FEBRUARY 2005 Policy Brief

OECD

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Nuclear Energy Today

Observer oecd

Introduction

Nuclear energy has been used to produce electricity for more than half a century. It currently provides about 17% of the world's supply and 23% in OECD countries.

The oil crisis of the early 1970s provoked a surge in nuclear power plant orders and construction, but as oil prices stabilised and even dropped, and enough electricity generating plants came into service to meet demand, orders tailed off. Accidents at Three Mile Island in the United States (1979) and at Chernobyl in Ukraine (1986) also raised serious questions in the public mind about nuclear safety.

Now nuclear energy is back in the spotlight as many countries reassess their energy policies in the light of concerns about future reliance on fossil fuels and ageing energy generation facilities. Oil, coal and gas currently provide more than two-thirds of the world's energy and electricity, but also produce the greenhouse gases largely responsible for global warming. At the same time, world energy demand is expected to rise sharply in the next 50 years, presenting all societies worldwide with a real challenge: how to provide the energy needed to fuel economic growth and improve social development while simultaneously addressing environmental protection issues. Recent oil price hikes, blackouts in North America and Europe and severe weather events have also focussed attention on issues such as long-term price stability, the security of energy supply and sustainable development.

The OECD Nuclear Energy Agency (NEA) has worked in these areas for more than 40 years, bringing together world specialists in every field to develop scientific and technical analyses that provide solid ground on which policymakers can establish nuclear and energy policies.

This Policy Brief looks at the current situation of nuclear energy, the prospects for the future and the policy challenges for governments. ■

The NEA is a semi-autonomous body within the OECD. It consists of 28 OECD member countries. The NEA's mission is to help its member countries to maintain and further develop, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes. The NEA also provides authoritative assessments and forges common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development. The NEA is an objective and non-promotional international instrument to advance co-operation in the safe and economic use of nuclear power among the most developed countries. ■

Can nuclear energy help make development sustainable?

Energy services are critical to economic development and prosperity. However, as energy use continues to grow, its effect on human health and the environment have to be controlled, alleviated or mitigated in order to achieve sustainable development goals. Current technologies for providing energy are increasingly viewed as unsustainable, either because supplies may be exhausted or because they produce greenhouse gases. Nuclear energy has certain clear advantages in that it produces heat and electricity without emitting carbon-dioxide into the atmosphere at the power plant level, and fuel supplies are not in danger of being exhausted.

Three "pillars" of sustainable development are commonly identified. These are: economic, environmental and social considerations.

On the *economic* front, the ability to provide reliable, low-cost electricity is an important aspect of sustainable development. Once a nuclear power plant is built, the electricity generated is often cheaper than many other generating methods. This is because the plants have a long life and ongoing operating and maintenance costs are low. However, the initial costs of building plants, conforming to regulations, decommissioning the plant at the end of its useful lifetime and ensuring long-term storage of waste is higher than for other technologies. Nevertheless, in most countries nuclear electricity generation is competitive with other technologies. New, more cost-effective designs, improved construction methods and multiple unit construction are all means to reduce the investment cost.

For plants powered by natural gas or coal, the initial investment is lower but fuel costs are higher and fluctuate unpredictably. Renewable sources of energy, such as wind and hydropower, are similar to nuclear energy in having high investment and low production costs per unit of power produced. However, renewable sources are currently available only on a small scale and typically provide intermittent, rather than baseload electricity supply.

Fossil fuel energy already bears some of the costs for reducing its emissions to air and water, but a considerable part of the waste goes into the atmosphere, imposing costs on the community that are not reflected in the price of its electricity. On the other hand, the costs of disposing of the high-level radioactive waste and decommissioning the facilities are already included in the price of the electricity charged to the consumer.

The economic competitiveness of nuclear power might be significantly increased if, for example, a "carbon tax" was imposed on greenhouse gas emissions by electricity producers.

