TECHNOLOGY AS A TOOL FOR REDUCING EMISSIONS

The Schwarze Pumpe power plant, located in Brandenburg, Germany, converts raw lignite from the Welzow-Süd open-cast mine into electricity. When operating at full capacity, it uses 36,000 tonnes of lignite daily. The Schwarze Pumpe power plant uses a combination of highly effective measures (such as low nitrogen oxide combustion, particle filters and flue-gas desulphurisation) to keep the plant operating comfortably within legal limits. The plant is also the site of Vattenfall's Carbon Capture and Storage (CCS) pilot plant.

Vattenfall is investing continuously to improve the environmental performance of its power plants. Taking a 30-year perspective on the reduction of emissions to air, the results have been significant. Vattenfall has virtually eliminated particulates, while SO_2 and NO_x emissions have been significantly reduced through modern technology. The plan now is to do the same with CO_2 emissions through the development of Carbon Capture and Storage (CCS) technology.

When burning fossil fuels, biomass and waste to generate electricity and heat, flue gas is produced, which needs to be cleaned before it is emitted into the atmosphere. The composition of flue gas varies depending on the fuel burned and the combustion process. Mostly, flue gas consists of water vapour, carbon dioxide (CO_2) and nitrogen. Nitrogen oxides (NO_X) and sulphur dioxide (SO_2) are formed during combustion from the sulphur in the fuel, and nitrogen in the fuel and air. When burning solid and liquid fuels, particles are also formed. In addition, flue gas contains a very small portion of pollutants such as hydrocarbons, carbon monoxide (CO) and gasified metals.

Reducing emissions from power plants is a concern all over the world. In Europe, emission reduction systems and regulations have been in place for some time. Vattenfall has been investing in state-of-the-art technology for decades, and systems and equipment for cleaning account for more than 60% of total plant size in combustion facilities. Over the years, the environmental performance of Vattenfall-operated plants has improved dramatically and tangible improvements in the natural environment can now be observed.

Emissions travel long distances, and downfall over one country may originate from many other countries. For example, in Sweden, the decreasing acidification of lakes, streams and forest soils is a result of the implementation of emission reducing technologies in other countries. The Swedish Environmental Protection Agency states that downfall of sulphur over Sweden decreased by 60% from 1990 to 2004, while nitrogen downfall decreased by 30% thanks to international agreements and focused environmental efforts.

First breakthrough – elimination of particulate emissions

The problems of pollutants in flue gases has been known for a long time, and studies of technologies to reduce pollutants have been conducted for more than a hundred years. The first major technological breakthrough dates back to the start of the 20th century and involved the most obvious pollutant from combustion – particles. Today, the most common method of reducing particulate emissions in flue gases from large plants is through a collection device that removes particles using an electrostatic force, an Electrostatic Precipitator (ESP). This technology is used in all large coal-fired combustion plants. Today's ESP solutions can clean more than 99.9% of particulate matter from flue gases. The resulting ash is commonly used in the production of cement and concrete. Large amounts are used to recultivate landscapes after open-cast mining. Vattenfall makes use of almost all the ash produced from its power plants.

In smaller plants, an alternative technology to ESP involves the use of fabric filters, where the flue gases are passed though a finely meshed textile. Such filters have a lower initial investment cost than ESP, but the operating cost is higher. The possibility to use fabric filters depends on the size of the facility, the fuel used and the amount of particles. One advantage of fabric filters is that they are even more effective for removing micro-sized particles.

In the 1970s, environmental standards and regulations regarding particles were heightened. As a result, the existing technology was greatly improved. Vattenfall's plants have advanced systems for cleaning particles that far exceed the regulatory requirements. After the particle filters, the smokestacks and cooling towers emit only one visible fraction: water vapour, while the invisible emissions of SO_2, NO_X and CO_2 is then targeted.

