

VATTENFALL IS INVESTING IN RENEWABLE ENERGY

Vattenfall is investing in renewable sources of energy, including wind power, hydro power and bioenergy. Substantial investments are being made in several areas, above all in wind power. Vattenfall is today one of the world's largest wind power operators.

Wind power – doubling of electricity generation in two years

Apart from virtually no fuel cost, wind power has several advantages. The technology has come far in its development and over its life cycle leads to very low emissions of greenhouse gases. But since it is not always windy, the need for regulation power is rising.

Vattenfall has invested and continues to invest heavily in wind power, and the share of electricity generation from wind power rose from 0.1 TWh to 1.7 TWh from 2004 to 2009. In addition, wind power is the renewable source of energy that is predicted to have the greatest potential for expansion in the medium term. The International Energy Agency forecasts a quadrupling in installed capacity from wind power in the EU by 2020 compared with today's situation.

Vattenfall is today one of the world's largest wind power operators. The Group has approximately 700 wind power turbines in nine countries, which together generate enough electricity to power approximately 350,000 households. Most of Vattenfall's wind farms are in Denmark and Sweden, including Lillgrund outside Malmö, which is Sweden's largest offshore wind farm, and Horns Rev off Esbjerg, Denmark, one of the world's largest offshore wind farms. The latter is 60%-owned by Vattenfall. Vattenfall is also developing and owns wind farms in the UK, Germany, Poland, the Netherlands and Belgium.

Vattenfall is currently conducting more than a hundred new construction projects for wind power in Europe, corresponding to 600 MW. Nearly 80% of this consists of offshore wind farms, many of which are being built off the coasts of Great Britain, which offers favourable market conditions and

support systems for wind power – not to mention very favourable wind conditions.

At year-end 2009 Vattenfall had a total of 988 MW of installed wind power, of which 370 MW (43%) was offshore. Also at year-end, construction was in progress of eight wind farms in six countries, which will result in a doubling of Vattenfall's wind power electricity generation when they come on stream in 2011.

Major wind power operator in the UK

Vattenfall is working continuously on finding new, suitable locations for wind power, both offshore and onshore, in all markets. Accordingly, Vattenfall has joined with ScottishPower Renewables in a partnership to investigate opportunities to establish new offshore wind power in the UK. In early 2010 Vattenfall and ScottishPower Renewables were granted rights to develop a major wind farm in the East Anglia zone offshore England's east coast, with the potential to generate electricity for more than 4 million households every year. The rights are part of Round 3, the British Crown Estate's licensing programme for developing offshore wind power. Vattenfall and ScottishPower Renewables hope to be able to file their first regulatory application in 2012. If Vattenfall and ScottishPower Renewables receive the necessary licences, construction could start in 2015 and be carried out in stages thereafter.

Thanet – world's largest offshore wind power project

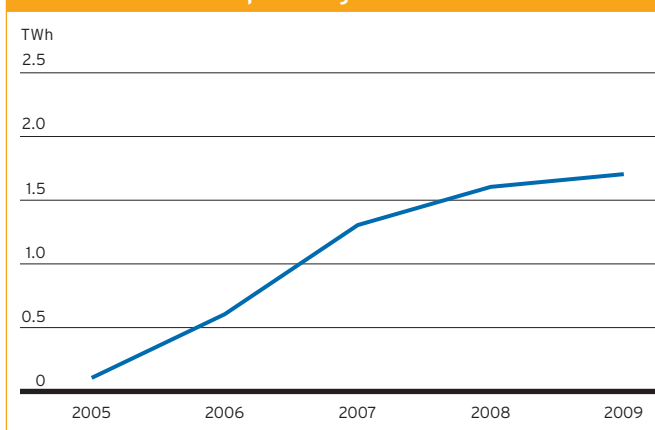
Vattenfall is investing in both offshore and onshore wind power. Onshore wind power is cheaper to build, operate and maintain, while offshore wind farms generate more electricity due to stronger and more steady winds than on land.

