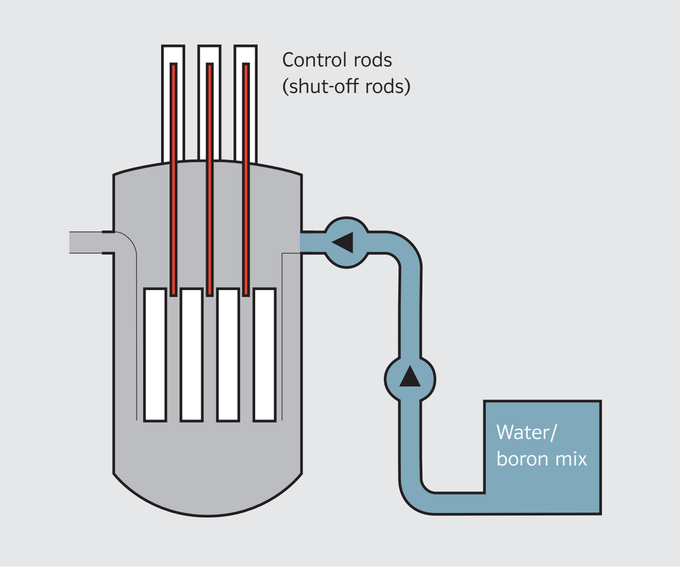
No moderator, no chain reaction

Once water loss occurs in a reactor moderated with water, the reaction stops immediately—for simple physical reasons. Since the high-speed neutrons are not 'decelerated,' they can no longer split the 235-grade uranium cores.

Absorption of surplus neutrons

During each nuclear fission, a neutron must be created, capable of effecting the next fission. Since two to three neutrons are released during each fission process, however, the surplus ones must be absorbed. The chain reaction can be controlled and monitored by influencing the number of neutrons. This task is handled by control rods made of neutron-absorbing material (such as boron), which are inserted into the reactor core. Their insertion depth determines how many neutrons are absorbed. To halt the entire chain reaction, the control rods are simply pushed completely into the reactor core. Furthermore, the chain reaction can be slowed down or interrupted by mixing boron into the water.

Controlling the chain reaction



Chronicle

Brokdorf nuclear power plant

1972	Kraftwerk Union AG commences planning work
1974	Construction permit application filed
1975	Kernkraftwerk Brokdorf GmbH established
1976	First partial clearance under German nuclear law Major demonstrations, construction halted temporarily
1981	Construction begins in February
1986	Continuous operation permit awarded Commercial commissioning
1992	World champion in gross annual output
1996	October: one hundred billionth kilowatt hour produced
2003	Clearance under German nuclear law for the construction of an interim storage facility
2004	Construction permit for the interim storage facility obtained Construction begins
2005	May: two hundred billionth kilowatt hour produced World champion in gross annual output
2006	May: permit to increase thermal capacity from 3,765 MW to 3,900 MW received
2007	March: commissioning/first use of the interim storage facility