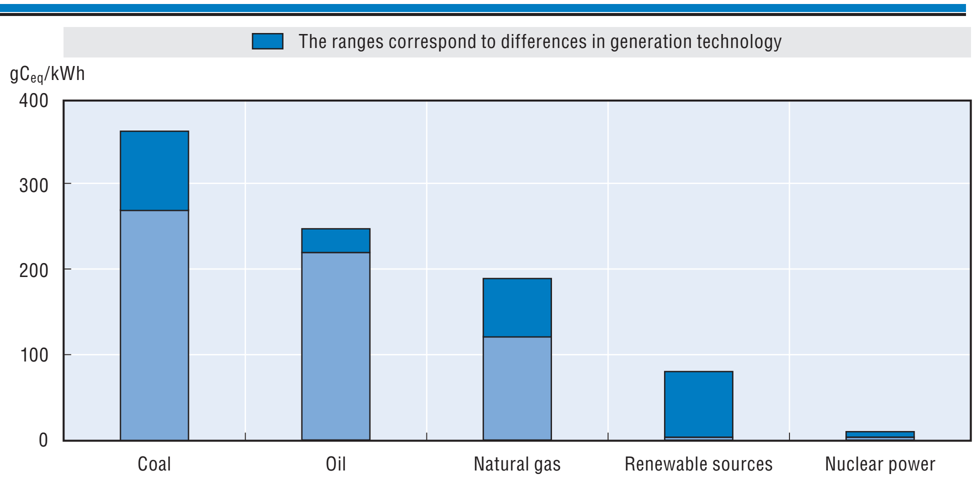
The economic dimension in each country is also heavily influenced by the availability of natural resources. Countries in the Middle East and the Russian Federation hold 70% of the world's dwindling reserves of oil and gas. Conversely, OECD countries produce almost 55% of the world's uranium, and have 40% of the estimated uranium resources – resources which at current rates of use are estimated to be enough to provide energy for roughly 100 years, even without reprocessing and recycling usable fuel materials or accounting for discoveries of additional resources. Fuel costs for the nuclear reactors currently in service make up only 20% of the total cost of the electricity produced. Doubling the price of the uranium used to make the fuel would have only a minimal impact on the price of nuclear-produced electricity. Doubling the price of natural gas would see electricity prices from natural gas power plants rise by some 70%.

In *environmental* terms, nuclear power is one of the few energy sources that emit virtually no greenhouse gases. The Kyoto Protocol emission targets call for total annual emissions in OECD countries to be reduced by about 700 million tonnes of carbon dioxide by 2008-2012, relative to 1990 levels. Without nuclear energy, OECD power plant emissions of carbon dioxide would be about one-third higher than they are at present. This is an annual saving of some 1 200 million tonnes of carbon dioxide, or about 10% of total CO_2 emissions from energy use in the OECD. Energy sources that do not pollute because of combustion gases, such as nuclear energy and renewable energy sources, will be of vital importance as regards the reduction of emissions.

For nuclear power to make a very large contribution to reducing global warming, a large expansion in nuclear generating capacity would be necessary. Such an expansion using existing technology would bring a corresponding rise in nuclear waste generation. If nuclear energy is to become an effective and acceptable option, advanced reactor technologies

Figure 1:

GREENHOUSE GAS EMISSIONS FROM ELECTRICITY GENERATION BY DIFFERENT SOURCES



Source: OECD/NEA (2001), *NEA News* 2001 – No. 19.1.

and recycling fuel strategies could be very helpful in alleviating this increase, beyond other advantages in economics, safety and non-proliferation.

On the *social* front, maintaining and improving the technical and intellectual infrastructure to support nuclear energy provides numerous spin-off benefits for society. Nuclear energy has historically played a very important role in the development of new materials, techniques and skills. These have been applied in other sectors such as medicine, manufacturing and public health and agriculture, with consequent economic benefit to all.

At the same time, all energy technologies have a tendency to create social concern, even conflict. Coal has its own profound history of conflict and social division, as, on an international scale, has oil. Some fear that increasing numbers of wind turbines will blight the landscape, in some cases cause noise pollution and pose an environmental hazard to birdlife. Hydropower presents particular environmental and social challenges. In the case of nuclear energy, this concern has focused on questions of safety, nuclear proliferation and waste disposal. ■

How safe is nuclear energy?