The Thanet wind farm offshore Britain's south-east coast is one of Vattenfall's largest current construction projects. Once it comes on stream in 2010 it will be the world's largest offshore wind farm and will account for a 30% jump in wind power generation in the UK. Thanet will have capacity of 300 MW generated by 100 wind turbines and will satisfy the electricity needs of 240,000 households.

Another major project is the Ormonde wind farm in the Irish Sea, with 30 turbines and combined capacity of 150 MW. The Ormonde wind farm is expected to come on stream in 2011/2012.

Also in Britain, Vattenfall operates the Kentish Flats wind farm offshore the northern coast of Kent, east of London. Kentish Flats has a capacity of 90 MW. Vattenfall's acquisition of Dutch energy group Nuon also included a number

Vattenfall's wind power generation





Vattenfall is one of the world's largest operators of offshore wind farms. Wind power is also the renewable energy source that is believed to have the greatest potential for expansion in the medium term.

of wind farms in the Netherlands and Belgium, with combined capacity of approximately 321 MW, of which 108 MW comes from offshore installations.

Testing of large turbines

In November Germany's first offshore wind farm, Alpha Ventus, was completed. Alpha Ventus, located offshore Germany's North Sea coast, is a development and demonstration project that is being conducted in partnership with E.ON and EWE (in which Vattenfall has a 26.25% interest). The project involves the testing of 12 turbines delivering 5 MW each.

Largest onshore wind power venture

Stor-Rotliden, in the municipality of Åsele in northern Sweden, will be Vattenfall's largest onshore wind power project. The wind farm will comprise 40 wind power turbines with capacity of 78 MW. The wind farm is scheduled for commissioning in 2011.

In Denmark, Vattenfall's work continues on replacing older wind power turbines with larger, more efficient turbines. In December the Nørrekær Enge wind farm was inaugurated, where 77 older, small turbines were repowered by 12 new, larger turbines.

Biomass – important contribution to climate targets

One way of reducing the climate impact of electricity and heat production is to use biomass instead of coal. Biomass is CO₂-neutral if the fuel that is burned is offset by a corresponding amount of regrowth. Much of biomass consists of forestry and agricultural residuals as well as construction and household waste. Co-combustion of coal and biomass is one technology that is already available today and is generating rapid results in the form of lower net carbon emissions. In the years ahead Vattenfall will therefore be sharply increasing the mix of biomass in its major coal-fired plants.

Vattenfall currently has more than 40 combined heat and power plants that are operated entirely or partly using biomass. The total volume of biomass from household and industrial waste amounts to more than three million tonnes a year. The use of biomass in Vattenfall's generation of heat and electricity is increasing steadily. Today Vattenfall is already one of the world's largest buyers of biomass for energy purposes.

However, there are risks involved in the increased use of biomass. Supply is limited, and important sustainability aspects, such as the risk of deforestation, loss of biological diversity and emissions of greenhouse gases from the entire



The Amager combined heat and power plant, outside Copenhagen, has been converted and can now be run on oil, coal or biomass. The biomass used by the plant consists mainly of straw from nearby farmland. The goal is for the plant to be run on 100% biomass.

fuel chain must be taken into account. Vattenfall therefore expects that bioenergy will have an important yet limited role in the future.

Vattenfall is working to develop the entire biomass chain, from growing to use and combustion via logistics and fuel-handling. One major challenge is in finding suppliers that can generate access to major volumes of biomass that meets high demands on sustainability at a competitive price.

In the absence of a certification system that addresses all aspects of biomass handling, Vattenfall is drawing up its own guidelines for sustainable development. Every project must be evaluated according to these guidelines.

