

# NUCLEAR POWER AN IMPORTANT PART OF MAKING ELECTRICITY CLEAN

Interest in building new nuclear power capacity has been revived around the world. Today nuclear power is viewed as a viable component in the effort to reduce climate impact and pursue sustainable development. At Vattenfall, nuclear power is a vital part of the company's strategic direction of Making electricity clean.

Approximately 440 nuclear reactors are currently in operation in more than 30 countries and account for roughly 15% of the world's energy generation. In the EU, nuclear power accounts for 28% of total energy generation. In Sweden, nuclear power accounts for nearly half of all electricity used in the country, while in Germany it accounts for about a fourth.

The revival of interest in new nuclear power is attributable in part to the climate threat. Nuclear power is reliable and efficient, and has competitive production costs. It is also virtually free from climate-affecting emissions. Calculated over a life cycle – from construction to dismantling, including fuel production, operations and waste – nuclear power emits about as much carbon dioxide per produced kWh electricity as hydro power or wind power (based on Vattenfall's LCA, life cycle analysis). The disadvantages are that it takes a long time to build a nuclear power plant, and the technology is advanced, which entails a high investment cost. Moreover, in most countries, final storage of spent nuclear fuel is a matter that has not yet been fully resolved.

Toward the end of 2008, 36 reactors were under construction around the world – most of which are in India, China, Russia and South Korea. New nuclear power plants are also being built in Canada, Finland, France, Japan and Slovakia. In addition, many other countries have plans for the continued expansion of nuclear power. The UK, for example, wants to replace ten older reactors with new ones, which is being motivated by the need to secure access to electricity and reduce CO<sub>2</sub> emissions.

## Long-term investment programme in Sweden

Nuclear power accounts for roughly a third of Vattenfall's electricity generation. In Sweden Vattenfall operates seven reactors – three in Forsmark and four in Ringhals. Since 2003 Vattenfall has, together with other owners, invested approximately SEK 10 billion in a major, long-term investment programme in the Swedish facilities. The programme covers measures for improving the level of safety, extending the plants' useful life, and increasing capacity. The goal is to maintain world-class nuclear safety and generation. Together with other owners, Vattenfall plans to invest approximately SEK 50 billion in its Swedish nuclear power plants 2003–2030.

In Germany Vattenfall operates the Brunsbüttel and Krümmel nuclear power plants. These two plants have been off-line since summer 2007, but according to plans will be restarted in 2009. Read more in the box below.

Vattenfall works within the political framework in the markets in which it is active.

## High safety requirements

In early 2008 the International Atomic Energy Agency (IAEA) conducted a review of operations at Forsmark. The IAEA concluded that Forsmark maintains a good international level in its safety work.

Safety standards at Vattenfall's nuclear power plants are very high. All safety work aims to ensure safe operation with a comfortable margin. Vattenfall conducts active safety

## Shutdowns disrupted production

During the year, Vattenfall's nuclear power generation was disrupted a number of times. Forsmark 2 was manually shut down in June after lightning struck a power line and caused a short circuit outside of the plant. However, as a result of a malfunction in certain non-safety technical equipment, the Forsmark 1 and 2 reactors have to be operated at slightly lower capacity until the next fuel exchange.

In mid-October the Forsmark 3 reactor was shut down due to an experience from an inspection of Oskarshamn 3 – which is the same type of reactor. The inspection at Oskarshamn 3 showed a fracture in one of 169 control rod shafts. All control rods at Forsmark 3 were checked, and a fracture was detected in one rod, while the formation of cracks was discovered on a fourth of the rods. After replacement of the defective rods, the reactor was restarted on 1 January 2009.

In connection with the restart following annual overhaul outages, both Ringhals 1 and Ringhals 2 were affected by operating problems that led to a loss of generation. During the outage of Ringhals 1, minor rebuilding work was performed on one of the plant's cooling systems. In conjunction with the tests prior to restarting the reactor, problems

were discovered with pressure variations. After corrective measures were taken, the reactor was restarted on 6 January 2009. At the Ringhals 2 reactor, it was found that two water pumps in the cooling system had insufficient flow, entailing that the reactor must be run at a slightly reduced capacity until the overhaul outage in 2010.

In June 2007, the Brunsbüttel and Krümmel nuclear power plants in Germany were shut down in response to two separate events – at Brunsbüttel due to a short circuit in a switchyard outside the plant, and at Krümmel due to a fire in a transformer outside of the reactor building. Safety was never jeopardised. During the time that the reactors were shut down for maintenance, other equipment was also inspected after shortcomings were discovered at other reactors. During these inspections, fractures were discovered in certain valves at the Krümmel reactor, and weaknesses in expander bolts were discovered at Brunsbüttel. Repairs were conducted in 2008 and will be completed in 2009. The standstills of the German nuclear power plants hurt earnings for 2008 by approximately SEK 5.5 billion.

## Safety work at Forsmark



In early 2008 the International Atomic Energy Agency (IAEA) conducted a review of operations at Forsmark. The IAEA concluded that Forsmark maintains a good international level in its safety work. Vattenfall conducts active safety work focusing on strong safety

management, a good safety culture and continuous improvements. Together with the other owners, Vattenfall will be investing a total of approximately SEK 50 billion 2003–2030 in raising safety and extending the useful life of its plants.

work focusing on strong safety management, a good safety culture and continuous improvements. A major effort is currently under way to regain a world-leading position in nuclear power safety.

Vattenfall has clearly emphasised the importance of safety in its organisation. Vattenfall's newly appointed Chief Nuclear Officer (CNO) serves as the Executive Group Management's nuclear power expert and reports directly to the CEO on matters concerning nuclear safety. In addition, Vattenfall has a Nuclear Safety Council that is chaired by the Group CEO. Further, Vattenfall is an active participant in international nuclear power organisations in order to ensure that the entire body of global experience is taken advantage of in the Group's safety work. The nuclear power companies bear full operational responsibility for operations of the nuclear power plants.

### Swedish site location for final storage 2009

The Swedish Nuclear Fuel and Waste Management Company (Svensk Kärnbränslehantering AB – SKB) is responsible for managing and disposing of radioactive waste from Sweden's nuclear power plants and ensuring it is stored in an environmentally safe manner. In 2009 SKB will be choosing a site for final storage of spent nuclear fuel. This choice follows 20 years of studies, site surveys and pre-studies in eight municipalities. In 2010 SKB will submit an application to build the final repository for spent nuclear fuel, and the repository is expected to be ready for use in 2018.

Spent nuclear fuel is currently being stored in SKB's central interim storage facility for spent nuclear fuel in Oskarshamn, where it is submerged in large water pools that cool and shield radiation for a period of approximately 30 years.<sup>1</sup>

In Germany, the federal government has studied the possibility of using the salt mine in Gorleben as a final repository for highly radioactive waste, however, a moratorium has been in place for this work since 2000.

1) Source: SKB