From an industrial safety viewpoint, in terms of injuries to its workforce, the nuclear industry has one of the best safety records. For example, in 2003 the worldwide industrial safety accident rate resulting in days off work at nuclear power plants was 0.28 accidents per 100 full-time workers. This can be compared with the US national average of 2.6 accidents per 100 full-time workers in 2003.

Nevertheless, an accident at a nuclear power plant has a greater potential to do harm than accidents in other types of industrial installation, since the fission process produces a major concentration of radioactivity. Very high levels of safety have therefore always been considered essential to its implementation.

Nuclear safety is provided by the ability of the installation's systems and its personnel to prevent accidents from occurring, and should one occur, to mitigate its consequences as much as possible. This can be achieved through a number of complementary and overlapping factors, referred to as "defence-in-depth". These defences encompass factors such as: care in selecting sites, robust design, high-quality construction; multiple levels of protection, fault prevention and an appropriate containment building; fostering a "safety culture" among all staff; and inspection by an independent regulatory authority.

Responsibility for nuclear safety is foremost national, with each country responsible for the safety of nuclear power plants within its borders. However, international co-operation, including organisations such as the NEA and the International Atomic Energy Agency (IAEA), have always made a fundamental contribution to developing relevant concepts and spreading good practice. For example, the Convention on Nuclear Safety under the auspices of the IAEA, to which all States operating nuclear power plants are signatories, defines internationally accepted principles and obligations relating to the basic elements of nuclear safety.

Despite the very high levels of safety maintained in all radiological activity, accidents involving the exposure of workers and of the public can occur, and can possibly (like Chernobyl) have international scope. The international community has therefore developed detailed programmes and approaches for nuclear emergency preparedness and nuclear accident management designed to minimise the consequences of any such event. All nuclear installations around the world maintain such plans and structures in conjunction with local and national authorities. Regular emergency exercises are conducted at both the national and international level.

Nuclear safety should not be confused with nuclear security. The physical protection of nuclear material and nuclear facilities – including against possible malicious acts – has always been taken seriously by OECD member countries and considerable work is being done to maximise security in this respect. Moreover, since 9/11 additional studies to ensure that nuclear installations are secure have been performed and enhanced security measures and safeguards have been adopted. Preventing the proliferation of nuclear weapons also remains a priority; notably through the IAEA's system of safeguards and verifications. ■

How best to deal with radioactive waste?

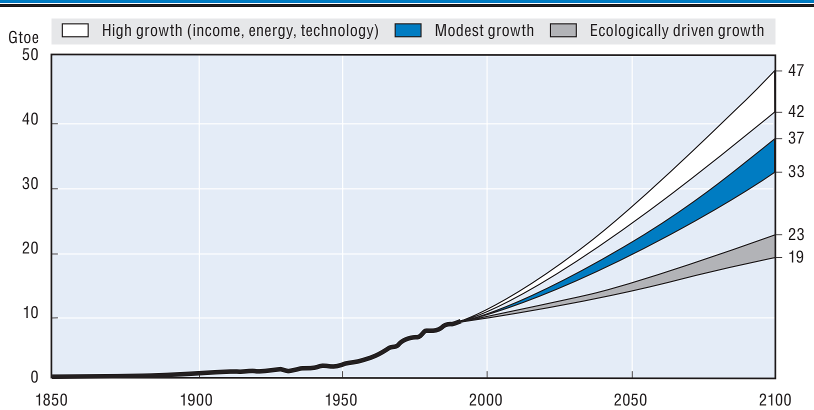
Several industrial and medical processes, such as particle accelerators, produce radioactive waste, but nuclear electricity production is the most important because of the quantity produced and its long radioactive life.

Generating electricity from a typical 1 000 MW(e) nuclear power station produces approximately 300 cubic metres of low and intermediate-level waste per year and some 30 tonnes of high level, solid, packed waste per year. Nuclear power generation facilities produce about 200 000 cubic metres of low-level waste and intermediate-level waste and 10 000 cubic metres of high-level waste, including spent fuel designated as waste each year worldwide. By comparison, the pre-enlargement members of the European Union alone produced on average about 10 million cubic metres of toxic industrial waste per year.