Reactor

Basic principle

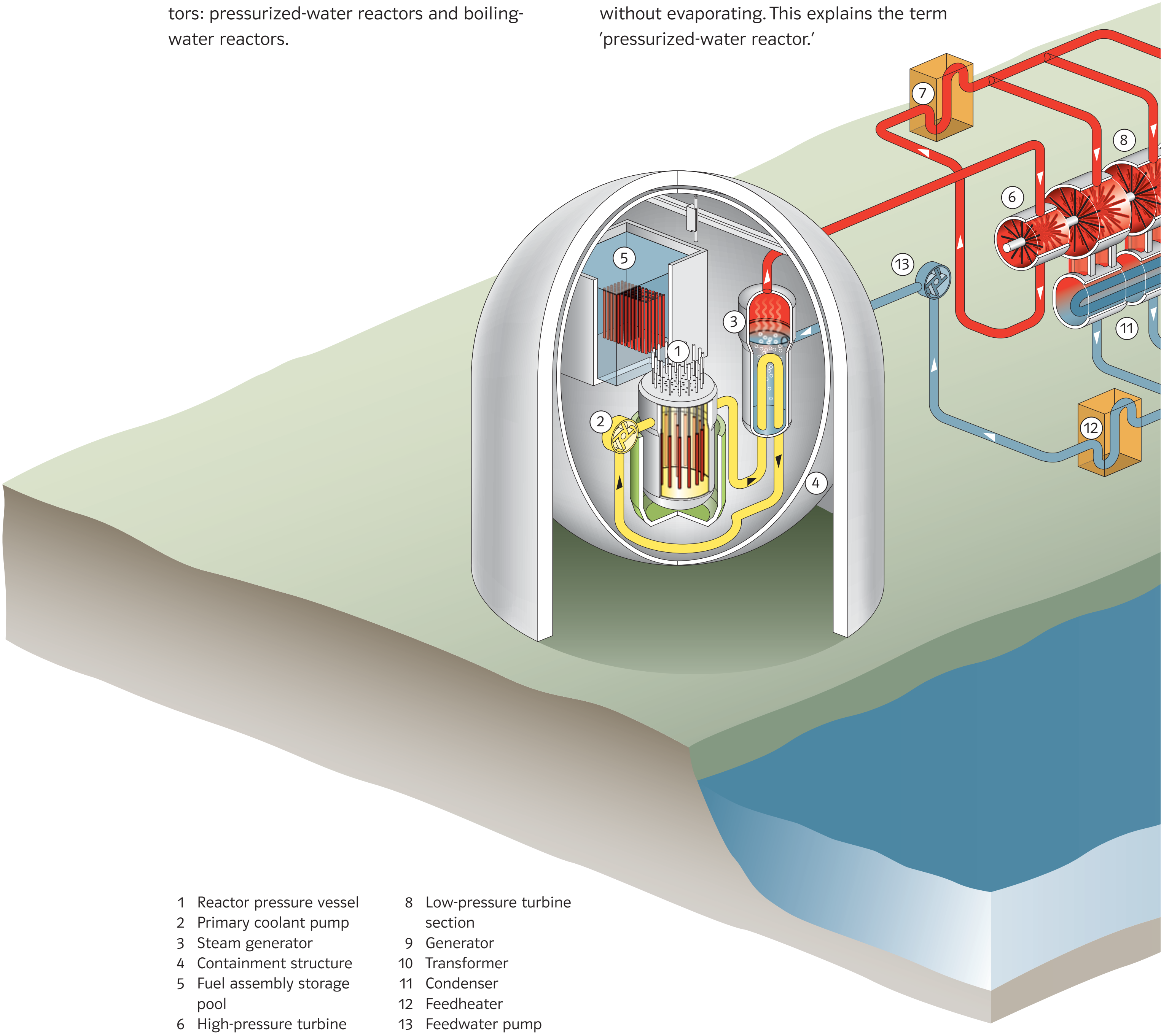
Nuclear power stations are part of the family of thermal power plants. This is how they work: heat produces water vapor. This steam is put under enough pressure to drive the turbine and the generator connected to it. The generator produces electricity.

E.ON Kernkraft operates two types of reactors: pressurized-water reactors and boiling-water reactors.

