Prospects for nuclear power generation

Benefits from the Atom

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Many countries have found nuclear power stations to be successful solutions. Poland will join them sooner or later. The point is for this decision to be taken with full understanding of the benefits to be gained

The electrical energy production costs at nuclear power stations are usually lower, and sometimes considerably lower, than at coal-fired stations. The Finns, for example, before deciding to build a new nuclear power station, carried out an analysis of the economic competitiveness of various electrical energy sources. The results of their research showed the lowest cost for electricity produced at nuclear power-plants - 23.7 euro/MWh, for gas-powered plants - 32.3 euro/MWh, and for coal-fired plants - 28.1 euro/MWh. Faced with these estimates, Finland ultimately opted to build a nuclear power-plant.

Economic benefits

The attractiveness of nuclear energy is based on the very low cost of nuclear fuel in comparison with coal or gas. However the costs of building a nuclear power-plant are high, considerably higher than for coal-fired plants - mainly because of the need to install extensive safety systems to prevent accidents and to take measures for protecting the personnel from radiation. All economic comparisons between nuclear and coal-powered plants lead in the end to this underlying question: do the decreased costs of fuel for nuclear power stations compensate for the increased construction costs?

The division of the unit costs for producing electricity at coal and nuclear plants is therefore fundamentally different. In a nuclear plant, investment costs account for 50-65% of the total energy production cost, while fuel accounts for 20-25%. In a coal-fired plant these proportions are more or less reversed (investment costs 20-35%, fuel 50-65%). Production costs at coal-fired plants are therefore very sensitive to changes in the price of fuel, whereas at nuclear plants they are greatly influenced by construction costs, the duration of construction, the capital discount rate and the load factor of the plant.

Let's simulate how the cost of electricity production rises in both types of power-plant if the costs of uranium and coal double. As we have seen, the price of coal contributes about 60% to overall energy production costs, nuclear fuel about 25%. But the cost of uranium itself only represents about 20% of the cost of nuclear fuel. Therefore, twofold growth in the cost of raw fuel materials will trigger about a 60% increase in the overall cost of the electricity produced in the case of a coal-fired plant, but only about a 5% increase for a nuclear plant.

This comparison is important because of the estimated magnitude of the resources of the various energy fuels (at the current rate of use: coal resources will last 200 years, gas - 60 years, oil - 40 years, uranium - 85 years). As the easily exploitable and cheapest deposits used today are exhausted, it will become necessary to extract from more technologically difficult but resource-rich deposits (deep coal mines, deep underwater oil extraction, and extraction of uranium from phosphorites) and to harness new and considerably more expensive technologies. It is at this moment that the impact of rising fuel costs on overall electricity production costs becomes crucial.

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Traditional methods of producing electricity, such as this coal-fired power station, are accompanied by significant emissions of carbon dioxide, partially responsible for global warming

supplies of energy, including electricity. At first glance, Poland is in a privileged position compared to other European countries in that it has relatively large power generation resources in the form of coal. Over 95% of Poland's national electricity generation is based on this. In 2006, 97.8 million tons of bituminous coal and 61.6 million tons of lignite were extracted. Practically all the extracted lignite and around half the extracted bituminous coal are used in electricity generation.