Disposal of low-level waste and most intermediate-level waste is so well-developed that some sites have already been filled and closed.

Figure 2:

PROJECTED ENERGY DEMAND TO 2100



Source: OECD/NEA (2003), *Nuclear Energy Today.*

But solutions for long-lived high-level waste and spent nuclear fuel have proved more elusive.

Spent nuclear fuel requires long-term isolation from the human environment while its radioactivity decreases. The current preferred option for eventual disposal of high-level waste is emplacement in repositories deep underground. In general, the geological disposal concept involves treating the waste in order to achieve a suitable physical and chemical form, packaging it inside long-lived engineered barriers placed deep underground, and sealing these facilities. In these underground surroundings, conditions remain stable over the long periods needed to allow the radioactivity to decay to a sufficiently low level.

The scientific and technical community has confidence that removing highly radioactive waste from the human environment by disposal in such deep geological repositories is ethically and environmentally sound. However, with the exception of the USA and Finland, OECD countries have yet to make a decision on where to site their high-level waste repositories.

Because of the comparatively small volumes of both high- and low-level radioactive waste and the need for long-term isolation, centralised storage and disposal is desirable. This in turn necessitates transport to the chosen localities. These repositories are also the final destination for spent nuclear fuel after its initial storage and cooling. Radioactive materials – including those used in industrial and medical applications – also need to be delivered from their supplier to their eventual user. All such transport must be carried out in accordance with the relevant national and internationally agreed safety standards. Numerous shipments of all forms of radioactive materials and waste take place each year and incidents are extremely rare. Since 1971 there have been over 20 000 shipments of spent nuclear fuel and high-level waste worldwide using trains, trucks and ships travelling a total of over 30 million kilometres. None have been involved in an accident that has breached a container or released radioactivity into the environment. ■

What is the future of nuclear energy?

Increasing world energy demand requires decisions on whether or not to build new nuclear power plants. At the same time, nuclear reactor design is changing; while nuclear energy is now a mature technology, there is still scope for technical and economic progress. Concepts under investigation include liquid metal reactors, high-temperature reactors, reactors that use thorium as fuel, and improved recycling technologies to better utilise uranium and plutonium resources. These advanced technologies offer the promise of greatly improving the sustainability of nuclear energy. The ten countries and Euratom that have joined together to form the Generation IV International Forum plan to develop and demonstrate one or more new nuclear energy systems offering advantages in the areas of economics, safety and sustainability. The new design could be deployed commercially by 2020-2030. The NEA serves as Technical Secretariat to the Generation IV International Forum.

So far, nuclear energy has been used almost exclusively to produce electricity. But there are other potential uses. A great deal of research is currently taking place on the possibility of hydrogen replacing carbon fuels used in motor vehicles. If this were successful, demand for hydrogen would expand dramatically. However, hydrogen production currently involves the use of natural gas, itself a carbon-emitter. More economic methods for producing hydrogen directly from water without using carbon fuels are required. Nuclear energy could therefore become an important "sustainable" source of hydrogen. Research and development into the use of nuclear energy to produce hydrogen is being conducted in a number of countries and through several international agencies, including the NEA. Other non-electricity applications of nuclear energy with potential for expansion include desalinating seawater and using the heat generated in nuclear reactors to produce hot water or steam for industrial or residential heating. Radioactive isotopes are very widely used, particularly in medicine, industry, agriculture, food processing and research. So far they have principally been produced as by-products of research activity, but a number of purpose-built isotope production reactors are now planned or under construction.