Dealing with the problem of sulphur and acidification

Sulphur dioxide (SO_2) has also been a problem in the past, and still is in certain regions where the technology adoption is lagging. Since coal and oil contain sulphur compounds, their combustion generates sulphur dioxide (SO_2). When emitted to the air, sulphur dioxide reacts with water and causes acidification of water and soil. The environmental impact of SO_2 emissions from fossil fuel combustion has been known for a long time, and the first cleaning technologies were introduced in the 1930s. Using fuels with less sulphur content was an early method of reducing SO_2 emissions.

More advanced and effective methods for treating SO_2 emissions were developed and ready for use in the 1980s, including Flue Gas Desulphurisation (FGD). In this method, the flue gases are cleaned using wet scrubbers or dry sorbants that absorb the sulphur using limestone as an absorbing agent. The wet scrubbers used mostly by Vattenfall have an efficiency of over 98%. The desulphurisation process leaves a very useful by-product, gypsum. Vattenfall takes care of this valuable asset and sells it to building material manufacturers for the production of plaster board, among other things.

Advancements in technology and fuel have had a huge impact; today sulphur downfall is 10% of the levels during 1970s and 1980s, and the remaining downfall stems mainly from motor vehicle emissions.

As was the case for particulate emissions, development of sulphur dioxide cleaning technology has largely been driven by regulation, although many companies are also taking initiatives themselves to improve environmental performance on their own accord.

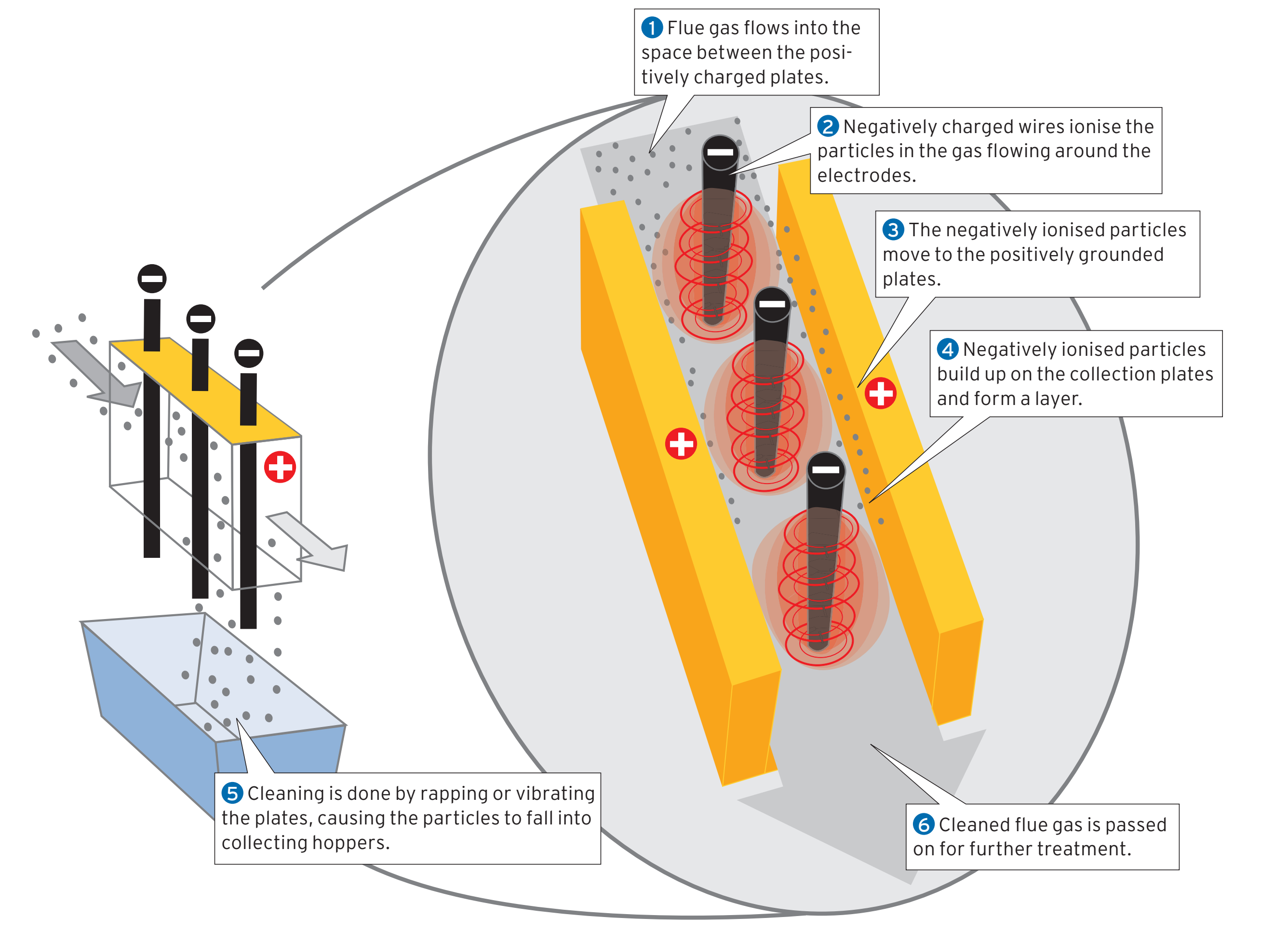
The main technologies used to fight emissions

