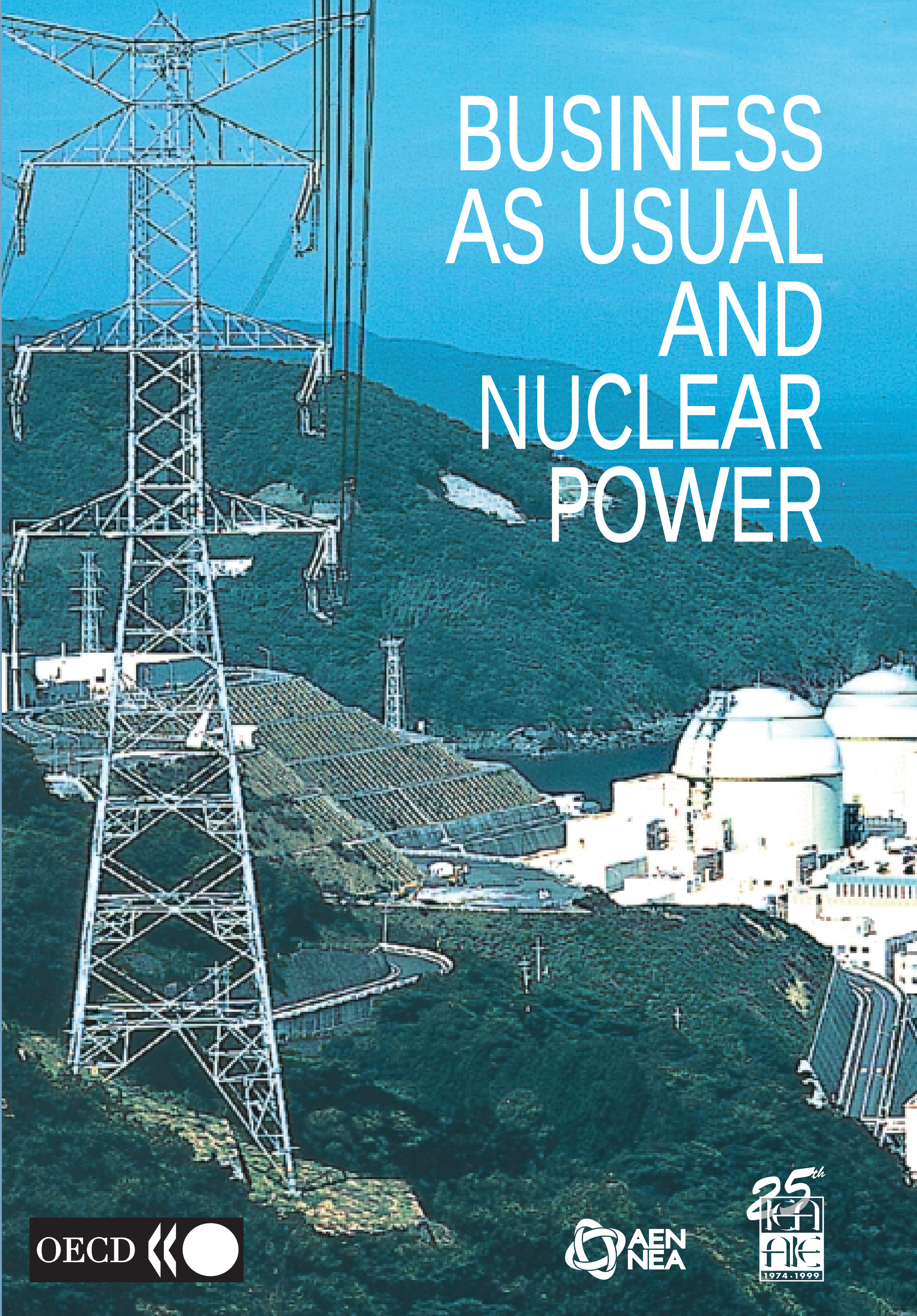
BUSINESS AS USUAL AND NUCLEAR POWER



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OECD PROCEEDINGS

BUSINESS AS USUAL AND NUCLEAR POWER

Joint IEA/NEA Meeting
Paris, France
14-15 October 1999

NUCLEAR ENERGY AGENCY
INTERNATIONAL ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, 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, as well as
- to provide authoritative assessments and to forge 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.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

Cover photo: General view of the Ikata nuclear power plant, courtesy of Shikoku Electric Power Co. Inc., Japan.

INTERNATIONAL ENERGY AGENCY

9, RUE DE LA FÉDÉRATION, 75739 PARIS CEDEX 15, FRANCE

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty four* of the OECD's twenty nine Member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions;
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- To operate a permanent information system on the international oil market;
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- To assist in the integration of environmental and energy policies.

** IEA Member countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

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FOREWORD

Nuclear power is an important contributor to OECD energy supply and energy security. Many OECD Member countries have, accordingly, seen nuclear power as an integral part of their energy policy. The IEA's "Shared Goals" acknowledge nuclear power's potential contribution for those countries wishing to retain the nuclear option. Yet the overall context for nuclear energy has changed. Today, few countries are expecting to build new nuclear plants in the coming decade and some have declared that they will not. Meanwhile, environmental concerns world-wide call for energy solutions which minimise impact on the climate and on the quality of the air we breathe. Nuclear power generation emits no carbon dioxide, the principal greenhouse gas.

The IEA's analysis of energy trends in the *World Energy Outlook* suggests that nuclear's share of global energy supply could decrease in coming decades. What are the implications of these "business as usual" trends for global energy supply and national energy policies? What are the issues that energy and nuclear policy-makers must evaluate when balancing environmental, economic and energy security goals? What are the consequences for the long-term availability of nuclear technology and expertise? This book identifies them in a series of papers presented at a meeting jointly organised by the International Energy Agency and the OECD Nuclear Energy Agency. The objective of the meeting was to have a considered and practical discussion of the issues, not to advocate or condemn nuclear power. We think the meeting and the papers succeeded in this. Participants from countries with and without nuclear power, with policies supporting and discouraging it, highlighted the key issues for nuclear power's future in the OECD and in global energy supply.

The IEA and the OECD/NEA are committed to working together with the common goal of assessing the contribution of nuclear power to the overall electricity supply of our Member countries. In particular, they share the fundamental objective of ensuring sound analysis and consistent policy advice on nuclear issues within the broad energy context. This meeting and book are a tangible product of that co-operation.

Robert Priddle
Executive Director
International Energy Agency

Luis Echávarri
Director General
OECD Nuclear Energy Agency

ACKNOWLEDGEMENTS

The meeting "Business as Usual and Nuclear Power" was organised jointly by the International Energy Agency and the OECD Nuclear Energy Agency. The following staff of the two agencies contributed to the organisation of the meeting and preparation of this document: John Paffenbarger, Peter Fraser and Caroline Varley of the IEA and Ivan Vera, Peter Wilmer and Evelyne Bertel of the NEA.

The Secretariats are indebted to the fourteen speakers and five chairmen who contributed their time and presentations to the meeting.

Electricité de France, the UK Department of Trade and Industry and the United States Department of Energy contributed financially to defray logistical expenses of the meeting. The three contributions are gratefully acknowledged.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction

The International Energy Agency and the Nuclear Energy Agency jointly organised a meeting to discuss issues relating to the future of nuclear power. The name of the meeting "Business as Usual and Nuclear Power" was taken from the "business as usual" scenario of the IEA's *World Energy Outlook*. This scenario, which assumes that government energy policies and market factors do not encounter any abrupt changes, suggests a decreasing role for nuclear power in the global energy supply mix. Within OECD countries, the share of electricity generated from nuclear plants could decrease from about one quarter to one eighth of the total by 2020.

This trend, if actually realised, would have far-reaching implications. This meeting was therefore organised to provide a forum for government officials involved in energy and nuclear policy to discuss:

- An overview of the "business as usual" projection and the factors driving this projection.
- Implications of the projection on energy policy and policy affecting the nuclear industry – both nationally and internationally.
- National government views of nuclear's role and future.
- Views of the nuclear and electric power industries on how they are adapting, and the role they expect governments to play.

The meeting was held on 14 and 15 October 1999 at the Paris headquarters of the IEA and was attended by about 100 government officials and industry executives from 21 OECD countries. There were participants from several countries without commercial nuclear programmes, including Australia, Austria, Denmark, Ireland, Italy, Norway, and Portugal. The meeting agenda and the presentations are provided in the proceedings. The key issues presented and debated at the seminar are summarised below.

Factors defining "business as usual"

The IEA Secretariat reviewed the "business as usual" perspective for nuclear energy. It is defined by many factors:

- Electricity market competition, which highlights the considerable value of existing nuclear plants and the challenges confronting the construction of new nuclear plants.