Several major development projects

Vattenfall is conducting several major bioenergy projects. In Germany, Vattenfall is planning two new biofuel-fired power plants in Berlin and one in Hamburg. In Poland, Vattenfall is increasing the use of biomass at the Zeran and Siekierki combined heat and power plants, and the mix of biomass in combustion will more than double in 2010 compared with 2009, entailing the combustion of 150,000 tonnes of biomass. By 2013 a blend of up to 400,000 tonnes of biomass will have been achieved. In Finland, Vattenfall is working on increasing the share of biomass at the Myllykoski combined heat and power plant, while installation of a new biofuel boiler at the Vanaja power plant in Tavastehus is proceeding according

to plan. In 2010 the share of renewable fuels in Vattenfall's production in Finland will reach 38%, which corresponds to the EU's target for the share of renewable energy in Finland. In Denmark, a new straw-fired unit was put in operation at the Fynsværket plant. In the MaxBio programme, which involves all units in the Danish combined heat and power operations, the goal is to replace up to 724,000 tonnes of coal per year with biomass.

Hydro power – a stable asset

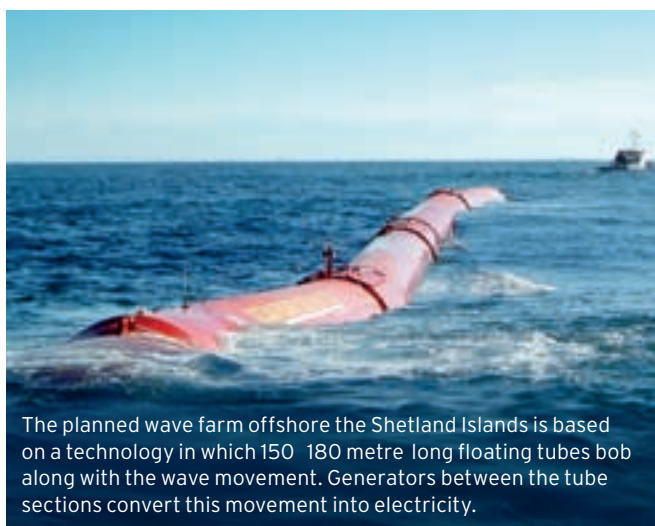
Hydro power today accounts for the absolute largest share of Vattenfall's renewable electricity generation. Vattenfall owns and operates 112 hydro power stations in the Nordic countries – most in Sweden and a few in Finland. The Group's Swedish hydro power plants generate slightly more than 30 TWh per year. This figure varies depending on water levels. Hydro power has the greatest importance as base, peak and regulation power as well as for storage of energy. It has low emissions throughout its useful life and will continue to play a very important role in Vattenfall's work to achieve climate-neutral operations. However, hydro power's share of total electricity generation is expected to decrease from 21% today to approximately 12% by 2030 due to limited expansion opportunities. The growth potential that exists today consists primarily of acquisitions outside of Vattenfall's existing markets and upgrades of existing plants. Vattenfall has an ambitious invest-

Vattenfall's first newly built hydro power plant in 15 years will come on stream in 2010. Construction of the Abelvattnet hydro power plant in Storuman, Sweden, was begun in 2008. The plant will have installed capacity of 4.6 MW.



ment programme for its hydro power operations – some 30 of the Group's hydro power stations are being upgraded during the period 2004–2013. In recent years Vattenfall has also been conducting a major programme surrounding dam safety.

In 2008, construction was begun of a new hydro power plant, Abelvattnet, with installed capacity of 4.6 MW, in the Swedish municipality of Storuman. The plant will come on stream in 2010 and will be Vattenfall's first entirely newly built hydro power plant in more than 15 years.



The planned wave farm offshore the Shetland Islands is based on a technology in which 150–180 metre long floating tubes bob along with the wave movement. Generators between the tube sections convert this movement into electricity.

Wave power – major future potential

Ocean energy in the form of wave power and tidal power has potential to be an important renewable source of energy. Its theoretical potential capacity is enormous: 15,000 TWh worldwide yearly, of which 2,000 TWh in Europe. The areas that are best-suited for ocean energy in Europe are the Atlantic coasts of the UK, Ireland, Norway and Denmark. With today's technology and conditions, researchers hope to be able to harness a tenth of Europe's potential.