Electrostatic precipitators (ESPs): The most basic precipitator uses a row of thin wires following stacks of large flat metal plates. The air stream flows through the spaces between the wires and passes along the plates. High voltage is applied between the wires and plates, creating a charge in the particles in the flue gas. The particles are forced by this electric field to collection plates, where they form a layer. This is then removed by vibration. The solution used today has evolved substantially with advanced discharge electrode designs and collection methods. Today's ESP solutions can clean more than 99.9% of the particles from the flue gases.

Fabric filters (FFs): Fabric filters are used in small power plants and have high collection efficiency, normally retaining 99.9% or more of the particles. Fabric filters are especially effective at handling micro-sized particles, while their technical complexity is still at a moderate level. Although the basic principles and design of fabric filters used today date back some 40 years, product development is still active. As fabric filters have higher operating cost than ESP solutions, focus is on developing more cost-efficient fabric filters.

Flue Gas Desulphurisation (FGD): FGD has been used to combat sulphur dioxide (SO_2) emissions for a long time, and today's solutions have been in effect since the 1980s. The flue gases are treated by bubbling them through a wet slurry containing water and limestone or lime that absorbs the SO_2. Other methods involve the spraying or injecting of dry sorbants. Scrubbers can reduce SO_2 emissions to an effect ranging from 50% to 99%. The modern wet scrubbers used mostly by Vattenfall have an efficiency of over 98%.

Technical concept of electrostatic precipitation



Selective Non-Catalytic Reduction (SNCR) reduces NO_x in conventional power plants by injecting either ammonia or urea straight into the furnace at a rather high temperature. The chemicals react with the nitrogen oxides in the flue gas, forming elementary nitrogen (N_2) and water. SNCR normally operates with around 70%–80% efficiency in reducing NO_x. SNCR is less expensive than systems using catalysts, because there is no cost for the catalyst, but often they are insufficient to meet emission requirements.

Selective catalytic reduction (SCR) converts NO_x gases with the aid of a catalyst into nitrogen (N_2) and water. Ammonia or urea is injected into the flue gas at a relatively low temperature, reacting with NO_x over a catalyst. SCR is substantially more efficient then SNCR, reaching efficiencies of more than 90%, but is more expensive. SCR solutions were introduced in the 1980s on a large scale. The adoption of SCR is very common in modern plants, as demands for reductions are set higher and higher.

Carbon Capture and Storage (CCS) technology is a method where CO_2 from fossil-fired power plants is captured, compressed into liquid form and permanently stored deep underground. Suitable storage sites include natural rock formations thousands of metres below the surface, which are similar to natural oil and gas reservoirs. The concept of applying CCS to power plants is new. However, parts of the technology already exist and are used in other applications. Currently Vattenfall is testing the technology in a new 30 MW_{th} pilot plant at Schwarze Pumpe in Germany. It is anticipated that CO_2 and all other emissions can be reduced to almost zero in this facility. (For further information see www.vattenfall.com/ccs.)

