Electron beams help Poland's coal-driven power industry clean up its air

By Nicole Jawerth

"Electron beam accelerators are a multi-pollutant treatment technology; no other technologies can provide similar results."

— Lech Sobolewski, Chief Engineer, Pomorzany Power Plant, Poland

Radiation technology is expected to play an increasing role in Poland and other countries in cleaning up air pollution to meet regulatory requirements and to protect the environment.

An IAEA-supported project in Poland has helped the country to build a full-scale electron beam accelerator facility to treat flue gases from coal-driven power plants, leading to a significant reduction in emissions of sulfur dioxide, nitrogen oxides and polycyclic aromatic hydrocarbons, which threaten human health, damage the environment and can lead to economic losses. Acidic pollutants in the air can also drift to other countries through acid rain.

Following the results achieved in treating flue gases, or combustion exhaust gases, produced by power plants in Poland, other countries are now working with the IAEA to draw on the Polish experience and develop the skills they need to adopt and benefit from this electron-harnessing tool.

"Poland is producing 90% of its electricity from coal combustion. So air pollution is a big problem, and Poland has to meet regulations regarding air pollution control," said Lech Sobolewski, Chief Engineer in charge of construction and operation of the electron beam cleaning installation, built with IAEA support, at the Pomorzany Power Plant. "This is important as the European Union will introduce more strict regulations in 2016."

Limiting emissions

Poland and the IAEA teamed up to develop a model project in 1992 to evaluate the effectiveness of electron beam accelerators — machines that produce beams of electron radiation — for cleaning flue gases (see box). Following the success of this model, Poland, the IAEA, and its partners constructed a full-scale plant in 2002 with 15 times the capacity of the pilot plant. This electron beam treatment facility efficiently removes up to 95% of sulfur dioxide (SO_2) and 70% of nitrogen oxides (NO_x) present in flue gases, allowing the coal-fired power plant to meet emission limits. The by-product of the process is a high quality fertilizer used in agriculture.

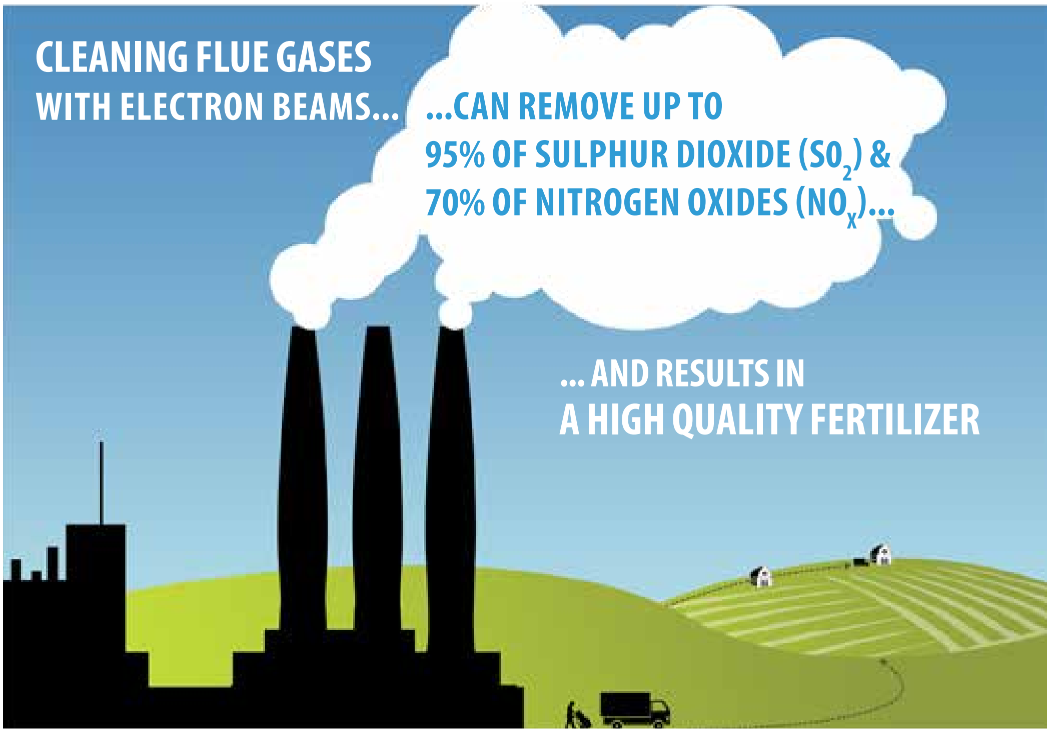
"Electron beam accelerators are a multi-pollutant treatment technology; no other technologies can provide similar results," said Sobolewski. Traditional technologies using various chemical and physical processes have a similar efficiency in removing both NO_x and SO_2 pollutants, but require the construction of two separate installations; consume large amounts of water; use a toxic, metal-doped catalyst; and produce a significant amount of waste that needs to be stored and treated.

"Conventional technology is generally more costly to install and operate, and requires special methods to dispose of the waste or to use the waste for other purposes," said Andrzej Chmielewski, Director General of the Institute of Nuclear Chemistry and Technology in Poland. "Electron beam accelerators are a proven, green technology that works. However, the accelerators are huge, high power units, which is a challenge. So we need to keep working to develop more reliable units that are easier to maintain. The IAEA can play an important role in developing such equipment through its scientific and technical support."

Slow to catch on, but effective

The use of electrons to treat flue gases is not a new concept. The technology was first developed in Japan in the 1970s, but its slow emergence at industrial scale meant many older coal power plants were fitted with other, more costly cleaning devices. However, despite the initially slow industrial-level progress, several countries are now actively pursuing this technology to reap its benefits.

Poland's pilot and full-scale industrial projects are a source of guidance and knowledge other countries draw on through IAEA coordinated research projects and



technical cooperation projects, publications, and scientific visits. "So far, more than 30 fellows have been trained and more than 150 persons have participated in scientific visits and technical meetings. The experiences gained are now being applied to their own power plants to reduce emissions and to make their plants more environmentally friendly," said Sobolewski.

Pilot plants have been constructed in Bulgaria, China, Malaysia, South Korea, Russia and Turkey. Brazil, Chile, the Philippines and Ukraine are also looking into technology transfers, while heavy oil combustion systems in Saudi Arabia and Denmark have undergone preliminary laboratory tests.

"The introduction of this new technology has an important impact on the power industry in how it develops monitoring and pollution control systems," said Sobolewski. Now that the electron beam has been proven to work in harsh industrial conditions, countries like Russia and South Korea, are developing new and bigger accelerators, he added. "These trends for using accelerators are still being disseminated all over the world."

THE SCIENCE

Electron beam dry scrubbing

Before flue gases — the combustion exhaust gases produced by power plants — escape through the chimney of a power plant, they are sent through a "cleaning" process called electron beam dry scrubbing.

In this process, the gases are cooled to between 70°C and 90°C with a spray of water and then diverted into a reaction chamber. There the wet gases are exposed to low energy electron radiation from an accelerator, which acts similarly to the tubes found in old television sets. Ammonia is then added to neutralize the SO_2 and NO_x, causing them to change chemical form and become solid aerosols. A high efficiency machine gathers and filters these sticky particles, converting them into high quality fertilizer. The remaining "cleaned" gases leave through the chimney.

Though radiation is used to treat the gases, there is no residual radiation in the cleaned gas or the fertilizer by-product.