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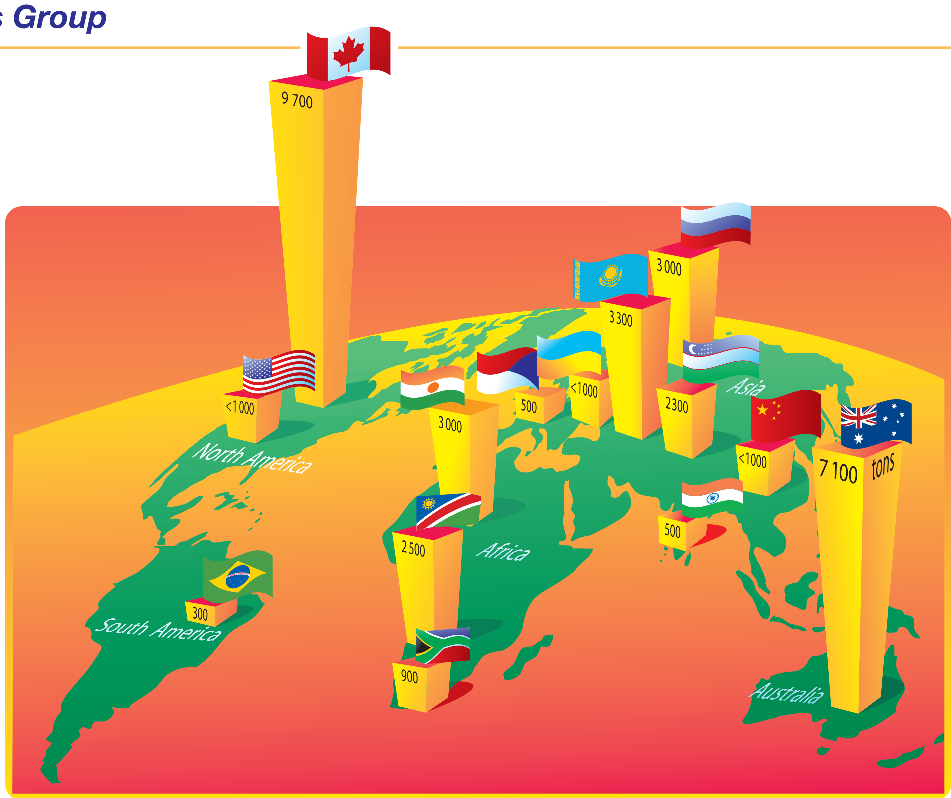


Commercial uranium production in 14 countries in 2003 – metric tons per year. Source: OECD, reference 1.

Uranium - a sustainable energy source

Uranium differs from natural gas, oil and coal in being a sustainable energy source, i.e. one that can play its part in sustainable development of society. The nuclear power fuel cycle is practically free of carbon dioxide emissions, and therefore differs from all types of fossil fuels and their impacts on the world's future climate.

The sun is, for all practical purposes, an inexhaustible energy source, which we are at present exploiting to only a limited extent for electricity and heat production. Wind and hydro power are forms of solar energy, and therefore renewable, but their use is restricted by environmental considerations. The same applies for biofuels, the long-term use of which requires the fuel ash to be returned to the cultivation site. But uranium is a mineral, and is used up in a nuclear reactor, so it is not a renewable energy source.

Nuclear power clearly meets the requirements of the Brundtland Report for sustainable development. Costs are stable in the long term, even in the event of substantial price rises for uranium, as the cost of the uranium makes up only a very small fraction of the overall cost of nuclear power. In that perspective, known uranium reserves will last for hundreds of years with present-day technology: with new types of reactors, they can be expected to last for thousands of years.

Sustainable development

The importance of developing sustainable energy sources has steadily climbed the environmental and energy agenda over the last few decades at both national and international levels.

Sweden's line in this debate seems to be concerned only with renewable energy sources; a limitation that is missing from the international debate.

The basis for the interest in sustainable development is to be found in the nowadays well-known fact that some of the raw materials that we now use, such as some minerals and fossil fuels (e.g. natural gas and oil), are becoming increasingly difficult to obtain, and so also therefore more expensive. We are also realising that the atmosphere and the oceans cannot withstand unlimited emissions from fossil fuels. Climate change is a real threat to the whole globe.

