



EFFICIENT USE OF NUCLEAR FUEL

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The use of nuclear fuel in power generation has come a long way. Today, fuel is used more efficiently thanks to improvements in fuel fabrication and how fuels are used in generation. This has resulted in less mining and reduced amounts of nuclear waste for the same amount of generated energy.

Together with a comprehensive safety management programme and responsible handling of nuclear waste, efficiency is a core aspect of nuclear power generation since it leads to economic as well as environmental benefits in society.

The importance of working with nuclear efficiency

Enhancing efficiency in power generation has positive effects both environmentally and economically. In nuclear power generation, the results of efficiency improvements in the use of nuclear fuel are very tangible. The environmental benefits are substantial – by producing more with less, uranium mining is reduced as is the need for handling spent nuclear fuel.

By decreasing uranium mining, the physical impact at mining sites can be reduced. Also, since there is less material to handle, indirect emissions (such as CO₂) from the mining, fuel fabrication process and transports are decreased.

Nuclear power generation uses very small amounts of fuel in the reactors compared with other types of energy generation in terms of weight. A single fuel pellet consists of 10 g of uranium and generates 4,000 kWh of electricity – which is the level of normal consumption for a single household. The fuel used in the reactor core is enriched uranium, where the uranium content has been increased to

3.5%–5% of the isotope U235, compared with 0.7% in the natural uranium. Vattenfall uses an estimated equivalent of 1,500 tonnes of natural uranium every year.

Handling nuclear waste is a key issue since it must be stored for a long time under very strict conditions. Efficient use of the fuel reduces the quantity of the waste. This is achieved by increasing fuel efficiency, for example by maximising burn-up (the rate at which the fuel is used up) and increasing the life span of fuels.

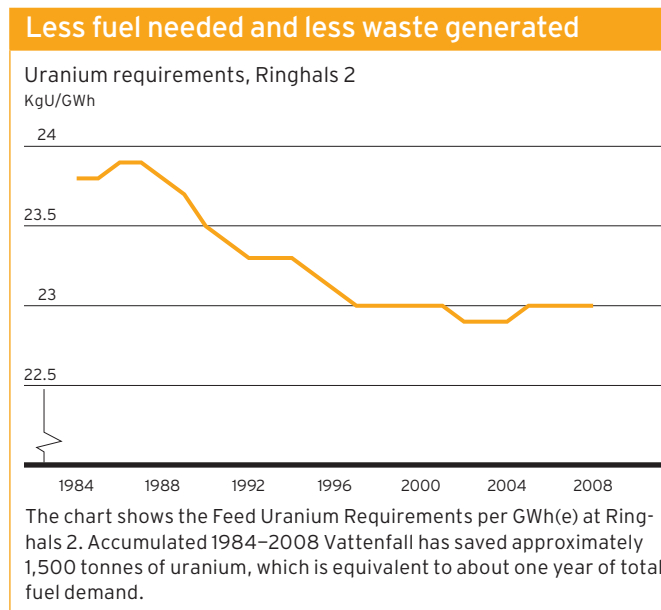
From an economic perspective, efficient use of nuclear fuel is a true cost-reducing measure. The efficiency-improvement work that is done contributes to stable and affordable electricity prices and a secure power supply.

How does Vattenfall improve efficiency?

Vattenfall’s work on improving fuel efficiency is twofold: suppliers are encouraged to further develop the fuels (both materials and the way they are constructed), while Vattenfall works on optimising the use of fuels in generation. Different types of fuel are used in different types of nuclear reactors.

Vattenfall works together with its suppliers and formulates demands and explains how the fuel is intended for use in the reactors. This information is crucial for suppliers in their work on developing a product that meets the demands and leads to increased efficiency. Vattenfall’s role as a purchaser is very important, and for more than 20 years, the company has been at the forefront of efforts to increase fuel efficiency. Collaboration between Vattenfall and its nuclear fuel suppliers has resulted in more advanced fuel technology and design, improved materials, and the possibility to use fuel with a higher degree of enrichment. In addition, Vattenfall makes demands on environmental and social standards for all its suppliers¹.