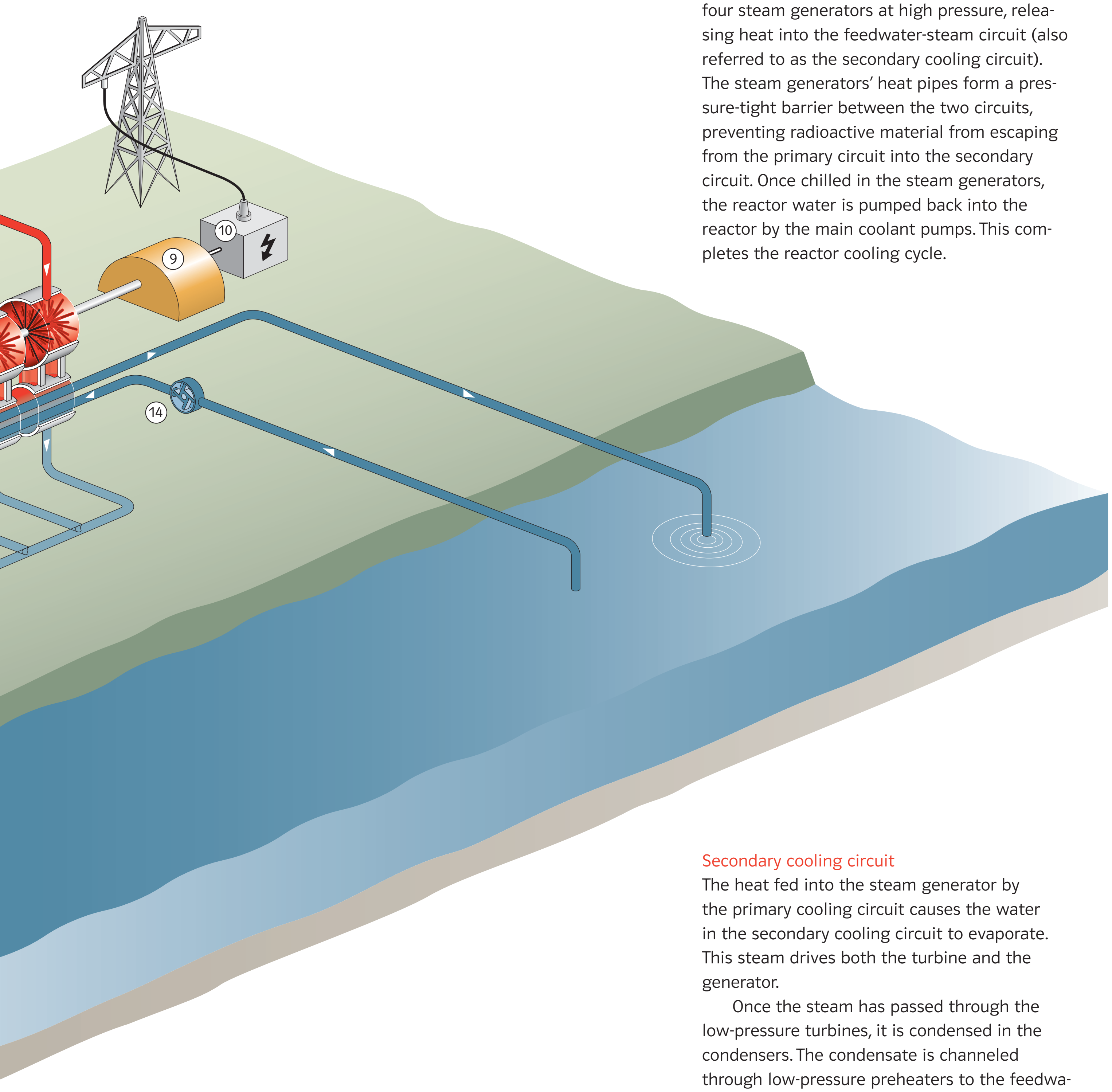
Brokdorf nuclear power plant
Electricity generated using a pressurized-water reactor

Primary cooling circuit

In this type of reactor, heat released by nuclear fission is absorbed by the water in the primary circuit. The water is kept under high pressure, without evaporating. This explains the term 'pressurized-water reactor.'



1 Reactor pressure vessel
2 Primary coolant pump
3 Steam generator
4 Containment structure
5 Fuel assembly storage pool
6 High-pressure turbine section
7 Water separator and reheater
8 Low-pressure turbine section
9 Generator
10 Transformer
11 Condenser
12 Feedheater
13 Feedwater pump
14 Primary coolant pump



The reactor water is transferred to the four steam generators at high pressure, releasing heat into the feedwater-steam circuit (also referred to as the secondary cooling circuit). The steam generators' heat pipes form a pressure-tight barrier between the two circuits, preventing radioactive material from escaping from the primary circuit into the secondary circuit. Once chilled in the steam generators, the reactor water is pumped back into the reactor by the main coolant pumps. This completes the reactor cooling cycle.