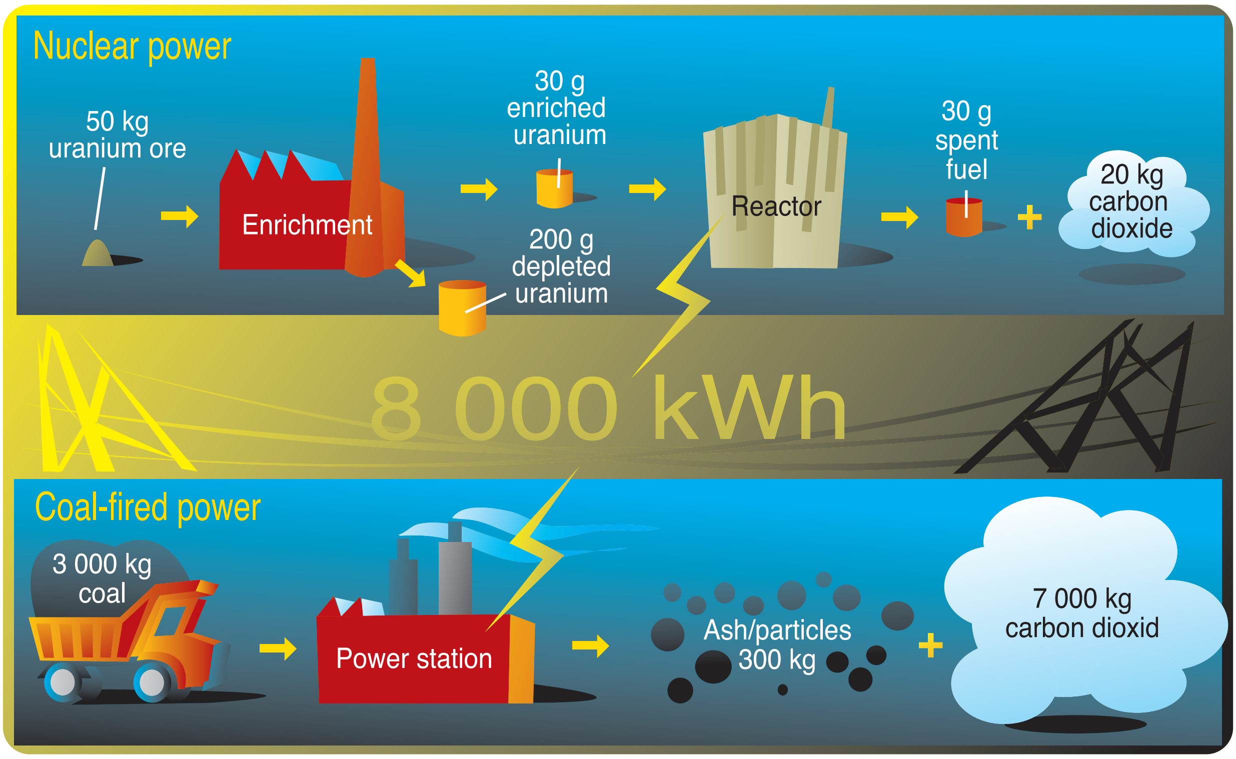
The concept of sustainable development made its appearance in a wider perspective for the first time at the First UN Environmental Policy Conference in Stockholm in 1972.

A carefully thought out, and nowadays classic, definition of sustainable development was formulated a few years later by Gro Harlem Brundtland, Chairman of the World Commission for the Environment and Development, in her report, 'Our Common Future' in 1987:

'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'

The Brundtland Report already recognised that worldwide sustainable development required sound technical and economic development, particularly in the developing countries, as well as in the already industrialised countries.

This theme has since been steadily augmented at the various UN environmental conferences, such as at Rio in 1992 and in Johannesburg in 2002.



Important parts of the fuel cycles for nuclear power and coal-fired power

Is uranium a sustainable fuel?

We can start by pointing out that no parts of the nuclear fuel cycle emit significant quantities of carbon dioxide. It has been claimed that enrichment of uranium requires large quantities of electricity, most of which is produced in coal-fired power stations, and therefore contributes to the greenhouse effect.

This is a distorted picture, as the amount of electricity required by a modern enrichment facility to produce a given quantity of enriched uranium is about one-thousandth of the amount of electricity that that quantity of uranium will subsequently generate.