In Vattenfall’s nuclear fuel operation, highly skilled experts in nuclear physics, thermo-hydraulics, mechanical design and materials behaviour utilise the latest knowledge and calculation methods to optimise how the fuel is designed and how the reactor core is formed. This optimisation requires extensive computer power and advanced calculation programs. The reactor core is re-formed and loaded with fresh fuel once a year, and the work on calculating and optimising the design takes several months. Each fuel assembly is in operation for a period of 4–6 years, and when the core is reloaded, the spent fuel assemblies are



1) For additional information, see Vattenfall 2007 CSR Report

replaced by fresh ones and a new reactor core is designed for the upcoming power generation cycle.

All efficiency improvements are subject to a stringent safety management approach. Safety margins in all aspects of nuclear power generation are strictly regulated, and compliance is verified both internally within Vattenfall as well as by the supervising authorities. Improved calculation methods and knowledge about how the fuel works has made it possible to improve fuel utilisation while maintaining high operational safety.

From a technical perspective, a range of specific innovations and factors has contributed to increased efficiency (see the fact box opposite “How nuclear fuel efficiency is increased”).

Development of nuclear fuel cost



Ali Etemad, Executive Vice President of Vattenfall Nuclear Fuel, has more than 40 years of experience in the nuclear power industry. He has spent 27 years with Vattenfall and has been responsible for nuclear fuel procurement since 1984.

Efficient use of fuel has saved considerable amounts of uranium since the 1980s, but what has happened with respect to cost?

“Vattenfall’s present cost of nuclear fuel is in fact lower than in the mid-1980s. Considering that the cost of everything else has gone up since then, nuclear fuel costs have come down by a factor of 3 to 4 when adjusted for general inflation.

This is due to several factors, including the efficient use of fuel and the general market situation. In addition, Vattenfall’s effective supply and procurement strategy has made it possible to take advantage of prevailing market conditions to achieve a lower fuel cost.

Uranium prices have risen considerably during the past three years, which will affect Vattenfall’s future fuel cost. We continue to work with our supply policy and procurement strategy in an effort to minimise the impact of higher prices while at the same time securing our fuel supply.”

How far has Vattenfall come?

As a result of improved fuel efficiency, Vattenfall saved approximately 1,500 tonnes of uranium during the period 1980–2008, which is about 5% of all uranium used by the company during this time period, or the equivalent of about one year of total fuel demand. Vattenfall’s efficiency improvement efforts yielded better relative results in the early 1980s, but have levelled out since 1998. This is because there often is more to improve in the beginning of efficiency work. In pace with Vattenfall’s use of more effective and advanced techniques, the scope for improvements decreases. Also, the level of efficiency has increased as a result of higher uranium enrichment up to the levels that can be managed in the fuel fabrication plants. As a result, the focus of further improvements is put on reliable operation of the fuel.

Challenges of efficiency improvement work

The challenge ahead is to continue to improve fuel materials and fuel design, such as by making fuels more reliable and thereby minimise stops in the operations. The reactor core and its surroundings exist in a very harsh environment due to high temperatures, pressures and radiation. This leads to high requirements on the design and construction of all equipment and materials used in the reactor. All materials undergo rigorous testing and controls, and independent measures and routines are in place to ensure the safety and reliability of the production process. In the future, it may be possible to use higher-enriched fuels than today, which would enable using the fuels longer and increasing the so-called burn-up (the rate of which the fuel is spent). But this requires new licensing and permits for fuel fabrication and handling, which is a global process that will take time.

Vattenfall continues to make improvements in its current nuclear power generation in terms of fuel and maintenance efficiency, and is committed to excellent safety and operational performance. But to make significant efficiency improvements in nuclear power generation, new and improved reactors with higher efficiency will be needed.

Additional information on Vattenfall’s nuclear operations can be found in the reporting section. For information on safety management, see page 64. For information on nuclear waste management, see page 47.