Limited resources

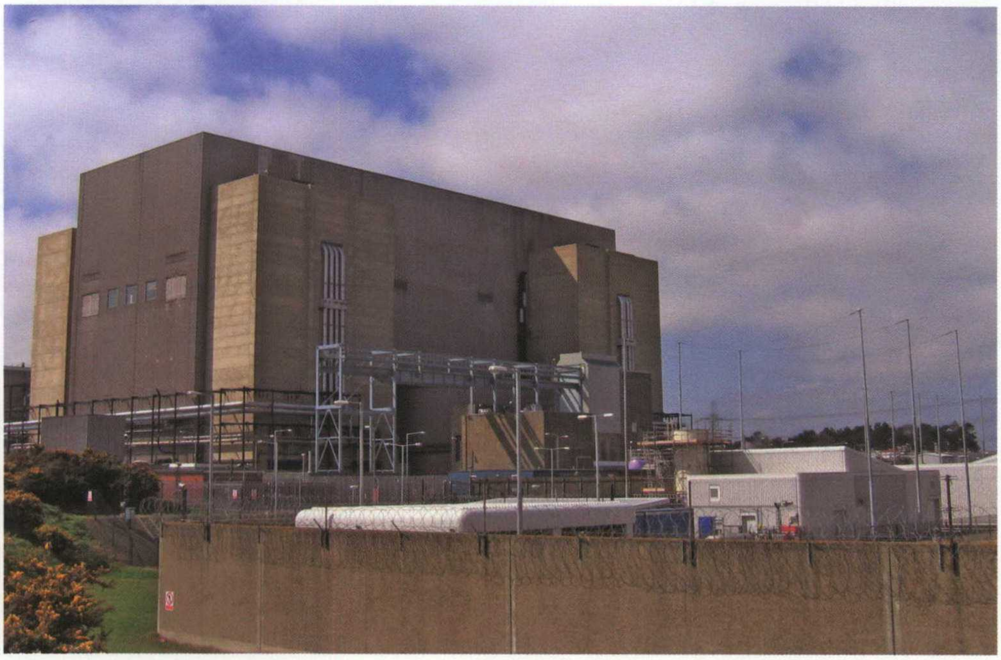
This optimistic image is not accurate, however. Coal resources extracted from existing mines will last about another 40 years. To increase extraction, new mines will have to be constructed both for bituminous coal and lignite. The construction of new mines is an extraordinarily capital-intensive investment, but boosting the extraction of coal will soon be a necessity. The rate of electrical energy use per inhabitant per year, which in some way serves as a gauge of a given country's level of advancement, is embarrassingly low for Poland, not only in comparison with other European Union countries, but even with former Comecon countries. In 2006, the average indicator for the EU-15 was almost two times higher than for Poland. It is estimated that in the next two decades this figure will grow in Poland at around 2% annually. This means that the growth curve will intersect the curve of electricity generation capacity halfway through the next decade. Following these forecasts, it will take about 20 years for us to reach today's average EU level of use.

The power installed in the country's power generation system is about 35 GW, and the power required at peak load (in the winter months) is about 25 GW. Comparing these two figures could give a misleading, distorted picture, seeming to indicate that Poland will have an excess of electrical power for a long time to come. In fact Poland faces the danger of an electrical energy deficit not only from the perspective of increasing demand, but also because of the difficulty in sustaining current levels of production.

If we look closer at the power sources in the Polish power-generation system, it turns out that a majority of the country's power-plants are used up and hopelessly outdated. Nearly 70% of the energy is created in blocks over 30 years old, 37% in blocks over 40, and over 10% in blocks which are over 50 years old. These must be decommissioned and replaced by up-to-date power generation units. They cannot be replaced by wind farms and other renewable energy plants - such measures can only alleviate the energy deficit to a small degree.

As it concerns the provision of electricity, energy security must rest soundly on fuel diversification (having an appropriate *generation mix*) and diversification of fuel supply sources. If we compare the levels of energy security provided by power stations fired by coal, gas, and nuclear fuel in the Polish situation, it turns out that nuclear power-plants guarantee the highest security. This is related to the characteristics of nuclear fuel, which contains an unusually concentrated dose of energy.

The greatest risk arises when the development of power generation is based on imported gas as a fuel because of the possibility of external political interference, particularly in the situation where gas supply is limited to one geographical direction. Coal, as a domestic raw material, is for Poland resistant to all forms of external political interference. It is,



The construction of nuclear power-plants will enable us to limit the emissions of carbon dioxide and avoid high fees related to its emission

however, sensitive to internal political interference (such as miners' or railmen's strikes) and climatic conditions (a harsh and snowy winter may paralyze the work of coal-fired power-plants). Coal-fired stations with a power of 1000 MW require an annual supply of nearly 3 million tons of bituminous coal (8 trains daily with fifty 20-ton wagons each!). For a nuclear power-plant of the same generating capacity only 25 tons of uranium is needed annually - and if the situation so requires, it would be easy to store enough fuel reserves to keep the plant running for many years. Nuclear fuel is easily available on the free international market. The distribution of uranium ore resources across the world is geopolitically beneficial because the largest reserves are held by developed free-market countries (Canada, Australia).

It is worth noting that the lifetime of world uranium resources is estimated at 80-100 years at the present level of use, with the existing deposits currently being mined today and at the costs currently accepted. But if we consider the small influence of the cost of uranium on the cost of electricity produced and therefore assume that the cost of uranium extraction may safely increase severalfold, its potentially accessible reserves grow vastly - it will then become profitable to extract uranium from poor quality ore with low uranium content (e.g. phosphorites). Once a decision is made to base nuclear energy on fast-breeder reactors and to accept multiple processing of spent fuel, the potential uranium reserves (and their lifetime) grow nearly 50 times. Despite the claims sometimes made by opponents of nuclear energy, then, there is no fear that worldwide reserves of uranium will quickly be exhausted.