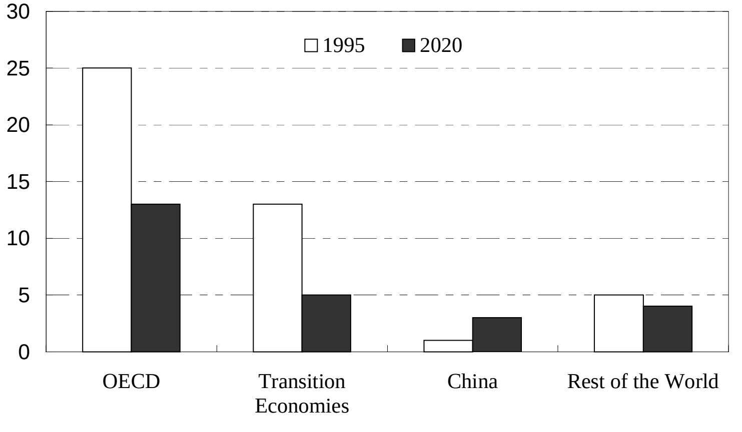
- Environmental issues and sustainability. Most prominent of these is the climate change debate.

- Supplies of fossil energy and energy security.

- Public acceptance and political decisions. Today these tend to restrict the potential role of new nuclear power plants and imperil existing plants.

Any view of business as usual is only a snapshot of how the energy future might look from the standpoint of where we are now. Today, at least, current trends show nuclear power's share of electricity production levelling off and declining, starting after the turn of the century. Figure 1, based on the results of the IEA's *World Energy Outlook*, shows the decreasing share of nuclear power in all major world regions except China.

Figure 1. **Nuclear share of electricity generation (%), 1995 and 2020**



Many speakers referred to "doldrums" or a "stagnation" in new plant construction. With few new plants, nuclear power's trajectory depends mainly on when existing plants are retired.

Some speakers explained the rationale for government support of nuclear power programmes in their countries. Some discussed the alternatives to nuclear power, for existing and new plants. Many governments place high hopes in renewables and energy conservation to take on the role once envisioned for nuclear power. IEA projections suggest that fossil fuels are likely to play the most important role in filling in for nuclear.

Strength of existing plants

Existing, well-run nuclear plants can have very competitive costs of generation. Electricity market competition will help to decrease operating costs in all existing nuclear plants. Speakers noted that this points to life extension and capacity increases for existing plants. Utilities in many countries are positioning themselves to take advantage of their existing nuclear capacity in competitive markets. If their lives are to be extended, nuclear plants must produce economic benefits while maintaining adequate levels of safety and environmental protection.

The strong economics of many existing plants explains some of the practical difficulties that countries may have in closing existing nuclear plants before their owners would like to. For example, in Germany and Sweden this is a major issue. There are other factors posing practical challenges to those countries favouring a rapid closure of existing plants. Economic replacements are not available in the short term. Efforts to lower energy intensity or introduce renewables appear unrealistic options to replace nuclear plant output in the short term, though most countries expect these to be key elements in long-term energy supply with or without nuclear power. Issues of electricity trade, environment, energy diversity and waste disposal are also relevant. Several countries have met these same challenges in the past.

New plant development

The economic viability and competitiveness of nuclear power is the central issue for the future of new nuclear plant development. For those wishing to facilitate nuclear plant development, perhaps the most important hurdle is to design and develop what markets require given the economic, financial, competitive and risk characteristics of progressively deregulated electricity markets. Capital cost reduction is an absolute imperative. There was a wide range of views on how electricity market competition might affect new plant development. In the short term, the business-as-usual outlook, foreseeing few new OECD nuclear power plants, would not be affected by electricity market competition because little growth in nuclear power is expected, with or without competition. Natural gas-fired power generation is expected to play a dominant role in new power plant development, according to many speakers.

In the longer term, however, electricity market competition could alter the prospects for new nuclear plants. Competitive pressure could help to improve their design and economics. Nuclear's ability to offer stable prices could be an attraction. On the other hand, nuclear's capital intensity, financial risks, and development time pose challenges for investors. The disappearance of regulated returns on generation assets is a key factor in this. The possible growth in distributed generation (small, decentralised power plants) would reduce opportunities for new nuclear power plants.

Speakers also reaffirmed that public and political acceptance remains a critical issue facing new plants in many countries.

Importance of the climate debate and environment

A strong commitment to reduce emissions of carbon dioxide could have a dramatic positive effect on the prospects for nuclear power over the coming decades. Nearly all speakers mentioned the issue of climate change. On the other hand, many speakers emphasised the importance of renewable energy and energy conservation in helping to control emissions of carbon dioxide.

Environmental protection is a two-edged sword for nuclear power. On the one hand, absence of CO_2 and other gaseous emissions is an acknowledged advantage. Nuclear power does not emit sulphur dioxide, nitrogen oxides or particulates. The effect of mining is relatively small for nuclear compared to fossil fuel extraction. Coal mines, for example, require the excavation of large volumes of earth.

On the other hand, environmental concerns continue to constrain the use of nuclear power. Fundamentally, restrictions on the use of nuclear power in some countries reflect a concern about nuclear's environmental impacts. Though extracting smaller quantities of mineral compared to fossil fuels, uranium mining does pose environmental risks. Enrichment, fuel fabrication, power generation and reprocessing involve the use of hazardous chemicals. They present risks of radioactive releases. One speaker addressing environmental policy issues noted that, while the magnitude of radioactive releases to the environment is projected to be small, plant accidents do happen. The Austrian speaker highlighted his country's sensitivity to the issue in light of its experience with the Chernobyl accident. Waste disposal is currently the most debated issue relating to nuclear power and environmental protection.

In a general sense, governments face the challenge of seeing that the full costs of environmental protection are incorporated in the cost of generating electricity from all sources, not just nuclear. There are analytical studies showing that the external costs of nuclear power are lower than those of alternatives. Other studies conclude the opposite. There is no agreement today that the costs of any individual means of producing electricity include the total costs of environmental protection.

Challenges in nuclear infrastructure

Nuclear power requires a certain infrastructure, including skilled personnel, regulatory bodies, industrial and research facilities. Speakers pointed out that nuclear power's future does not depend only on power plants, but also on the associated infrastructure. Today's perspective of a shrinking role for nuclear power implies a growing value to world-wide co-operation to sustain that infrastructure. It also implies increasing pressure for efficiency in the provision of nuclear infrastructure.

Nuclear power does not exist without a nuclear industry. Utilities, nuclear plant manufacturers and nuclear service providers have adapted and must continue to adapt to the changing perspective for nuclear power. Among reactor manufacturers and suppliers of fuel and nuclear services, over-capacity has produced a trend towards consolidation. It is in the reactor-design sector where consolidation and co-operation have first taken place. The outlook for spent fuel management, reprocessing and instrumentation and control services over the next 10 to 20 years is one of broadly flat, or decreasing, global requirements. On the other hand, the market for non-military cleanup services is likely to grow and provide new industrial opportunities. Policy decisions on high-level waste disposal and recycling of surplus military plutonium are important factors affecting industrial opportunities.

Several speakers noted that non-proliferation cannot be overlooked as an issue of importance. There must be a sound international system for minimising the risk that civilian nuclear materials are misused.

Nuclear safety regulation

It is now broadly accepted that nuclear safety regulation is mature, but nuclear safety regulators are nonetheless under pressure to become more effective. The process of ensuring plant safety is a continuously changing one in light of changes in the electricity market, nuclear fuel cycle, and other elements of the industry. Perhaps the sharpest issue is that of regulating high-level waste disposal. Extension of the operating lives of existing reactors also poses new regulatory challenges. Ensuring the independence of nuclear safety regulators is important.

Human factors are critical to maintaining safety. Yet these factors have to be among the most difficult to master. The quality of management, engineering and training must be high to ensure safety. Some participants doubted that they could ever consider the requisite level of quality to be attained. Others noted the absence of any serious effects on public health or the environment of civilian nuclear programmes in the OECD as evidence of the high levels of safety already attained.

The challenge of energy security

Energy security is a fundamental consideration of some countries that have chosen to develop nuclear power. For these countries, the business-as-usual perspective of a decreasing share of nuclear power raises concerns about how to maintain diversity of energy sources and a secure energy supply. Notably, Japan and France share this perspective because of their limited domestic energy sources. Nuclear energy today displaces significant amounts of energy that would otherwise have to be purchased outside OECD countries.

Several speakers acknowledged that energy security has lessened as an issue of political debate since the 1970s, though all OECD countries pursue policies to maintain and improve it. The low profile of energy security policy presents a challenge to governments wishing to develop a strategy for maintaining a nuclear contribution to energy security.

Research and development

Research and development must also adapt to changing priorities. The potential competitive advantages in keeping existing nuclear plants operating highlights the importance of research on safely managing the ageing of nuclear plants. Work on streamlining regulatory processes is also called for. For new plants, the challenges of competitive markets focus research and development on concepts and technologies to reduce capital costs. Few companies are ready to finance long-term research for concepts that move beyond current technologies.