Secondary cooling circuit

The heat fed into the steam generator by the primary cooling circuit causes the water in the secondary cooling circuit to evaporate. This steam drives both the turbine and the generator.

Once the steam has passed through the low-pressure turbines, it is condensed in the condensers. The condensate is channeled through low-pressure preheaters to the feedwater reservoir using condensate pumps. Here the feedwater pumps take over, pushing the water through high-pressure preheaters back to the steam generators.

Cooling

Water obtained from the Elbe serves as coolant for the condenser. Some 15,000 cubic meters of water rush by the site every second, changing direction depending on the tide. The nuclear power station uses 60 cubic meters a second as cooling water.

Water usage is subject to strict statutory regulations: it may not be heated by more than 10 degrees centigrade or exceed a total temperature of 33 degrees centigrade. The maximum allowable temperature is especially important in the summer. Whenever the limit is in danger of being surpassed, the plant's output must be reduced until the risk has been eliminated.

To increase the water's biological self-cleansing powers, it is aerated before being fed back into the Elbe, causing it to absorb oxygen—a positive environmental effect.

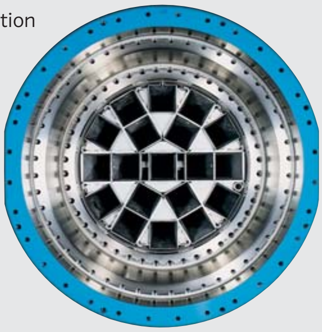
Technical specifications

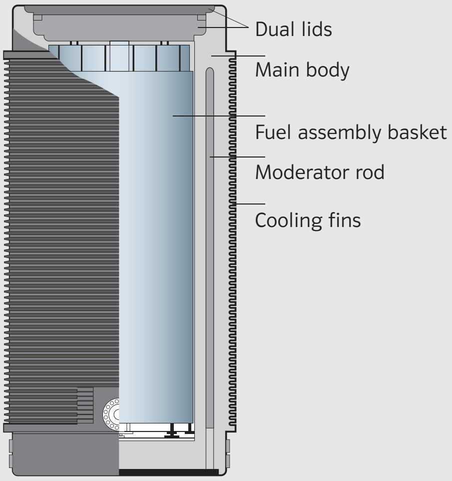
Brokdorf nuclear power plant	
Owner	
E.ON Kernkraft GmbH	80%
Vattenfall Europe Nuclear Energy GmbH	20%
Commercial commissioning	December 22, 1986
Total plant	
Reactor type	Pressurized-water reactor
Net installed capacity	1,480 MW (gross)/ 1,410 MW (net)
Nuclear plant	
Reactor pressure vessel	
Design pressure above atmospheric	175 bar
Inner diameter	5,000 mm
Total height	12,670 mm
Cylindrical section wall thickness (including cladding)	250 + 6 mm
Total weight	535 mt
Reactor core	
Fuel elements	193
Total amount of uranium	103 mt
Control rods	61
Steam generators	
Quantity	4
Steam generated per unit	536 kg/s
Steam pressure at outlet	67.0 bar
Steam temperature at outlet	283.8 °C
Reactor cooling system	
Coolant pumps	4
Average coolant temperature	308.6 °C
Containment structure	
Sphere diameter	56 m
Design pressure above atmospheric	6.3 bar
Wall thickness	30 mm
Engine plant	
Turbine and condenser	
High-pressure (HP) section	1
Low-pressure (LP) section	3
Speed	1,500 min^{-1}
Condenser coolant temperature rise	10 K
Generator	
Output	1,640 MVA
Terminal voltage	27 kV
Power factor (cos phi)	0.83
Block transformers	
Units	2
Unit output	780 MVA
Frequency	50 Hz

Interim storage facility

Castor V/19 container

Cross section





The interim storage facilities used to store nuclear fuel set up at the Brokdorf nuclear power plant comply with the requirements set forth in the German Nuclear Energy Act, which stipulates that a solution be found for the on-site storage of spent fuel elements. The German federal government’s aim behind this legislation was to limit the number of radioactive material transports and ensure that such substances be stored safely until the federal government has erected a final storage facility.