It must also be remembered that there are systems and well-proven methods for dealing with all the waste from the nuclear power cycle, in such a way as to ensure safety for all coming generations.

All the costs of future safe waste storage are paid in the present by the generations that use the nuclear power. The amount of waste produced by nuclear power production requires only very small storage volumes. (All the waste from the planned Swedish nuclear power production – 12 units with an installed capacity of 10 000 MW - could be held in a single deep repository about the size of the Globe indoor sports arena in Stockholm.) Nuclear power does not, in other words, leave any problems for coming generations.

Uranium is the only fuel raw material for nuclear power production, and has no other useful or important purpose, either now or in the foreseeable future. In addition, weapons-grade nuclear materials equivalent to two years' fuelling of all the world's reactors is being recycled in commercial reactors, making future use in weapons more difficult.

Uranium therefore fulfils the Brundtland Report definition of a sustainable energy source. But there are still some important questions on the sustainability of nuclear power:

- How long will the uranium last?
- Is nuclear power a long-term sustainable technology?

How long will the uranium last?

Uranium is a common mineral, occurring almost everywhere on land and in the oceans. It is about as common as tin, and 500 times more common that gold. Most types of rocks and soils contain uranium, although often in low concentrations.

The richest deposits in Sweden, in the Billingen shale deposits, contain 300 g per tonne of ore, i.e. 0.03 per cent. Granite normally contains 0.0004 per cent uranium, while the concentration in sea water is about 1000 times lower.

The highest concentrations, at almost 20 per cent, occur in a few deposits in Canada.

At present, economically viable deposits are regarded as being those with concentrations of at least 0.1 per cent uranium. At this cost level, available reserves would last for 50 years at the present rate of use.

Doubling the price of uranium, which would have only little effect on the overall cost of nuclear power, would increase reserves to hundreds of years.

More detailed figures are in the next chapter.

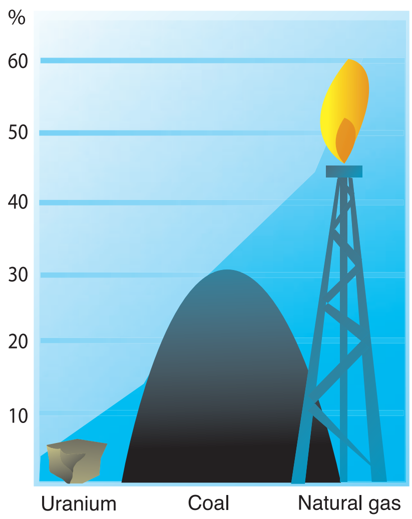
Nuclear power costs

Swedish nuclear power costs, in rough figures, not more than 20 öre/kWh to produce. This includes the costs of capital, modernisation, operation and maintenance, fuel, disposal, taxes and levies. (100 öre = SEK 1 = 0.11 Euro)

Nuclear power generation in Sweden today pays all its own costs, including those of future waste disposal, and receives no public subsidies. In fact, if anything, it is a golden-egg-laying goose for the State: the nuclear power companies pay about SEK 2 billion a year in the special nuclear power tax and electricity tax.

As with hydro power and wind power, nuclear power is capital-intensive and, as for these power forms, has low variable costs. The opposite is the case particularly for power production from natural gas, the cost of which is dominated by the fuel cost. Much the same applies for other fossil fuel power sources and for bioenergy.

Nuclear power's variable cost is 3,5 öre/kWh, of which almost 3 öre is for the fuel and about 1 öre for future waste disposal. The fuel costs break down into three approximately equal parts: uranium, enrichment and fuel rod fabrication. Each costs about 1 öre/kWh. This means that a doubling in the cost of natural uranium, from 1 öre/kWh to 2 öre/kWh, would increase the total cost of nuclear power from 20 öre/kWh to 21 öre/kWh, i.e. a 5 per cent increase.



Percentage increase in the cost of electricity production if the price of fuel is doubled

On the other hand, if the price of natural gas was doubled, the cost of gas-fired power would increase by about 60 per cent. Doubling the price of coal would increase the cost of power production in a large coal-fired power station by about 30 per cent. Another interesting illustration is that the production cost of coal power would increase by at least 60 per cent if carbon dioxide had to be removed at the power station.