Research and development into alternative energy sources is essential for countries wishing to forego nuclear power. So-called "new" renewables (solar, wind) are currently the least-cost option only in limited circumstances. For non-hydro renewable energy sources to be economically viable alternatives, they must be further developed. Research into technologies with higher levels of energy efficiency is also needed to help limit the growth in energy demand. Many countries provide support or subsidies to renewables to facilitate their growth in the electricity market.

Globalisation of nuclear power

Governments are recognising that the context for nuclear power development is becoming less national and more international. Each of the areas mentioned above is becoming more international in scope, stimulated by the globalisation of financial capital. There is growing international co-operation in nuclear infrastructure, safety regulation, industry and research and development. International organisations, including the NEA, the IEA and the International Atomic Energy Agency, have important roles in helping to co-ordinate international exchanges on nuclear power.

The prospect of continued stagnation or decline of the nuclear industry in OECD Europe and North America implies a shifting geographic centre for nuclear expertise and infrastructure towards Asia, including in non-OECD countries. Such a shift gives rise to concerns that OECD countries would have less influence on design and operating standards of plants outside the OECD. It also implies that governments should consider how any shift in nuclear expertise could affect their own nuclear programmes and industries.

The globalisation of nuclear power gives increased importance to avoiding accidents. A serious accident at a civilian nuclear facility anywhere in the world could harm prospects for nuclear plants in all countries.

Conclusions

This seminar considered the specific issues and challenges facing governments as they evaluate the most appropriate role, if any, for nuclear energy in their countries. Should governments continue with business as usual, promote nuclear power, keep the option open for the future or eliminate it? There is no path without hurdles, controversy or challenges.

The organisation of the seminar was proof in itself that the context for nuclear power development is becoming less national and more international. All the issues addressed during the meeting are international in scope. The meeting indicated a shared interest in debating them, across the whole spectrum of views on nuclear power represented by the participants.

It can be expected that developments in many areas will transform business as usual into a future we do not expect. The policy issues of liberalisation and globalisation, environment and climate change, public opinion, and the fuel mix will remain on the agenda for all governments. They are likely to grow in importance for the nuclear debate.

Session 1

BUSINESS-AS-USUAL SCENARIOS FOR OECD NUCLEAR POWER USE

Chairman:

Dr. Nigel Lucas
Royal Academy of Engineering

NUCLEAR POWER IN THE WORLD ENERGY OUTLOOK

Dr. Fatih Birol
Head, Economic Analysis Division
International Energy Agency

In my presentation today, I shall talk about nuclear power in the World Energy Outlook.[1] I shall also consider the implications for nuclear power of three major energy policy issues: sustainability, climate change and electricity market competition. Those issues were addressed in detail in a recent IEA publication on nuclear power".[2]

The World Energy Outlook is a biannual publication of the International Energy Agency that provides key energy trend projections and discusses the main issues affecting world energy demand and supply over the medium term. The most recent Outlook was published in November 1998.

The analysis of global energy issues in this edition is done in the framework of a business-as-usual (BAU) projection and covers the time horizon to 2020. It assumes that patterns of energy demand and production carry on smoothly from the recent past. It also supposes that energy policies existing before the Kyoto Conference of December 1997 remain in place and that no major new policies are adopted to reduce energy-related greenhouse gases.

The analytical tool that is used to derive these projections is the World Energy Model. The model consists of a suite of regional modules that provide energy supply and demand balances for ten world regions (of which three in the OECD) for coal, oil, gas and electricity.

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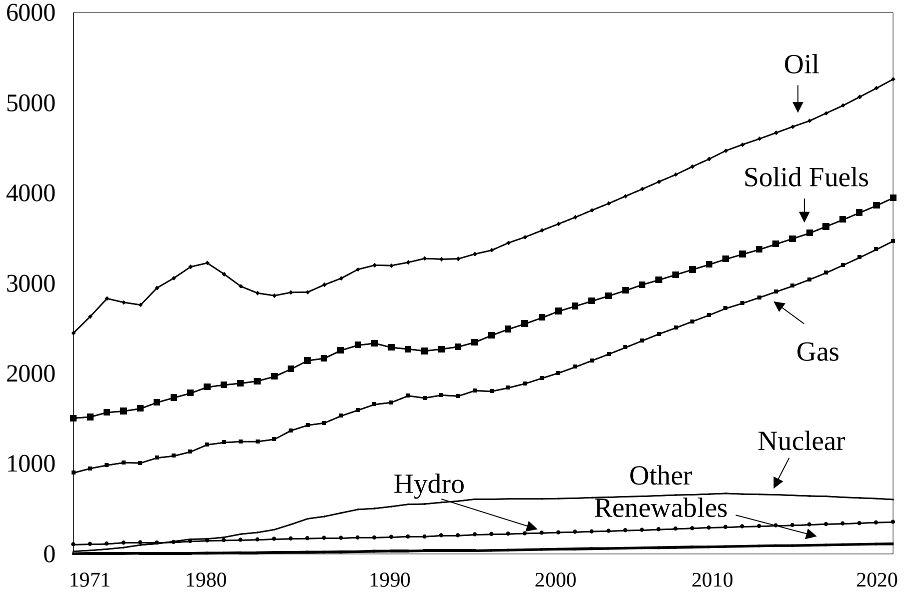
1. *World Energy Outlook, 1998 edition*, IEA/OECD, Paris, 1998.
2. *Nuclear Power: Sustainability, Climate Change and Competition*, IEA/OECD, Paris, 1998.

On the demand side, the model uses conventional econometric techniques, based on several economic indicators and fuel prices, to project future paths of energy use in all sectors.

On the supply side, a power-generation model built for each region, allows us to determine the future mix of capacity and generation. The model uses least-cost criteria to determine the optimum fuel mix. For new plant, the choice is based on levelised costs. Short-run costs are used to determine the merit order of existing plants.

A conventional oil supply model has been prepared that takes into account increases in recoverable reserves of conventional oil arising from the reduction in uncertainties over time, as new information on oil reserves becomes available, and from the application of new technologies. Gas and coal supplies are projected separately on a regional basis.

Figure 1. **World primary energy demand (Mtoe)**



A key message of this outlook, as shown in Figure 1, is that fossil fuels will continue to dominate the energy mix. Indeed, 95% of the additional energy demand between 1995 and 2020 will be met by fossil fuels. In absolute terms, some 92% of total primary energy demand in 2020 will be fossil-fuel based.

The share of solid fuels, mostly coal, remains unchanged. Three quarters of additional demand for solid fuels will be in the power generation sector. Growth is fast in China and South Asia, which are expected to develop further their indigenous supplies of coal.

Oil continues to be the dominant energy source. Most of the increase in oil demand will stem from additional demand for transportation.

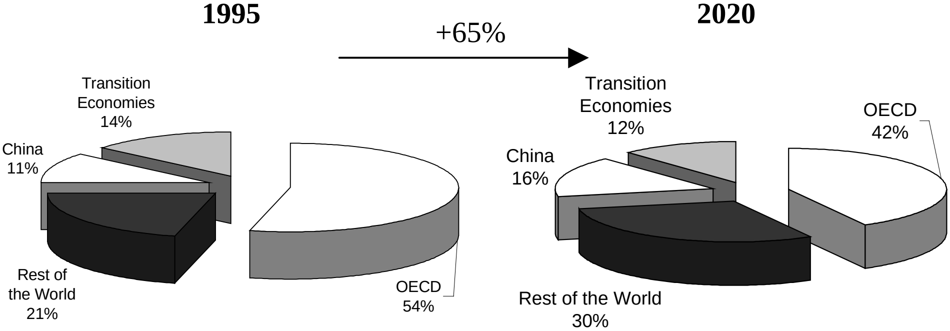
Demand for gas increases fast, particularly in the OECD regions. Natural gas is the preferred fuel for many applications, especially for new power stations. Gas consumption nearly doubles over the outlook period.

World nuclear power remains almost static. During the outlook period, the retirement of several units will offset the increase in nuclear output from construction of new plants.

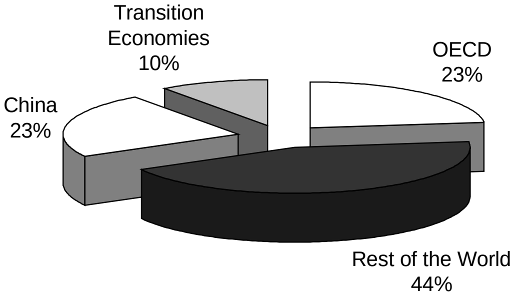
Hydro power is expected to show moderate growth, with most of the increase coming from outside the OECD.