The interim storage facilities are only intended for the fuel assemblies irradiated at the Brokdorf site. All decommissioned fuel elements are kept in the nuclear power plant’s fuel cooling station for a pre-determined period of time before they are placed in final storage. After approximately five years, they are packaged into hermetically sealed, highly stable containers for interim storage.

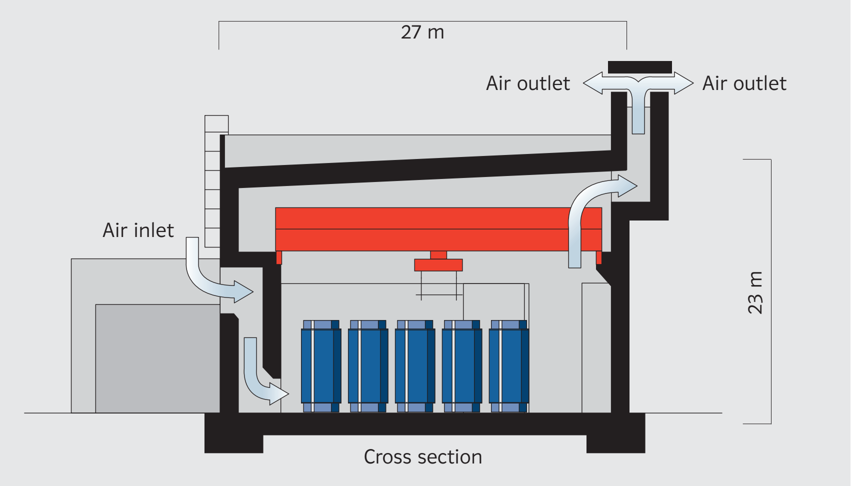
Containers

Thanks to the engineering work that goes into the casks, they are capable of withstanding extreme stresses and comply with all statutory regulations as well as international control and supervisory authorities.

The first casks in use at Brokdorf are of the CASTOR V/19 variant. This model can accommodate a maximum of 19 fuel assemblies. Featuring a dual lid, it weighs some 126 metric tons, including its protective cladding. The containers are made from a single piece of expandable cast iron, and their walls and floors are about 40 centimeters thick. A multilayered decontamination paint coat is applied to protect the casks from corrosion. Each container’s operating state is monitored continuously and separately as well as documented. Each cask has an envisaged storage time of no more than 40 years.

Storage building

The storage building is about 93 meters long, 27 meters wide and 23 meters high. Its external walls are made of approximately 1.2-meter-thick reinforced concrete, and the ceiling is 1.3 meters thick. This results in an optimal shield that is even capable of withstanding an earthquake, a strike of lightning or a plane crash—all highly improbable, but not completely inconceivable events. The storage area has a floorspace of 1,650 m², 950 m² of which are used as effective storage space. Containers are arranged in twenty rows, each of which has a total of five slots, resulting in a maximum holding capacity of 100 casks.



Cross section

Environmental compatibility

The construction and operation of an interim storage facility have no significant impact on humans, animals or vegetation in the surroundings. This finding has been confirmed by numerous studies and scientific investigations carried out within the scope of an environmental compatibility audit required to obtain federal clearance. No radioactive substances escape from the containers, since they are hermetically sealed. This renders internal radiation impossible, which means that there is no internal exposure to radiation resulting from the inhalation or ingestion of contaminated matter.

There is only minimal external exposure to radiation. Radiation emanating from the fuel assemblies is significantly weakened by the containers themselves and minimized even further by the storage building. The maximum value recorded at the periphery of the plant's premises is less than 0.03 mSv/a.