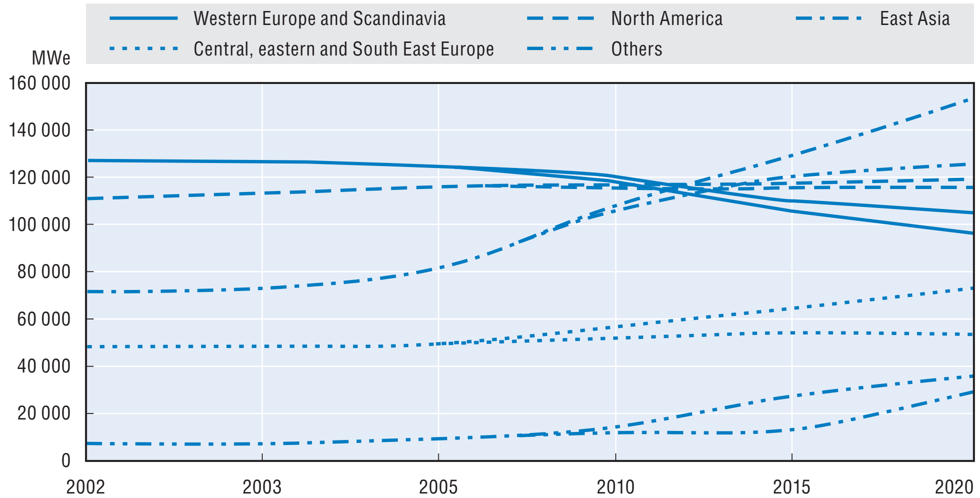
Nuclear energy is at a crossroads. Decision makers are faced with the difficulty of how to meet the continued growth in world energy demand while minimising the environmental impacts of energy production. They must do so while accounting for public attitudes, the cost and competitiveness of the various energy sources and public policy objectives such as security of supply and non-proliferation. How they resolve the tension between these sometimes conflicting factors will ultimately define the extent of nuclear energy's use worldwide. ■

For further information

For more information on this *Policy Brief*, please contact:
Karen Daifuku, Head of External and Public Affairs, OECD Nuclear Energy Agency
Tel.: +33 1 45 24 10 10,
Fax: +33 1 45 24 11 10,
email: daifuku@nea.fr.

Figure 3:

PROJECTED INSTALLED NUCLEAR CAPACITY TO 2020 (LOW AND HIGH PROJECTIONS)



Source: OECD/NEA (2004), *Uranium 2003: Resources, Production and Demand.*

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For further reading

Projected Costs of Generating Electricity: Update 2005, ISBN 92-64-00826-8, € 70, 230 p.

Government and Nuclear Energy (2004), ISBN 92-64-01538-8, € 21, 94 p.

Nuclear Energy Data (2004), ISBN 92-64-1632-5, € 21, 102 p.

Nuclear Energy Today (2003), ISBN 92-64-10328-7, € 21, 112 p.

Where to contact us?

OECD HEADQUARTERS
2, rue André-Pascal
75775 PARIS Cedex 16
Tel.: (33) 01 45 24 81 67
Fax: (33) 01 45 24 19 50
E-mail: sales@oecd.org
Internet: *www.oecd.org*

GERMANY
OECD Berlin Centre
Schumannstrasse 10
D-10117 BERLIN
Tel.: (49-30) 288 8353
Fax: (49-30) 288 83545
E-mail:
berlin.contact@oecd.org
Internet:
www.oecd.org/deutschland

JAPAN
OECD Tokyo Centre
Nippon Press Center Bldg
2-2-1 Uchisaiwaicho,
Chiyoda-ku
TOKYO 100-0011
Tel.: (81-3) 5532 0021
Fax: (81-3) 5532 0035
E-mail: center@oecdtokyo.org
Internet: *www.oecdtokyo.org*

MEXICO
OECD Mexico Centre
Av. Presidente Mazaryk 526
Colonia: Polanco
C.P. 11560 MEXICO, D.F.
Tel.: (00.52.55) 9138 6233
Fax: (00.52.55) 5280 0480
E-mail:
mexico.contact@oecd.org
Internet:
www.rtn.net.mx/ocde

UNITED STATES
OECD Washington Center
2001 L Street N.W., Suite 650
WASHINGTON DC. 20036-4922
Tel.: (1-202) 785 6323
Fax: (1-202) 785 0350
E-mail:
washington.contact@oecd.org
Internet: *www.oecdwash.org*
Toll free: (1-800) 456 6323

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