Environmental protection

Burning different types of coal causes pollution to be released into the biosphere, in gaseous (SO2, NOx, hydrocarbons) or solid (cinders, airborne particles) form. The majority of airborne pollution is removed by ever more effective filter systems; nevertheless, the unremoved proportion of pollution may still cause serious harm. In cost calculations for electricity production the cost of this harm is defined as "external" as energy producers are not burdened with it, but pollution costs are still borne by society as a whole - often not just in the country which produced the energy but also in neighboring countries.

In the calculation methods for electricity costs currently used, external costs are usually omitted because of the great difficulty in defining the amounts. It is particularly difficult to define the value of harm to human health. Research on developing a quantitative approach to the various types of external costs is being undertaken with the aim of introducing them into comparative economic calculations. In the 1990s, the European Union countries started up the "ExternE" (*External*

Energy Costs) program, which aimed to devise a methodology for quantitative calculation of external costs. The results of this research indicate considerable external costs of coal-fired power-plants and slight ones associated with nuclear power-plants. The addition of external costs to comparative calculations of the various power generation options foreseeable in the nearer or more distant future further increases the already clear economic superiority of the nuclear option.

Another problem which has gained in importance in recent years is CO_2 emissions. Traditional methods of producing electricity, such as this coal-fired power station, are accompanied by significant emissions of carbon dioxide, partially responsible for global warming. The European Union is calling for a decrease in CO_2 emissions by 2020 of 20% in relation to 2003. The EU considers one of the most important methods for reducing emissions (alongside those such as increasing the efficiency of energy sources or reducing energy use in manufacturing) to be the harnessing of renewable energy sources. Nevertheless, such efforts bring considerable costs attached. When we compare the various power generation options in terms of the magnitude of CO_2 emissions per unit of electricity produced (emission is defined for the full production cycle including the building of facilities and the removal of waste), it turns out that nuclear power generation has the lowest emission.

Return of the atom

Recently the European Union's priority program has been limiting the emission of CO_2 into the atmosphere. This has had a positive influence on the EU authorities' approach to nuclear energy: although it was previously somewhat cool and reserved, recently a clear change has been observed. Signs of this change have been evident both in the speeches of European Parliament members at sittings of the Commission, and in a resolution approved at a European Parliament plenary session (October 2007). The predicted difficulties in achieving the targeted reduction in CO_2 emissions without a significant reliance on nuclear energy are certainly contributing to this change, but the growing awareness of the infeasibility of achieving the very ambitious goals using renewable energy resources is another possible influence.

In 2006, Poland released 326.5 million tons of CO_2 into the atmosphere. The National Allocation Plan for CO_2 Emissions (2005) proposed a total annual limit for Poland of 284 million tons of CO_2 through 2014, including annual limits of 125 million tons of CO_2 for power-plants. In later years the limits are to be gradually reduced. Currently, Poland has been allocated permission for the emission of 208 million tons of CO_2 - a quantity far from sufficient. The situation will prove a serious challenge for Polish power generation. To meet it, it will be necessary to act in three directions simultaneously:

- to purchase the extra allocation required on the (soon-to-be) free market,
- to implement CO_2 exhaust cleansing and sequestration technologies (the technology is not yet available),
- to step up plans to build nuclear power-plants, which do not emit CO_2 (a 1000 MW nuclear power-plant enables an emission reduction of about 7 million tons of CO_2 annually).

Coal resources extracted from existing mines will last about another 40 years

It is difficult to predict today how much the costs of electricity production will rise as a result of the introduction of CO_2 emission limits. Pessimistic forecasts speak of as much as a doubling of costs. This could have catastrophic political and economic effects. The construction of nuclear power-plants will enable us to limit the emissions of carbon dioxide and avoid high fees related to its emission. It needs to be made clear that without a significant input by nuclear power there is no real possibility of considerably limiting CO_2 emissions in Polish power generation. Unfortunately it is impossible to make this happen today or tomorrow; it is a process to be spread over decades. The faster we begin using nuclear power in Polish power generation, the faster we will obtain beneficial results for the economy and the population. ■

Further reading:

Poland's Energy Policy Through 2030 - Economy Ministry document, March 2009.