Vattenfall is far advanced in this development and estimates that wave power can be a commercially viable source of energy within 10 to 15 years. Vattenfall is participating in several wave power pilot projects offshore the coasts of Sweden, Norway and Ireland, and is also monitoring developments in several other countries, such as Portugal. Together with an Irish site development company for ocean energy, Vattenfall has formed a company whose goal is to generate electricity on a commercial basis using wave power offshore Ireland's west coast. In collaboration with a Scottish company, Vattenfall is making plans to build a wave power installation offshore the Shetland Islands in the Atlantic Ocean. Vattenfall plans to continue the work with pilot tests and demonstration facilities towards the goal of having commercial wave power farms of 100 MW and upwards operating by 2020. Wave power is estimated to account for approximately 8% of Vattenfall's electricity generation by 2030.

CCS – A BRIDGE TO THE FUTURE

Coal will continue to be an important source of energy in Europe for many years to come. CCS technology, entailing the capture and storage of carbon dioxide from combustion of fossil fuels, will therefore be a key means of reducing CO₂ emissions in the future. With CCS, carbon dioxide from fossil-based power plants can be captured for permanent storage deep underground. Vattenfall has taken a leading position in the development and demonstration of CCS technology through its pilot plant at Schwarze Pumpe in Brandenburg, Germany.

Climate change caused by emissions of carbon dioxide and other greenhouse gases is the greatest environmental challenge of our time. Parallel with this, the world's energy need is expected to rise, and most of the increased use of energy will be met with fossil fuels, since the renewable energy sources do not have high enough capacity to replace these entirely.

The capture and storage of carbon dioxide from fossil fuels is therefore a very important instrument for reduc-

ing environmental impact. The potential is great, but the technology needs to be upscaled, and the costs must be brought down. It is not until 2020 that initial commercial use of CCS technology is regarded as possible.

It is not only the actual technology and how fast it can be implemented that is decisive for the future of CCS. A lot depends on political decisions on support and subsidies as well as on regulations governing prices of carbon emissions. In addition, legislation is needed surrounding the



Several different types of test programmes are being carried out at the Schwarze Pumpe pilot plant in Germany. The project shows that CCS technology works as intended, and the results have exceeded expectations. The percentage of carbon dioxide separated from flue gases is currently more than 90%.

capture and storage of carbon dioxide. In summer 2008 the EU issued a directive on CCS. Through this directive, the Commission wants to ensure that the capture and storage of carbon dioxide in geological formations is conducted in an environmentally sound manner. Now it is up to the Member States to follow through with national legislation. In addition, general, broad acceptance is needed for the continued use of fossil fuels and for CCS technology.

Vattenfall has a leading position

As one of Europe's largest generators of electricity and one of those that emit the most carbon dioxide, Vattenfall has a major responsibility to lower environment-impacting emissions from the company's electricity and heat production. Vattenfall is investing in making the use of fossil fuels as effective as possible through highly efficient plants and in developing CCS technology and thereby achieving substantial reductions in CO₂ emissions. Vattenfall therefore has its sights on having a fully commercial CCS concept ready by 2020.

Vattenfall has been engaged in the development and demonstration of technology for capturing and storing carbon dioxide since 2001. An important milestone in Vattenfall's work on CCS is the construction of the Schwarze Pumpe pilot plant, near Cottbus, Germany, for testing so-called oxyfuel technology. The plant – the first of its kind in the world – was inaugurated on 9 September 2008 and has installed capacity of 30 MW.

Oxyfuel technology entails that the fuel, in this case lignite, is burned in a mixture of pure oxygen and recirculated flue gases. The only residual product is carbon dioxide. The pilot project shows that the technology works as intended, and the result has exceeded expectations. The share of carbon dioxide that is captured is currently more than 90%. Several different types of test programmes are being conducted at the pilot plant. These involve optimising the conditions for combustion of the coal and learning how variations in fuel quality affect the process.

The Schwarze Pumpe pilot plant has attracted major international attention and hosts many visits by industry specialists and researchers.