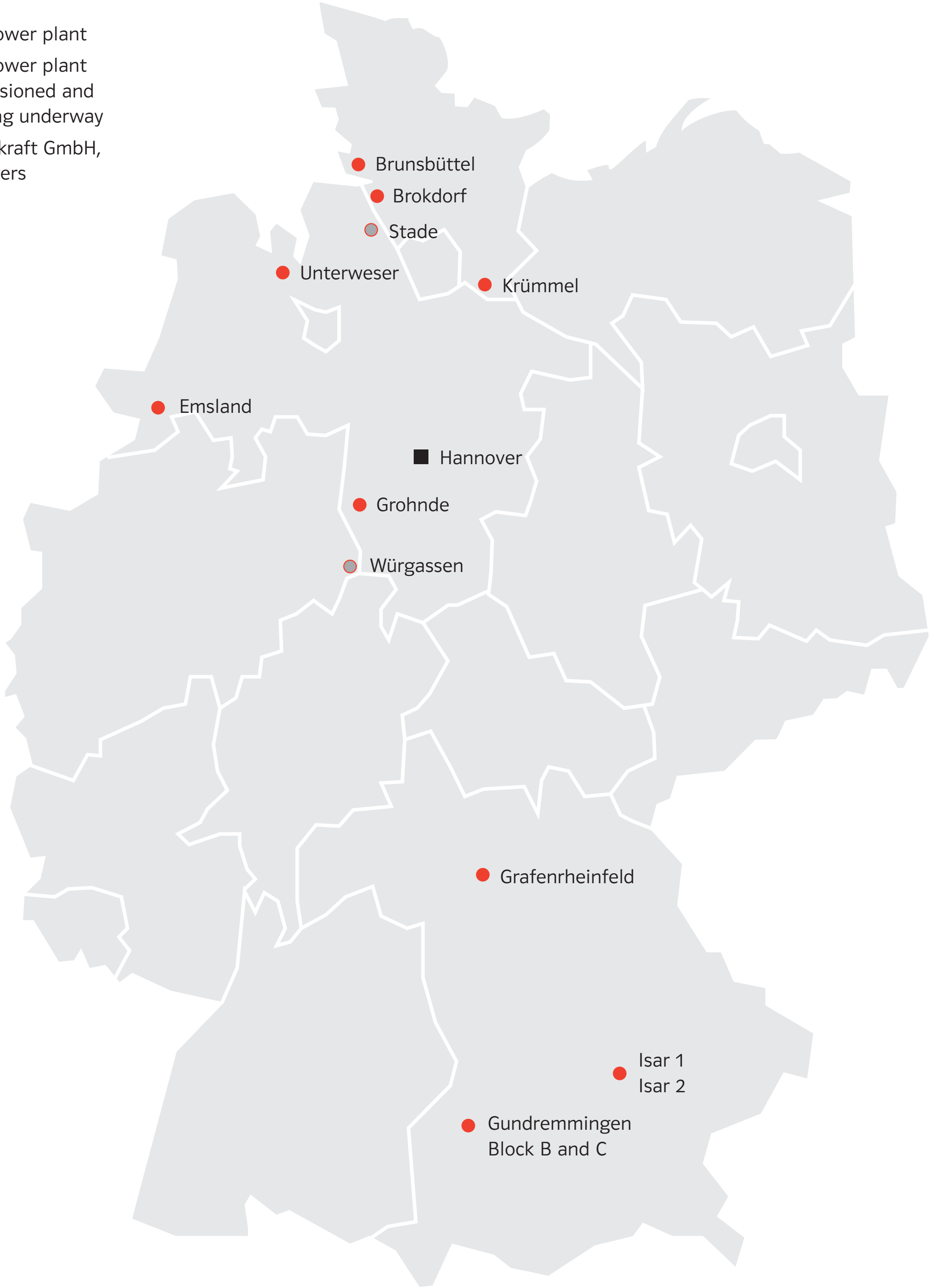
Come talk to us

We would be happy to welcome you to one of our power plants’ information centers. Presentations, films, models and guided tours will give you easy insight into the generation of electricity from nuclear fuel.