Figure 2. **World energy demand**

Situation in 1995 and forecast for 2020



Increase in annual demand, 1995 to 2020



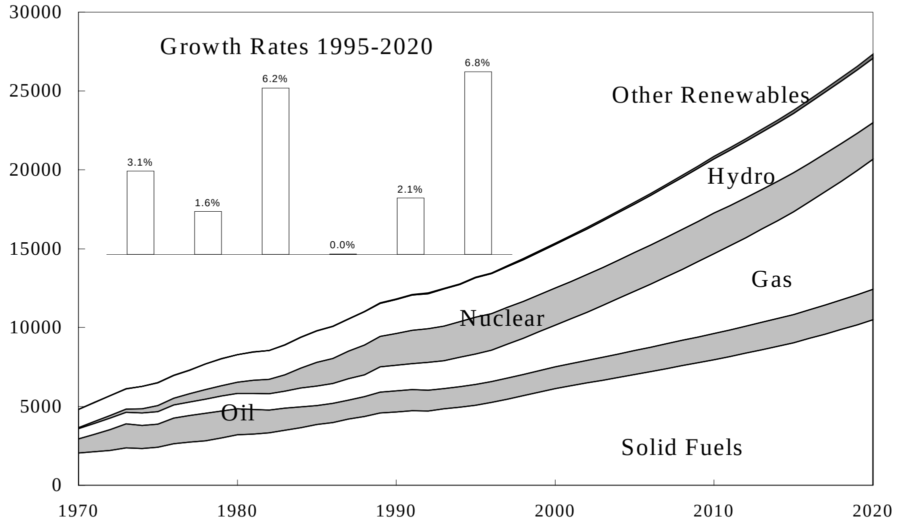
Finally, the use of other renewable energy sources increases steadily, but remains at low levels. Under business-as-usual assumptions, the share of non-hydro renewables will be around 1% of the primary energy mix by 2020.

Our projections show that world energy demand could grow by 65% between 1995 and 2020 (Figure 2). This is equivalent to an average annual rate of 2% over the projection period.

Two-thirds of the increase in energy demand over the period 1995-2020 is in China and the other developing countries. By 2020, China could be the second largest energy-consuming region in the world, after North America.

A structural shift in the shares of different regions in world energy demand is, therefore, likely to occur and the OECD share of world energy demand will fall.

Figure 3. **World electricity generation by fuel (TWh)**



Electricity generation grows strongly in all regions, particularly in the developing world. Despite the high growth in developing countries – 4.5% per annum, compared with 2% in the OECD – electricity generation continues to be dominated by the OECD (Figure 3).

Coal is projected to retain a strong position in power generation. It is the favoured fuel where domestic coal resources exist and gas is unavailable or expensive. Coal-fired generation increases strongly in China and India, as these two countries are expected to continue using their abundant coal resources.

Electricity generation from gas increases rapidly, at an annual average rate of 6%, during the projection period. By 2020, gas becomes the second largest source of electricity at world level.

Within the OECD, gas-fired generation quadruples over the outlook period. Outside the OECD, gas is expected to be increasingly used in the Former Soviet Union, especially in Russia. It will also grow in several countries in Eastern Europe where many inefficient coal-fired plants could be replaced by modern gas-fired plants. Strong growth in gas-fired generation is also expected for Latin America, East Asia, the Middle East and the northern part of Africa.

Some increase is expected in oil-based output. Oil will grow in use for standby or peaking power plants and for use where seasonal variations in price make other fuels (especially gas) uncompetitive at certain times. Because of the relative ease and low cost of oil storage, it is an ideal generating fuel for remote locations where other fuels are difficult or costly to obtain.

World nuclear power increases slightly to 2010 and then starts declining. In the OECD, some new nuclear plants are expected to be built during the outlook period, for example, in Japan. At the same time, some plants will reach the end of their operational life, leading to an overall decline of nuclear power in the region. Many of these plants will be replaced by gas-fired, combined-cycle plants. Outside the OECD, growth could be higher, with nuclear power increasing in Asia and in the transition economies.

Hydro power is expected to increase moderately. Within the OECD, most potential sites have already been exploited and therefore growth is expected to be limited to 0.7% per annum. Developing regions endowed with hydro resources will increase the use of this energy form to generate more electricity. China and East Asia are the regions where growth in hydropower is expected to be highest.

The use of other renewable energy sources increases steadily, but remains at low levels. Among the different forms of renewable energy (wind, geothermal, solar, tidal), generation from wind power is expected to make the largest contribution, particularly in the OECD.

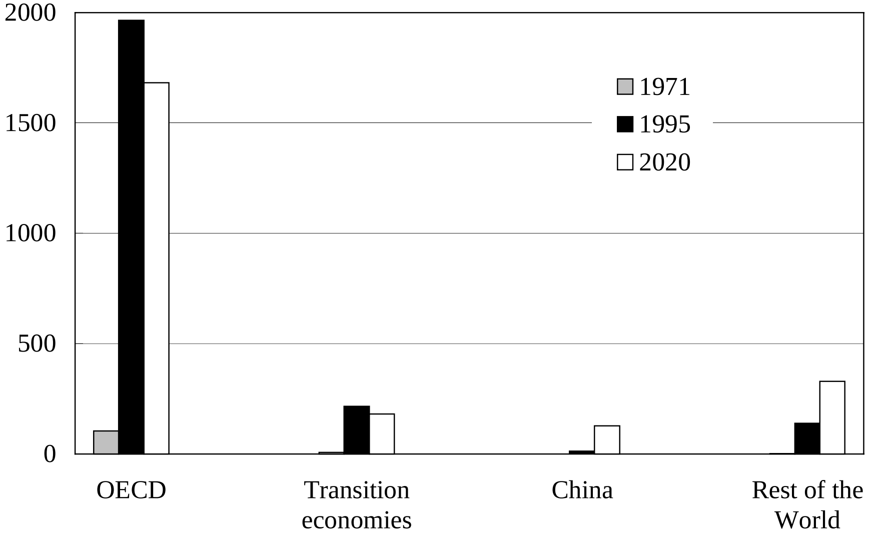
As mentioned above, the power generation projections in the World Energy Outlook are produced using a least-cost approach that involves a lifetime least-cost calculation for the choice of new plant and a short-run least-cost calculation on distributing power to the grid from existing plants.

However, nuclear and renewables are not modelled using least-cost economic criteria. Investment in such plants is frequently determined on a semi-political basis and the costs of renewables are highly site- and country-specific. Therefore, in the model, new nuclear and renewable capacities are assumed.

The projections of nuclear power presented here are based on information on construction of new plants collected from a variety of sources, including the International Atomic Energy Agency (IAEA), the OECD Nuclear Energy Agency (NEA), the US Department of Energy's Energy Information Administration, the French Commissariat à l'énergie atomique (CEA), other national sources, and the business and trade press.

This information is then carefully assessed by the Secretariat to determine how nuclear power will evolve in the future under business-as-usual assumptions. Growth in nuclear power capacity is expected only in countries that have firm plans for it.

Figure 4. **Nuclear electricity generation by region (TWh)**

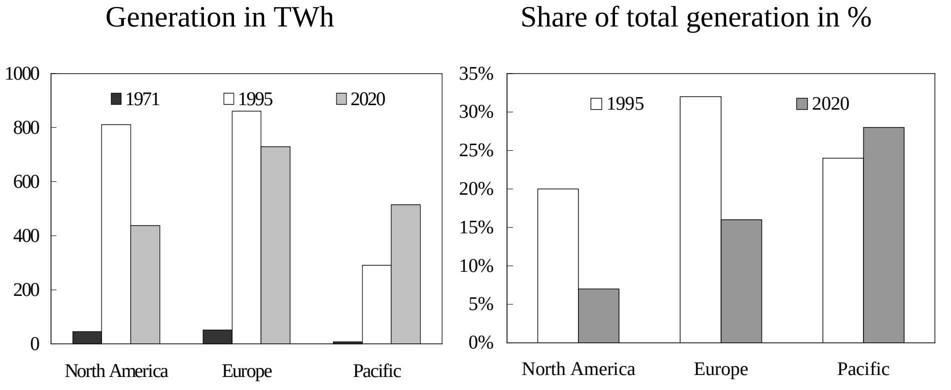


At a world level, nuclear electricity generation in 2020 is expected to be at about the same level as in 1995, the base year of our projections. However, the generation profiles across regions vary.

In the OECD and in the transition economies, an overall decline in nuclear electricity generation is expected, especially after 2010, when many of the nuclear plants that exist today reach the end of their life (Figure 4).

Nuclear power increases in China and in other developing countries, and particularly in Asia (Korea, although an OECD Member country, is included for modelling purposes in East Asia).