If the price of uranium doubles at some time in the future, it will mean that viable reserves of present-known deposits will increase something like tenfold. In addition, there will be an incentive for increased prospecting for new, at present unknown, deposits. Uranium supplies would then suffice to power present nuclear power stations, with present-day technology, for several hundred years.

In the longer term, say 30-40 years, and starting from present-day knowledge, it is very likely that new types of reactors will become commercially practical.

They are likely to be breeder reactors (the technology has been demonstrated in several projects) and what are known as accelerator-powered transmutation reactors (not yet demonstrated in full scale).

What is particularly interesting about these reactors is that they utilise the fuel 50 times more efficiently than present reactor types. The underlying price of uranium can then further increase without significantly affecting the final cost of electricity production. It is also possible to re-use spent nuclear fuel in transmutation reactors for further electricity production, while at the same time reducing the half-life of the radioactivity in the new waste.

There are naturally uncertainties in the economics of some future types of reactors. However, it is already clear that there is a considerable development potential for nuclear power technology, following several lines of development, so that much better use can be made of the fuel raw material than in present-day reactors. There is therefor justification for the claim that the world's uranium resources can suffice for increased nuclear power production for thousands of years.

Is nuclear power a long term sustainable technology?

In the USA, Sweden and several other countries, the power industry has drawn the conclusion that most of the nuclear power stations now in operation can be used cost-efficiently and with proper safety margins for about 60 years. Some plant lives might be less than this, and some more. This means that the present Swedish nuclear power stations could continue in commercial operation for another 30-40 years. New, improved and more fuel-efficient nuclear power plants will certainly be commercially available long before then.

Nevertheless, the risk of accidents can result in public wariness or even a complete loss of confidence in nuclear power. This situation is not unique to nuclear power: it affects other industries such as aviation, chemical plants, pharma-ceuticals, passenger ferries, coal mines, and reservoir dams.

As far as reactors are concerned, the types used in Sweden have very high safety levels. If all world reactors held the same standard, the risk of a core meltdown among all the 500 reactors in the world would be once per 200 years.

And even the core meltdown that occurred at Three Mile Island in the USA in 1979 - which is the only accident to a light water reactor that has hitherto occurred - did not result in any significant release of radioactivity. There was no health effect on persons in the vicinity of the reactor.

There are therefore good grounds for claiming that nuclear power, as it is today, and as it can be expected to develop, is a sustainable energy source as defined in the international energy and environmental debate, and as it is understood by the public at large.

Conclusions

For better or worse, nuclear power is a 'concentrated' power source. Its land use per kWh of output is less than that of coal-fired or oil-fired power production, of solar energy or of wind energy. This applies not only to the point of production, but also to the entire fuel chain, backwards to the uranium mine and forwards to final repository disposal.

On the other hand, proper management of nuclear power does require extensive and in-depth technical competence and highly developed technologies. Matters relating to safety, environmental impact and public health are therefore complicated and difficult to communicate.

Nuclear technology in the west has so far lived up to high expectations in terms of safety, environmental impact and health. The many years of good experience in these respects seem to be creating a slowly growing international acceptance of nuclear power: an acceptance that can provide a basis for long-term use and development of nuclear power, at least in advanced industrialised countries.

Fuel costs already make up only a very small fraction of the cost of nuclear power, which means that the overall economics are relatively immune even to substantial changes in the price of uranium. Future reactor designs will further exploit this feature, so that world uranium resources, even at low concentrations, can be used for many thousands of years.

Uranium can be regarded as a long-term sustainable resource in the context of the internationally accepted definition of sustainable development, such as in the Brundtland Report.

This does not, of course, necessarily mean that nuclear power must become a dominant energy source in the long term. But there is a need for society today to accept nuclear power as one of many energy sources that will make it possible to continue to produce the electricity required, and to reduce dependence on fossil fuels and their climate effects.

Continued sustainable global development requires a much wider use of electricity and a reduction in the use of fossil fuels. In such a world, there is room for both nuclear power and renewable energy sources.

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The Backgrounders and Facts Series of publications are published by the Analysis Group of Swedish Nuclear Training and Safety Centre (KSU).

The Group's main working objective is to collect and analyse data concerning points raised in the public debate on reactor safety, radiation protection, radiobiology and research into risks.

They, and other reports, can be downloaded from the Group's web site, www.analys.se, which also carries links to an extensive range of national and international research organisations, nuclear power authorities and power utilities.