Demonstration plant in Jämschwalde ready 2015

The next step is to build a demonstration power plant that is big enough to enable an evaluation of the commercial

prospects. Vattenfall plans to build a 385 MW CCS demonstration plant in Jämschwalde, Germany. At this location, Vattenfall has a lignite-fired power plant comprising six units; the opportunities to rebuild one unit are being studied. A new boiler employing oxyfuel technology is planned in addition to fitting one of the two existing boilers with postcombustion technology. With postcombustion technology, the flue gases from combustion are scrubbed free of carbon dioxide after conventional combustion. The demonstration project in Jämschwalde, involving two CCS technologies, can become a reality by 2015 at the earliest. In December the EU Commission announced that Vattenfall will be receiving up to EUR 180 million (approximately SEK 1.9 billion) in funding from the EU to drive this project further.

Other CCS projects being conducted by Vattenfall

Through its subsidiary Nuon in the Netherlands, Vattenfall is building a CCS pilot at the Willem–Alexander coal-fired power plant in Buggenum. A portion of the combustible gas produced by the power plant, which is based on gasification of coal, will be cleaned from carbon dioxide. This technology is called precombustion.

In Vedsted, in northern Denmark, Vattenfall has investigated the potential for storing carbon dioxide in a geological formation 1–2 km underground. The studies and plans for fitting unit 3 at the Nordjyllandsværket plant with a full-scale facility for capturing carbon dioxide through postcombustion technology have been put off to the future.

Carbon Capture and Storage (CCS)

Capturing carbon dioxide

The principle of CCS is to capture carbon dioxide after combustion and compress it into liquid form for further transport and permanent storage deep underground. Today there are three main methods of capturing carbon dioxide:

Oxyfuel – the fuel is pre-burned in a mixture of pure oxygen and recirculated flue gases. Carbon dioxide is the only residual product.

Postcombustion – the flue gases are scrubbed after conventional combustion, leaving a higher concentration of carbon dioxide.

Precombustion – carbon is separated from the fuel through gasification, and the resulting hydrogen gas (H₂) is burned.

The challenges for all three concepts include reducing the higher need of fuel required by the capture process, and the higher investment cost.

WORK ON ATTAINING WORLD-CLASS NUCLEAR SAFETY

Vattenfall is working continuously on restoring trust in the company as a nuclear power operator and attain world-class nuclear power safety and generation. High safety is a prerequisite for the company's ability to maintain a high level of availability and thereby generate stable revenue. Nuclear power is also an important part in Vattenfall's work to achieve climate-neutral operations.

During its life cycle, nuclear power does not create more emissions than wind power and is regarded as a reliable and efficient energy technology. The drawbacks are that it takes a long time to build a nuclear power plant, and the technology is advanced, which entails a high investment cost. Further, means and methods for final storage of spent nuclear fuel are still not fully developed in most countries.

At year-end 2009, nearly 40 reactors were under construction around the world – most of which are in India, China, Russia and South Korea. New nuclear plants are also being built in Finland and France. The UK plans to replace ten older reactors with new ones, corresponding to 10–15 GW of new nuclear power by 2025. In Sweden, too, it is now possible to plan for new nuclear power after the Swedish government decided in February 2009 to remove the legal obstacles to replacing old nuclear power. In Germany, discussions are being held on extending the remaining useful life of the country's nuclear reactors.

Nuclear power accounts for a substantial share of Vattenfall's electricity generation. In Sweden Vattenfall operates seven reactors – four in Ringhals and three in Forsmark. In Germany, Vattenfall runs the Brunsbüttel and Krümmel nuclear power plants, with one reactor each. Vattenfall also has a minority interest in the Brokdorf nuclear power plant in Germany. Vattenfall is interested in participating in the development of new nuclear power, but no decisions have been made yet.

Disruptions in nuclear power generation in 2009

During the year, Vattenfall was affected by several disruptions and unplanned, extended outages in its nuclear power generation. On 21 June the Krümmel reactor was restarted following a nearly two-year outage. On 4 July, a short circuit in one of two transformers that connect the plant to the grid resulted in the plant being scrambled. The event did not pose any risk to the environment, but it nevertheless attracted great attention, and Vattenfall was harshly criticised. Krümmel had not been restarted as of year-end 2009. Vattenfall's other nuclear power plant in Germany, Brunsbüttel, has been off line since 2007 for extensive safety enhancement work.