Figure 5. **Nuclear electricity generation in the OECD**



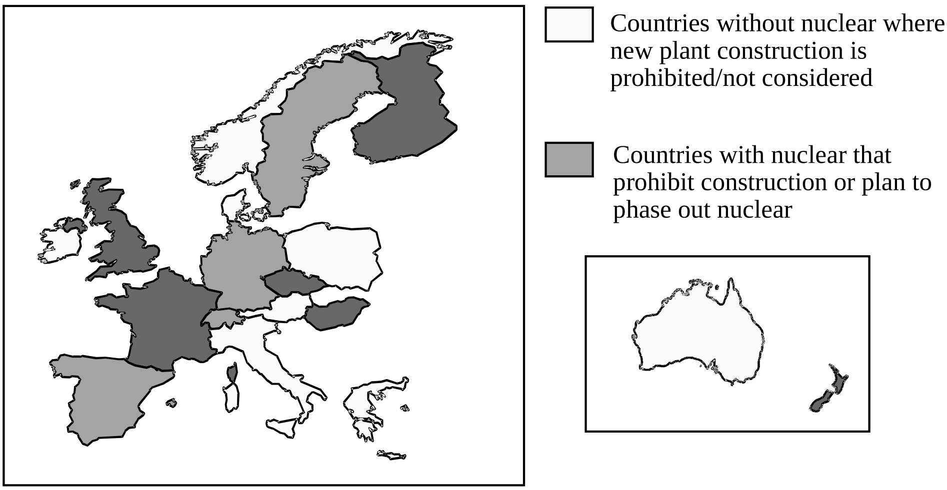
Within the OECD, nuclear power declines significantly, as few new plants are built and several nuclear reactors reach the end of their design life. The World Energy Outlook assumes as a general rule a 40-year lifetime for existing nuclear plants, unless a different lifetime is given for specific plants.

The most dramatic decline is expected in North America, where some of the oldest plants are located. By 2020, nuclear electricity generation could shrink to half of today’s level and its share in total electricity generation could fall to one third of what it is today (Figure 5).

In OECD Europe, the decline is less pronounced. A number of nuclear reactors have been completed recently, and a few more are under construction. Plant upgrades in some countries will also add extra capacity. The share of nuclear in the electricity generation mix is nevertheless projected to be halved by 2020.

In the OECD Pacific region, nuclear electricity generation increases substantially, and the share of nuclear in total electricity increases, because several new plants are built in Japan. Also, in this region, retirements are not expected to occur at the same rate since the nuclear units are fairly recent compared to those operating in OECD Europe and North America. Indeed, between 1990 and 1997, nuclear capacity in OECD Pacific increased by more than 40%.

Figure 6. **Restrictions on nuclear plants in OECD countries**



The reasons for the decline of nuclear in most OECD countries are partly economic – competition from fossil fuels and notably natural gas in CCGTs – and partly political. As shown in Figure 6, several OECD countries have policies (often enforced by law) to restrict nuclear power.

Figure 6 illustrates the restrictions imposed by several OECD Member governments on nuclear power for existing and/or new plants. For most of these countries the duration of the restrictions is indefinite.

Australia, Austria, Denmark, Greece, Ireland and Norway do not have nuclear power and have restrictions on new plant construction. Italy shut down its nuclear plants in 1990. Poland discontinued its nuclear power projects in 1990.

Belgium, Germany, Netherlands, Spain, Sweden and Switzerland all rely on nuclear power but have decided not to build new plants or intend to phase out nuclear power.

The results of a recent OECD study[3] confirm the current cost advantage of fossil-fuelled power generation. In particular, they show the strong competitiveness of gas-fired power generation (CCGTs).

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3. *Projected Costs of Generating Electricity – Update 1998*, OECD, Paris, 1998.

Clearly, under business-as-usual assumptions, the contribution of nuclear power over the next two decades will be limited, but nuclear possibly could have a larger role in energy supply than is suggested by business as usual. This should be seen in the context of three increasingly important energy issues: sustainability, climate change and electricity market competition.

A number of IEA Member countries wish to retain and improve the nuclear option for the future, because it is free of carbon dioxide emissions. This potential role depends on three key factors:

- First, better use of uranium resources. With current technology, reserves could last for 60 years. New technology will be needed to make better use of the energy resource, and that would entail uncertain costs.

- Second, environmental risks from nuclear must be reduced to the minimum. Problems such as the disposal of high-level radioactive waste must be resolved.

- Third, nuclear will have to demonstrate its economic value in increasingly competitive electricity markets.

Throughout the OECD, governments are promoting competitive electricity markets. Competition in liberalised electricity markets is expected to bring reductions in generating costs through improved performance of plants and nuclear power will not be immune to that.

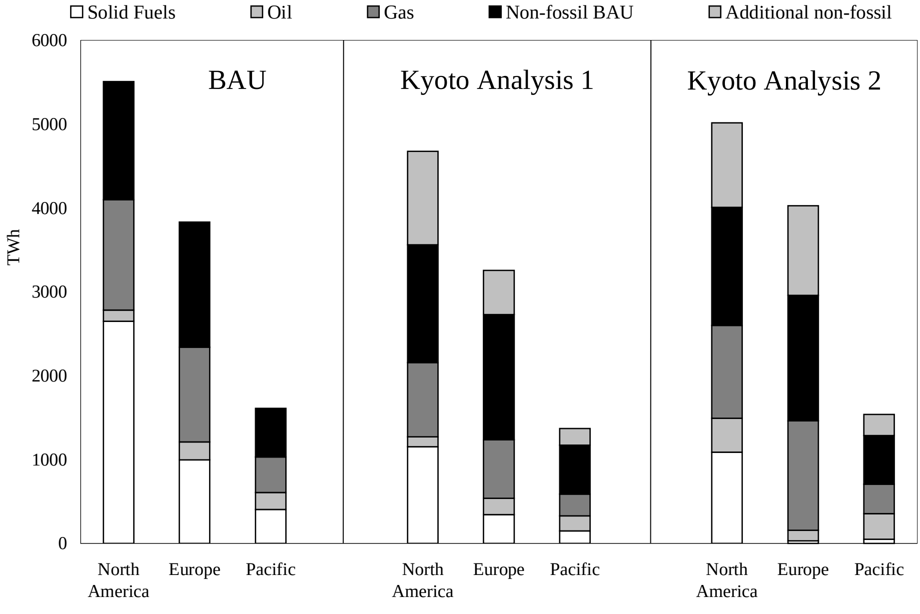
Nuclear's strong asset is its low operating and fuel costs, which explains why nuclear plants operate in base-load mode. In a competitive market, plants with low costs will thrive; plants with high costs may have to shut down.

Over the short- to medium-term, competition will give an incentive to existing nuclear plants to reduce their costs. Their output will be maximised and their lives extended to maximise revenues from generation.

The assumptions on nuclear capacity factors in the World Energy Outlook already include improvements over time. But it is likely that as electricity market reforms proceed, some nuclear plants will seek to extend their licences. With continued investment and refurbishment, some nuclear plants may be able to operate 60 years or even longer. Extension of the lifetime of existing plants would help in turn to restrain growth in carbon dioxide emissions.

For new plants, the outlook is more uncertain. Competition could improve nuclear economics, if capital costs – its main economic disadvantage compared to fossil fuels – and operating costs are reduced. But fossil-fuel technologies are not expected to stand still either.

Figure 7. **Kyoto analyses and electricity generation**



In December 1997, in Kyoto, Japan, the Conference of the Parties to the Framework Convention on Climate Change established an international commitment to reduce greenhouse gas emissions by 2008-2012.

The World Energy Outlook provides two stylised analyses to show the scale of emissions reductions required to achieve the Kyoto target and to illustrate how policies to curb GHG emissions (market-oriented or regulatory) would affect patterns of energy demand and supply (Figure 7).

The first (Kyoto Analysis 1) indicates the scale of regulation that would be required by OECD countries to meet their Kyoto commitments. The second (Kyoto Analysis 2) indicates the "carbon value" that would need to be built into fossil fuel prices to meet the Kyoto commitments.

In both cases, about half of the required emission reductions are achieved by introducing uniform energy savings of 1.25% per annum (Kyoto Analysis 1) or imposing a "carbon value" of US$250 per tonne of carbon (Kyoto Analysis 2).

The other half of the emission reductions is achieved by substituting non-fossil for coal-fired power generation. Existing coal-fired power plants are assumed to be retired early and replaced by non-carbon emitting plants (nuclear or renewables).

Because of its large contribution to carbon dioxide emissions (about one third of total), the electricity sector will be involved in any effort to curb GHG emissions. Also, the power generation sector is one of the easiest and most flexible sectors to tackle. Unlike other sectors, it has the advantage of being able to use carbon-free fuels (nuclear and renewables) on a large scale. This means that if market-based mechanisms, such as a carbon value, are chosen to curb emissions, nuclear and renewables would benefit in the longer term. Regulatory measures could also be used to establish carbon values, although implicitly.

The introduction of a carbon value would first affect the position of coal, since it is the most carbon-intensive of fossil fuels. Gas-fired combined cycle gas turbine plants are less sensitive to a carbon value. This is the combined effect of their high conversion efficiency and the low carbon content of natural gas.

If commitments to reduce GHG emissions are extended beyond the Kyoto time horizon, nuclear power could clearly have a comparative economic advantage over fossil fuels, especially if fossil fuel prices begin to rise.

The World Energy Outlook shows that under business-as-usual assumptions, demand for energy will continue to grow steadily. The world will continue to rely on fossil fuels to meet its energy needs.

Under these assumptions, the role of nuclear power in OECD countries over the next 20 years will be declining.