Ask us questions and talk to us - we look forward to engaging in dialog with you.

Our sites

- ● Nuclear power plant
- ◉ Nuclear power plant decommissioned and dismantling underway
- ■ E.ON Kernkraft GmbH, headquarters



Nuclear power plants

Name	Address	Phone	Reactor type	Net installed electric capacity	Commercial commissioning	Operator	Shareholders/owners
Brokdorf	Osterende 25576 Brokdorf	04829-752560	Pressurized-water reactor	1,410 MW	12/22/1986	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 80% Vattenfall Europe Nuclear Energy GmbH 20%
Brunsbüttel	Otto-Hahn-Straße 25541 Brunsbüttel	04852-87334	Boiling-water reactor	771 MW	02/09/1977	Kernkraftwerk Brunsbüttel GmbH & Co OHG	Vattenfall Europe Nuclear Energy GmbH 66.7% E.ON Kernkraft GmbH 33.3%
Emsland	Am Hilgenberg 49811 Lingen	0591-8061611	Pressurized-water reactor	1,329 MW	06/20/1988	Kernkraftwerke Lippe-Ems GmbH	RWE Power AG 87.5% E.ON Kernkraft GmbH 12.5%
Grafenrheinfeld	Kraftwerkstraße 97506 Grafenrheinfeld	09723-622206	Pressurized-water reactor	1,275 MW	06/17/1982	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 100%
Grohnde	31860 Emmerthal	05155-672377	Pressurized-water reactor	1,360 MW	02/01/1985	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 83.3% Stadtwerke Bielefeld AG 16.7%
Gundremmingen Block B	Dr.-August-Weckesser Straße 1 89355 Gundremmingen	08224-782231	Boiling-water reactor	1,284 MW	07/19/1984	Kernkraftwerk Gundremmingen GmbH	RWE Power AG 75% E.ON Kernkraft GmbH 25%
Gundremmingen Block C	Dr.-August-Weckesser Straße 1 89355 Gundremmingen	08224-782231	Boiling-water reactor	1,288 MW	01/18/1985	Kernkraftwerk Gundremmingen GmbH	RWE Power AG 75% E.ON Kernkraft GmbH 25%
Isar 1	Dammstraße 84051 Essenbach	08702-382465	Boiling-water reactor	878 MW	03/21/1979	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 100%
Isar 2	Dammstraße 84051 Essenbach	08702-382465	Pressurized-water reactor	1,400 MW	04/09/1988	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 75% Stadtwerke München 25%
Krümmel	Elbuferstraße 82 21502 Geesthacht	04152-5940	Boiling-water reactor	1,260 MW	03/28/1984	Kernkraftwerk Krümmel GmbH & Co OHG	Vattenfall Europe Nuclear Energy GmbH 50% E.ON Kernkraft GmbH 50%
Stade	Bassenflether Chaussee 21723 Bassenfleth	04141-772390	Pressurized-water reactor	630 MW	Decommissioned and dismantling underway since 2003	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 66.7% Vattenfall Europe Nuclear Energy GmbH 33.3%
Unterweser	Dedesdorfer Straße 2 26935 Stadland	04732-802501	Pressurized-water reactor	1,345 MW	09/06/1979	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 100%
Würgassen	Zum Kernkraftwerk 25 37688 Beverungen	05273-380	Boiling-water reactor	640 MW	Decommissioned and dismantling underway since 1995	E.ON Kernkraft GmbH	E.ON Kernkraft GmbH 100%

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Imprint
Publisher
E.ON Kernkraft GmbH, Hannover, Germany
Editor
Corporate Communications
Image sources
Peter Hamel, Hamburg, Germany
trend media TV, Isernhagen, Germany
E.ON Kernkraft archive
Layout
Maurer Werbeagentur, Hannover, Germany
Production
Carl Küster Druckerei GmbH, Hannover, Germany

EKK 05/2008