The Forsmark nuclear power plant was under special oversight by the Swedish Radiation Safety Authority (SSM) following shortcomings in the safety culture that were discovered following an incident in July 2006, when a short

circuit in a switchyard outside the plant caused the reactor to be scrambled. In April 2009, SSM removed Vattenfall from this special oversight and has thereafter recommended that the government resume its regulatory process concerning raising the capacity of Forsmark's reactors.

In July, SSM decided on special conditions for the operation of Ringhals as a result of shortcomings it had discovered in the safety culture at the plant. In November, in accordance with SSM's demands, Ringhals submitted a description of the action plan that has been initiated to remedy the shortcomings.

Major efforts to restore trust

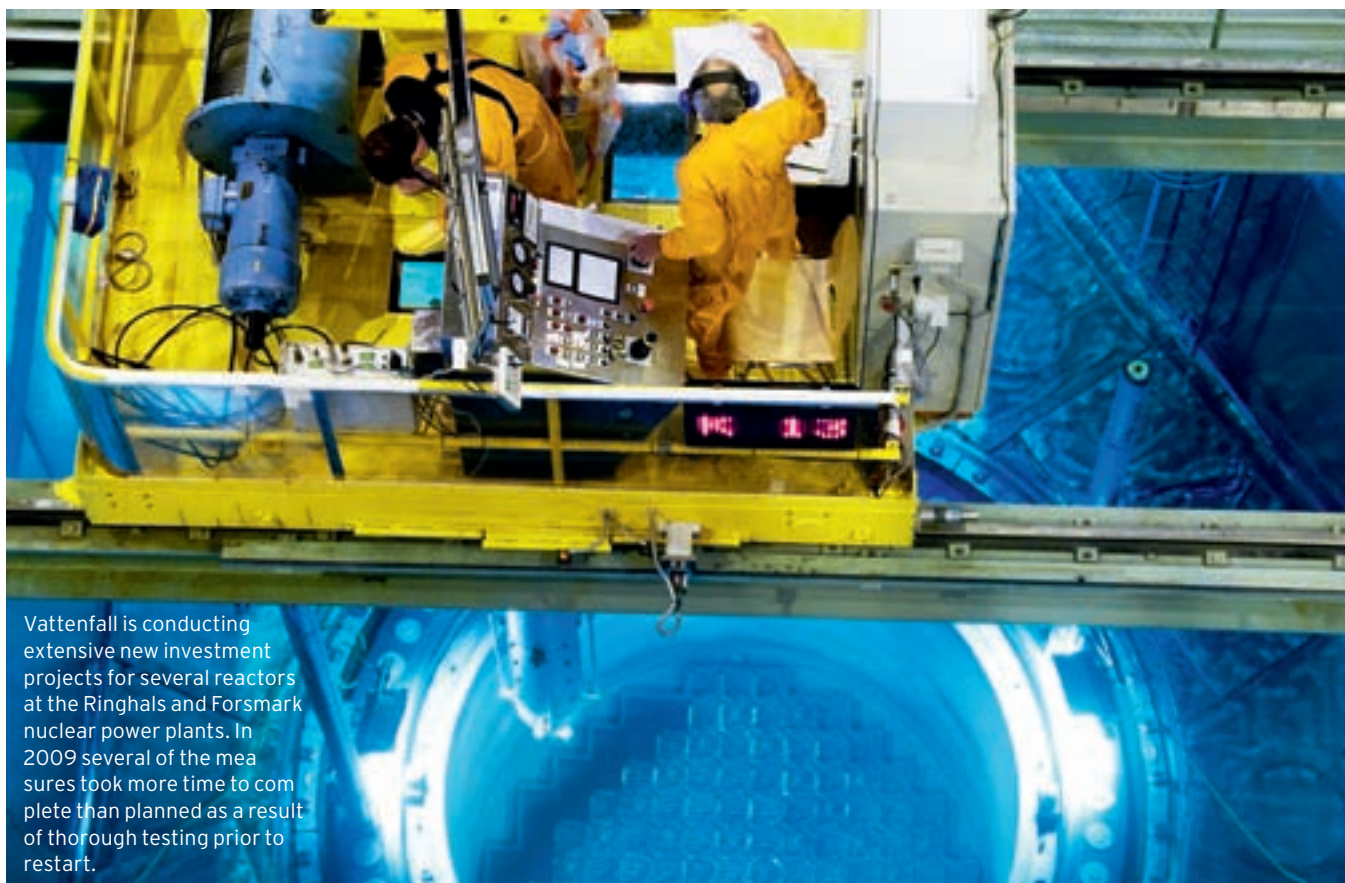
Vattenfall is working intensively to restore trust in the company's nuclear power operations and to attain a world-class level of nuclear power safety. Since 2003, Vattenfall – together with other part-owners – has been conducting a major, long-term investment programme in its Swedish facilities. In all, the programme is worth roughly SEK 50 billion during the period 2003–2030. Of this total, SEK 13 billion is included in the current investment programme for 2010–2014. A large part of this programme involves continued efforts to raise the level of safety, with particular emphasis on the older reactors. At the same time, the plants' useful life and availability are being increased.