It is possible, however, that competition will encourage life extensions of existing nuclear plants. This may slow the potential decline in nuclear capacity within the OECD and contribute to efforts to curb CO_2 emissions.

Over the longer term, the role of nuclear could be much different from what is foreseen in the business-as-usual scenario. Sustainable development, climate change and competition are three issues which could have a profound, and potentially positive, effect on the role of nuclear. The challenge to proponents of nuclear power is to leverage its positive contributions and change the apparent course of business as usual.

NUCLEAR POWER IN THE ELECTRICITY MARKET

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Introduction

Nuclear power plays a very significant role in OECD countries' electricity markets. In 1998, 345 reactors were in operation and supplied 23.8% of total demand.

Some OECD countries are reliant on nuclear energy; eleven met more that 25% of demand in 1998 from this energy source.

Commercial nuclear power is a mature, established technology having accumulated 6 400 reactor years of successful operation in OECD countries over a period of 37 years.

Yet doubts remain in some countries and within some groups about the value of the contribution which nuclear energy makes today and its potential for continuing to do so in the future. There are many facets and viewpoints to the arguments which abound but the central issue in our global market-oriented world at the turn of the millennium is the economic viability or competitiveness of the option. In the circumstances of seeking to act contrary to the fundamental economics, governments, companies, utilities do find and will continue to find that "the going gets tough" and this paper seeks to illustrate this point, both to the favour and the detriment of nuclear energy.

Operation of existing plants

About 40% of the levelised cost of nuclear generated electricity is variable, shared roughly equally between operations and maintenance expenses and the supply of fuel services, including spent fuel and radioactive waste management and disposal. Those variable, marginal costs are those which determine the competitiveness of existing plants, fixed costs constituting a sunk investment. In general they are low and it is attractive to economic stakeholders to maximise use of the facilities, as evidenced by nuclear plant usually being used principally for baseload purposes. There are examples where the market conditions are not met, usually in small plants where economies of scale are not prevalent or if further investment in repair, refurbishment or upgrading of plant is necessary. In these circumstances, nuclear power plants are likely to be closed.

These variable costs are the focus of a great deal of the nuclear industry's attention, and substantial cost reductions have been successfully achieved. Most notable of these is the average reduction in fuel cost by 40% in real terms over the period 1978-1994.

More visible is the technical response to the economic attractiveness of nuclear generation from today's plants, with operators seeking to maximise the generation available at low prices. The endeavour to maintain or improve plant availability and hence units generated is universal; uprating plant to higher capacity is relatively commonplace; extending plant life is a general aim. Whereas initial licensing of nuclear plant was set for a very limited time at the outset of the industry, 40 years is now usual, 50 years has been achieved in some circumstances and 60 years is frequently mooted.

The outlook, therefore, is for competitive forces to extend the time horizons of current plants, consistent with meeting the safety needs of society and business. It is reasonable to expect that nuclear generation in 2020 will be greater than reflected in the "business as usual" data available to us today.

It is this economic advantage of existing nuclear power plants and the market drive to lower production costs which has been a major impediment to governments seeking to curtail nuclear power operation. The costs of doing so can be very large indeed, to the extent that political decisions to shut down nuclear units have been tempered in many OECD countries.

New nuclear plants

We have clear data on the competitiveness of new plants from a recently completed joint NEA/IEA study. Cost elements for various electricity generation options were provided by our Member countries and have been analysed and presented as levelised costs. Twelve countries provided cost data for nuclear, coal-fired and gas-fired power plants that could be commissioned by 2005. The study shows that for those plants, at 5% per annum discount rate, the nuclear option is cheaper by at least 10% in five countries. At 10% discount rate, however, gas is the most competitive option in all but one country. It is evident that the fixed 60% of nuclear energy's total cost, constituting capital and plant decommissioning is a major obstacle to new plants being competitive in the marketplace.

Generic approaches to reducing overnight specific capital costs, such as replication, standardisation, fast construction and large plants are not perceived as sufficient in conjunction with today's nuclear technology to make nuclear widely attractive economically today. A breakthrough by industry in this area would be needed to transform the economic outlook. With few exceptions, OECD Member countries are responding to the economic realities, with the result that new nuclear plant construction is stagnating. In two countries (Japan and Republic of Korea), plant construction continues for specific economic and strategic reasons, albeit at a reduced rate because of national economic difficulties. In France, there is no need for more base-load generating capacity at present.

Electricity market deregulation

Yesterday's decisions on energy technology are not necessarily economically robust in today's competitive environment in which global capital is the principal funding source. Today OECD countries have access to an abundant supply of fossil fuels at very low prices, a situation not envisaged by the energy planners in the 1960s or 1970s. Consequently, on making a change in regulatory environment, long-term commitments – in nuclear power plants or coal supply contracts – can become stranded assets, and arrangements are needed to protect the earlier investors. Nevertheless, the fundamental economic drivers are unchanged in the move to deregulation, although the response can change as shareholders replace rate payers as the beneficiaries of savings. An evident example of this would be staff reductions.

Transfer of financial risk to shareholders enhances the expectations of return on investments and this puts extra demands on investment decisions which are dominated by a capital element, worsening the prognosis of nuclear plant. For clarity, it should be stated that the financial risk here is dominated by securing the revenue streams from electricity sales over a period of many decades in order to secure a return of the original investment and to earn an appropriate return.

The assignment of risk in a deregulated market is a key issue for smaller companies. Whereas their acceptance of a nuclear plant within a portfolio of generating plant might be acceptable in a regulated environment, their capacity to raise capital and accept revenue risk may become difficult or impossible in the competitive market. This is likely to be a motivating element in the increasing market for companies divesting existing nuclear plants in the United States.

Placing electricity generating assets in the hands of private sector companies has the effect of weakening government's control over the implementation of energy policy, unless new regulations are introduced. Whereas, in a regulated utility, decisions may be taken which reflect security of supply, employment, trade or environmental considerations alongside economics, in a marketplace it is business issues which are uppermost and this means "the bottom line". There is thus the potential for conflict between the interests of a company seeking to maximise its short-term return for shareholders and those of governments which may see the longer-term issues as having national importance, therefore regarding lower short-term returns as more appropriate.

The expectation is that the costs of these longer-term, not directly economic issues, should be reflected within the marketplace.

Internalisation of costs

The key costs of nuclear energy are fully internalised, that is included in the prices for which electricity is sold. This includes radioactive waste disposal, decommissioning and most of the consequences of serious accidents.

For fossil fuels, on the other side, external costs are not internalised. Nuclear energy is not responsible for greenhouse gas emissions and has virtually no other emissions. It has plentiful and accessible resources, benign transport, minimal land use and offers high quality jobs. It has an attractive pedigree as one of only two commercially available large scale sources of non-carbon based fuels for electricity generation and is therefore a potentially valuable contribution to development in a sustainable framework.

Today economic models indicate that the environmental cost of carbon emitted is of the order of US$100 per tonne of carbon. Such a cost, if internalised within a market framework, would make nuclear unambiguously attractive in economic terms in all but one OECD country.

Summary

In general, the outlook for the operation of existing nuclear plants is increasing generation to take advantage of low variable costs that are competitive on liberalised markets. This particularly points to plant life extension and the prolongation of the present contribution of nuclear energy to the electricity portfolios of OECD Member countries.

With a few notable exceptions, major developments are necessary to justify new plants being constructed. A breakthrough in plant capital costs by industry or the internalisation by governments of the cost consequences of carbon emitted by fossil plants are the prime candidates for this.

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NUCLEAR POWER AND ENVIRONMENTAL POLICY

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Introduction

Nuclear power, which presently accounts for approximately 20% of global electricity generation and one quarter of OECD power generation, is still beset with environmental problems. Such problems are found throughout the fuel cycle - from mining and milling to processing to plant operation and finally (perhaps most significantly) to waste disposal. The danger of possible radioactive emissions remains the primary environmental factor constraining its current and possible future use.

Nuclear power does, however, offer some environmental benefits. Some of the environmental damages from nuclear power generation may be more limited than those arising from other energy sources. Perhaps most significantly, nuclear power emits no greenhouse gases – and in a world increasingly conscious of CO_2 and other GHG emissions, this could be a critical factor in the long-term power-mix equation. The world continues to seek to balance the potential damages and benefits of nuclear power.

Nuclear power: environmental hazards in the fuel cycle

Mining uranium generates significant environmental damage. As with much of the production of mineral resources, considerably more waste material is produced than final product: in the case of uranium, open-pit and underground mining yield only approximately 1 000 tonnes of uranium per 400 000 tonnes ore. However, it should be noted that other energy sources are significantly more resource-intensive. For example, generating one TWh of electricity requires only 32 tonnes of uranium concentrate, but would require

122 000 tonnes of natural gas or 330 000 tonnes of coal (and this latter figure does not account for any associated mining wastes).