Nitrogen oxides are combated in two ways

Normal combustion emits nitrogen oxides, because nitrogen reacts with oxygen during combustion. This happens when anything is burned, from the smallest candle, to a wood fire, to biomass, as well as fossil fuel combustion. Nitrogen oxides (NO_X) have many adverse effects on the environment such as causing ground-level ozone that triggers respiratory problems, and contributing to acidification and eutrophication. NO_X, and pollutants formed from NO_X, can be transported over long distances, following wind patterns.

There are two major ways of combating NO_X. One is through controlled combustion, and the other is with catalytic cleaning technologies and the injection of chemicals.

NO_X formation is dependent on temperature and oxygen availability, which is why the chief method of reducing NO_X involves adjusting temperatures and air flow during combustion. By using low NO_X burners or fluidised beds and controlling the level of oxygen in the boiler, NO_X formation can be limited. This is how NO_X emission levels are kept down in Vattenfall's lignite-fired plants.

Hard coal and biomass-fired plants usually cannot avoid higher formation of NO_X and need technologies to clean the flue gases from NO_X (see fact box). The technologies differ from plant to plant depending on their respective conditions and the emission requirements.

Like other pollutants, development of NO_X cleaning technology has been driven primarily by regulation, although some very effective incentives have also played a part. Sweden makes use of an incentive programme for reducing NO_X emissions. Companies that emit NO_X pay a fee based on the level of emissions. This fee is allocated to a pool, and each company receives money back from the pool in relation to the amount of energy it generates. In effect, low-emitting power plants can actually make money at the expense of high-emitting competitors. For Vattenfall this has been a constructive and favourable solution, in many ways more effective than traditional regulation.

The focus from now and onward

The cleaning technologies used to treat SO_2, NO_X and particulates are mature, well-established and highly effective, and they have been used by Vattenfall for many years. In newly acquired facilities that have not adopted the latest technologies and equipment, work is done to bring them up to Vattenfall's standards.

In Poland, several projects have been carried out to modernise existing plants and meet higher environmental standards. In 2007 and 2008, Vattenfall conducted a large modernisation project at three plants in Warsaw. EUR 30 million was spent on modernisation and replacement of old electrostatic precipitators (ESPs), resulting in emission concentrations 50% below legal requirements. Vattenfall plans to invest an additional EUR 130 million to equip 14 boilers at the Siekierki CHP plant in Warsaw with desulphurisation equipment. This investment has been broken down into two stages: half of the plant will be equipped with desulphurisation by 2010, and the other half by 2011.

Vattenfall's greatest challenge moving forward is not the emissions that have an effect on the local and regional environment – such as SO_2, NO_X and particulates – but dealing with CO_2 emissions that contribute to global warming. Vattenfall believes that reducing CO_2 emissions is the overriding environmental challenge of our time. Further, Vattenfall believes that a global framework for reducing greenhouse gas emissions will be essential to solving this problem and has taken the initiative to propose such a programme to curb climate change.

In the long term, reducing emissions will make Vattenfall more profitable, and doing so proactively will give the company a competitive advantage. For this reason, Vattenfall is taking the lead in the development of a number of CO_2 emission–reducing technologies, including energy efficiency measures, a focus on renewable energy, nuclear power and Carbon Capture and Storage (CCS). In September 2008, a 30 MW_{th} CCS pilot plant was inaugurated in Schwarze Pumpe, Germany, which will give the company valuable experience that will be needed to develop demonstration plants and full-scale commercial power plants employing CCS. (For more information about Vattenfall's CCS efforts, see the 2008 Annual Report, the 2007 CSR report and www.vattenfall.com/ccs.)

For emission data, see the environmental performance section on page 56.

In 2001 Vattenfall initiated a Carbon Capture and Storage (CCS) research programme with the goal of developing commercial concepts for CCS technology at power plants by 2020 at the latest. Seen here are a few images from Vattenfall's CCS pilot plant at Schwarze Pumpe in Brandenburg, Germany. The 30 MW_{th} pilot plant, which was inaugurated on 9 September 2008, provides a valuable opportunity to test technology that has so far only been tested in laboratories.