In Ringhals and Forsmark, extensive new investment projects are being carried out at a number of reactors. In 2009 several of these measures took longer time to perform than planned. This is due to the need for thorough testing within the framework of these complex projects prior to restart.

During the spring, extensive projects were initiated to modernise and upgrade reactors 1 and 2 at Ringhals. Major safety enhancement installations have been made, entailing a virtual doubling of vital safety systems. As a result, Ringhals 1 can in many respects be compared to a new, modern facility. At Ringhals 2, an extensive project is currently under way in which all of the analogue instruments and control equipment are being replaced with state-of-the-art digital technology.

Organisational work on nuclear power safety

Responsibility for nuclear power safety rests with the licence holders, i.e., the nuclear power companies. To complement, strengthen and maintain oversight of the power plants' safety organisations, Vattenfall has created the function of Chief Nuclear Officer, which is the Execu-



Vattenfall is conducting extensive new investment projects for several reactors at the Ringhals and Forsmark nuclear power plants. In 2009 several of the measures took more time to complete than planned as a result of thorough testing prior to restart.

Group Management's nuclear power expert and who reports directly to the Group CEO. In addition, Vattenfall has a Nuclear Safety Council that includes external members and is chaired by the Group CEO. Vattenfall has also adopted a Safety Governance System with demands for continuous evaluation and oversight of all plants, and higher demands for external oversight.

Favourable result of IAEA review

The International Atomic Energy Agency (IAEA), through its Operational Safety Review Team (OSART) of international experts, regularly reviews nuclear power plants around the world. The IAEA's oversight of Forsmark was followed up in 2009, and in November the result of its follow-up review were presented. The results were very favourable. Of 24 points for improvement that were identified in the first review in 2008, Forsmark received "Measure completed" in 19 areas and "Satisfactory progress" in five areas. This is one of the best follow-up results ever received during the nearly 20 years that the IAEA has been conducting OSART follow-up reviews. The result

of the review indicates that Vattenfall's work on restoring trust in the company's nuclear power operations is on track.

Forsmark proposed as final repository for spent nuclear fuel in Sweden

In June, the Swedish Nuclear Fuel and Waste Management Company (SKB) decided to prepare an application for a permit to build and operate a final repository for spent nuclear fuel in Forsmark. The site location is the result of nearly 20 years of work in which SKB conducted oversight studies in large parts of Sweden, pre-studies in eight municipalities, and thereafter site studies and analyses in Forsmark and Oskarshamn from 2002 to 2007. SKB is now moving forward and completing the applications for the permits that will be reviewed by the Swedish Radiation Safety Authority and the Environmental Court. The applications will be submitted in 2010 and will include, among other things, an environmental consequence analysis and safety analysis for the nuclear fuel repository in Forsmark.