The milling and leaching processes also produce waste products. For example, barium chloride is used in the treatment of uranium ore to produce yellow cake. Chemical disposal problems and possible groundwater contamination are sometimes associated with such nuclear processing facilities. In addition (as with much of the fuel cycle for uranium) there is the possible release (albeit, at this stage in low quantities) of radon and various uranium isotopes during the milling process.

Enrichment and fabrication of nuclear fuel also require treatment with toxic chemicals, and can result in possible environmental exposures. Nitric acid, ammonium, and fluorine are all used in the enrichment stage – and small quantities of such chemicals are released during normal operations. However, as with most aspects of chemicals manufacture, accidents are responsible for a larger share of total releases than normal operations. In the case of nuclear processing, such accidents (albeit infrequent) are compounded by the potential for release of radioactive isotopes.

The operation of any nuclear power plant or fuel cycle facility creates its own environmental impact. Plant operations can result in local thermal pollution (heating large quantities of water), and occasionally the release of toxic chemicals used in normal operations (e.g., hydrazine and oxalic acid). Of much more serious concern is the long-term contamination of the facility with radioactive isotopes: normal maintenance and operating practices lead to the creation of relatively large volumes of low-level radioactive wastes – particularly during decommissioning.

It is at the end of its life cycle that nuclear power is perhaps most worrisome: comprehensive procedures to protect the environment during the decommissioning of nuclear power plants and the disposal of waste products have yet to be fully developed. Problems range from how to handle the environmental effects of the disposal-site construction itself, to safely storing long-lived radioactive decay product, with lifetimes measured in thousands of years. Perhaps the greatest concern is reserved for the disposal of low-, medium- and high-level radioactive materials that are produced. While some medium- and low-level waste disposal sites are in operation or soon will be, no long-term disposal facility has been designed to deal with high-level wastes. To date, much of the high-level waste has been stored on power generating sites. While the volumes are quite small, they present the greatest potential danger for health and environmental damage.

At nearly every stage of this fuel cycle, the transportation of radioactive materials (and other toxic chemicals) presents potential environmental hazards. According to the European ExternE Project, approximately 8 m^3 of uranium ore, 90 m^3 of low-level waste and/or intermediate-level waste, and 0.5 m^3 of high-level waste must be transported for each TWh of electricity generated through nuclear power. While the volumes are small by contrast to the volumes of coal or oil that are transported annually, the distances are often quite large. Furthermore (particularly with high-level waste) the consequences of accidental releases are significant – although to date, no such accident has occurred.

Notwithstanding the potential for environmental damage, including those from radioactive releases, overall radiation released has been extremely low. France, which produces 78% of its energy from nuclear power, is projected to have a collective dose of only 13 man.Sv/TWh over the next 100 000 years. Reprocessing, generation, mining and milling, and high-level waste disposal account for 95% of this dose (Source: ExternE Project).

While projected radioactive releases for normal operations is extremely low, much of the environmental risk comes from the potential for accidents. Some probability analyses for core accidents project a rate of 5×10^{-5} per reactor year, with a conditional probability of large and small releases of 0.19 and 0.81 respectively for such accidents. Table 1 lists some of the most significant events over the past 30 years:

Table 1. **Selected nuclear facility accidents, 1966 to l999**
Source: IAEA, DSIN

Plant Name	Year of Accident	INES* Level
Fermi-1	1966	3
Wind-scale	1973	4
Three Mile Island	1979	5
Saint Laurent A2	1980	4
La Hague Reprocessing Plant	1981	3
Chernobyl 4	1986	7
Vandellós 1	1989	3
Sellafield Reprocessing Plant	1992	3
Tokaimura Reprocessing Plant	1997	3
Tokaimura Nuclear Fuel Plant	1999	4

* *International Nuclear Event Scale*

Nuclear Power: Environmental Benefits

While there are numerous environmental hazards associated with the use of nuclear power, there are also significant benefits, particularly when compared to some of the other, commonly used energy sources. These include lower effects from mining (as discussed above), as well as low or no pollutant emissions, as shown in Table 2.

Table 2. **Environmental pollutants**

	Nuclear	Coal	Gas	Renewables
SO_2	None	X	Negligible	None
NO_X	None	X	X	None
Particulate	None	X	Negligible	None
Radioisotopes	X	Negligible	None	None
Other	X	X	X	X

* Other includes: chlorine, heavy metals, noise pollution, water quality/flow, visual disturbances, etc.

The issue of climate change adds a new environmental dimension to the discussion of nuclear power. As with the safe disposal of nuclear waste, climate change itself is a long-term problem. Current estimates suggest significant changes in the global climate system may lag by 100 years or more behind the emission of climate-changing greenhouse gases (GHGs). Energy use figures prominently among the causes of climate change: energy is responsible for approximately 85% of total GHG emissions, and electricity generation is a key component of such use. Of the human-induced GHG responsible for climate change, carbon dioxide is the most significant: it is responsible for about 82% of all climate change effects. In this context, any electricity generation options which are carbon free become attractive.

To address the issue of climate change, the international community adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. That agreement set non-binding limits on the developed country parties (including countries in the OECD, as well as countries with economies in transition to market economies). By 1995, however, it was clear that the "aim" set in the Convention would not be met – and more stringent actions were negotiated. These were agreed in 1997 under the Kyoto Protocol. To date, the Protocol has only been ratified by 18 countries; it does not enter into force until it is ratified by 55 countries representing at least 55% of developed-country emissions.

The Protocol set aggressive emissions limits to be achieved by developed countries between the years of 2008 and 2012 (e.g., for the EU, 8% below 1990 levels – with "burden-sharing"; for the USA, 7% below; for Japan, 6% below; for Canada, 6% below; for Australia, 8% above; and for Iceland, 10% above). Such targets were assessed across the six key GHGs (CO_2, CH_4, N_2O, HFC, PFC, SF_6); the targets also provided for Parties to include actions to increase "sinks" as part of their mitigation efforts. In addition, the Protocol allowed Parties to offset domestic emissions through international activities either through project-based efforts, e.g., the Clean Development Mechanism (CDM) or joint implementation, or through emissions trading. While the overall target was set, no specific obligations were delineated on how to meet the goals; each country was given flexibility on how to achieve its target commitment.

Countries have identified a range of possible climate-change mitigation policies and measures. These include:

- The development or promotion of low- or zero-emitting energy sources.
- The reduction of emissions from existing sources through efficiency programs.
- Increasing prices to reflect a fuel's carbon or GHG content or eliminating subsidies for high-carbon sources and increasing low-carbon source subsidies.
- Setting binding limits on emissions – establishing regulatory caps.
- Promoting R&D.
- Establishing domestic and international emissions trading or using joint implementation or the Clean Development Mechanism.

Clearly, the use of nuclear power can figure in several of these choices. Its current importance in keeping energy-related emissions low is unquestionable, and can be seen from Table 3. This table shows the share of nuclear power in the current fuel mix – and then, the share of energy and CO_2 if nuclear power were to be removed from the mix, and the energy demand apportioned among the remaining sources. The net result would be an increase of nearly 32% in total CO_2 emissions within the OECD.

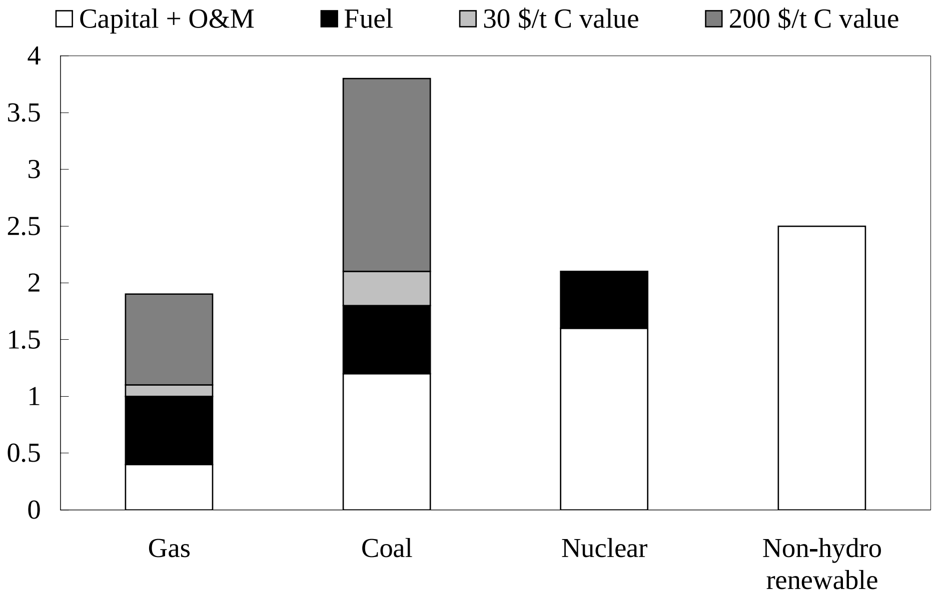
Table 3. **OECD "no nuclear" scenario**
(Source: IEA)

Fuel	1997 Levels		No Nuclear Scenario	
	TWh	Mt CO_2	TWh	Mt CO_2
Coal	3 145	2 616	4 136	3 440
Oil	510	252	671	332
Gas	1 125	346	1 480	455
Renewables	1 462		1 922	
Nuclear	1 967		0	
Total	8 209	3 214	8 209	4 227

It is clear that meeting the costs of the Kyoto Protocol will not be free: analyses by the IEA, as well as the OECD and others indicate costs ranging up to several percent of global GDP in the year 2010. Costs can be substantially reduced through the use of the Kyoto mechanisms (emissions trading, joint implementation and the CDM). However, even with such actions, costs per are anticipated to range between approximately US$25/tonne and nearly US$85/tonne of CO_2. In this context, it is useful to consider the additional carbon cost that might make nuclear power competitive with other energy generating sources. Such a comparison is shown in Figure 1 – where a US$30/tonne carbon value makes nuclear competitive with coal, and a US$200/tonne carbon value brings nuclear power into competition even with natural gas.

Much of the foregoing discussion on climate change is based on the assumption that atmospheric concentrations of GHGs will ultimately stabilise in the atmosphere. Scientific analyses of the effects of climate change are based on models that assume a stabilisation at twice pre-industrial levels – or about 550 parts per million of CO_2 by volume. However, current emissions must be cut significantly even to reach such limits; without actions to reverse the emissions trends, concentrations will continue to climb well beyond doubling. It is clear also that even if the Kyoto targets are met, they will not bring trends down far enough. Stabilising emissions at Kyoto levels in developed countries only will lead to atmospheric concentrations well in excess of 550 parts per million. Thus, Kyoto should be regarded only as a first step in a longer-term effort to combat the threat of climate change – and future steps will also need to be taken.

Figure 1. **Effects of carbon values on electricity generation costs**
Normalised costs of electricity (CCGT = 1)
(Source: IEA)



Notes: Calculations are illustrative only and are not representative of specific regions or utilities. Cost of electricity assumptions: nuclear power 20% more expensive than coal plants; power from renewable energy 40% more expensive.

Conclusions: balancing the pluses and minuses

Based on our current understanding of the climate system, it is clear that some mitigation actions will be necessary to reduce the threat of climate change. The long-term projections of energy demand require new sources of power generation. How these are balanced – providing low-carbon fuels while protecting the long-term safety of the environment – remains a difficult political question. National circumstances and technical progress are certain to make a difference in the discussions. To date, there has been no definitive conclusion in the debate over the trade-off between the advantages of nuclear power (with its low pollution and zero GHG) ends its disadvantages (with long-lived radioactive waste and the possibility of accidents).

Session 2

ENERGY POLICY IMPLICATIONS OF BUSINESS AS USUAL: COUNTRY VIEWS

Chairman:

Mr. John Ferriter
Former Deputy Executive Director, IEA

THE GERMAN POLICY ON THE PHASING OUT OF NUCLEAR POWER AND ITS IMPLICATIONS

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Current energy policy in Germany is dominated by three issues: the nuclear phaseout policy, implications of this policy and electricity market liberalisation.

This paper briefly summarises the main issues under these three headings.

Nuclear phaseout policy

The German nuclear phaseout policy is the "culmination" of a series of policies that have constrained nuclear power development since 1978, when President Carter signed the Nuclear Non-Proliferation Act. This year was the turning point in German public opinion towards nuclear power. Up to 1978 the general attitude had been supportive, but since 1978 there have been public debates suggesting that this policy should be modified. Antinuclear sentiment grew as a result of the 1979 accident at Three Mile Island, the 1986 accident in Chernobyl, and the discovery that several non-OECD countries had developed atomic weapons. Construction of the German reprocessing plant was terminated in 1990, and the fast breeder reactor project and the Hanau MOX plant were abandoned in the 1990s.

The nuclear phaseout policy was a part of the coalition party agreement of 1998 between the Social Democrat Party and the Green Party. The three essential elements of the agreement were that:

- The policy should entail no costs to the government.
- A new energy consensus should be sought.
- A new energy policy should be developed based on this consensus.

The phaseout policy included the termination of the reprocessing of nuclear spent fuels and the phasing out of nuclear power generation. A draft law implementing these points was prepared in January 1999, but was abandoned in April 1999, due to the lack of consensus within the Government and with the nuclear industry. A particularly difficult point continues to be the operating lifetimes of existing nuclear power plants. A new comprehensive report on the major issues is under development by a working party composed of representatives of four ministries and is due in November 1999.

Implications of the nuclear phaseout policy

The many implications of the new German policy are summarised below under 10 headings.

An end to reprocessing

At end 1998, the newly elected Government decided to stop foreign reprocessing of spent nuclear fuels as of January 2000 and to build intermediate storage facilities at reactor sites. Due to the lack of consensus within the Government and opposition from the nuclear industry and diplomatic issues with France and the UK, the German Government has postponed the deadline. It is considering ending foreign reprocessing between 2004 and 2006. The main difficulties are as follows:

- The nuclear industry was opposed to this decision and underlined the difficulties to implement it. In particular electricity companies needed a minimum of two to three years to obtain a licence to build intermediate repositories. In the meantime, serious storage difficulties may arise.
- Cogéma and British Nuclear Fuels (BNFL) which had reprocessing contracts with German nuclear industries would have been severely hurt by this decision and were asking for compensation excluded by the aforementioned policy.

Development of a direct storage centre for high-level wastes

A centre for storage of high-level wastes remains to be developed. To date, a total of DM 3 billion have been spent on the repository at Gorleben. According to the coalition party agreement, there should be a moratorium on its further development, but there has not yet been a decision to implement this.

Nuclear transport

In May 1998, the previous German Government put a ban on the transport of spent fuel after some "CASTOR"[1] casks were found to be contaminated, and it made a catalogue of 10 points to ensure safe transport. The new Government first lengthened the list to 59 points, then shortened it to 27 conditions. The Government considers that these conditions have not yet been met and has not allowed transport to resume.

As companies cannot send their spent fuels to France and the United Kingdom, some nuclear plant operators argue that they will have to stop operations in the near future because they lack storage capacity. In turn German utilities, which have to take the reprocessed waste stored in the UK and French reprocessing plants, are not able to fulfil their commitment.

Cogéma last sent reprocessed fuels back to Germany in 1997. In Germany, this created considerable demonstrations from nuclear opponents.

Nuclear transport is not likely until the second half of 2000 because of sensitivities connected to the 2000 World Fair in Hanover. Since transport to the nuclear deposits would necessarily involve the state of Lower Saxony (capital: Hanover), the Government may wish to avoid any negative publicity associated with that town and state.

Reactor lifetime

The Green Party is in favour of a rapid shutdown of all 19 nuclear plants and it proposed allowing an average of 25 years for the operation of nuclear power plants. The nuclear industry rejected this proposal, but it may be prepared to accept the phasing out of nuclear power plants after 35 full-power years. Compensation payments would be demanded for any early shut down.

Fiscal issues

The nuclear industry has accumulated tax-exempt financial reserves of more than DM 50 billion for decommissioning and nuclear waste disposal costs. The Government has proposed to tax these reserves. Taxes are likely to be between DM 7 billion and DM 25 billion spread over a ten year period. The latest publicly known tax figure is DM 13 billion.

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1. Casks used to transport nuclear waste.

Foreign reactors

Given the government's commitment to phasing out nuclear power in Germany, a coherent policy requires that Germany should not support or contribute to nuclear power in other countries. There are questions about the continuation of international nuclear programmes, and in particular on the European Pressurised Reactor. Commitments for financial contributions to nuclear projects in other countries (Ukraine, Turkey) are in intensive dispute.

New energy policy

A new energy policy plan called "Energy Dialogue 2000" is being drafted by a Working Party of representatives from all social/industrial areas and is expected to be published in June 2000. The target is to find solutions for the replacement of nuclear power. The main point is how to stop nuclear power generation without replacing it by the use of fossil fuels that would increase emissions of carbon dioxide. There are at present few new, concrete proposals.

Trade issues

There are some concerns that the phasing out of German nuclear power plants would lead to increased electricity imports to Germany. The open market limits the German government's ability to control this.

Environmental issues

One of the major issues is how a nuclear phaseout would affect Germany's ability to meet its commitments made under the climate treaty. Specific plans to resolve the problem are at present under study.

Electricity prices

Some existing reactors have low capital charges and will be competitive in the new electricity market. Closing these reactors would tend to increase electricity prices, although market liberalisation should overall contribute to declining electricity prices.

Relevant developments in electricity market liberalisation

There are many questions on how electricity market liberalisation will unfold. Future developments in the following areas are important:

- Prices.
- Mergers and industrial concentration.
- International participation in the market.
- Usefulness and applicability of the "reciprocity clause" of the electricity directive.
- Endangering of local utilities including co-generators.
- Development of electricity brokers.
- An electricity exchange in Frankfurt and possibly Leipzig.
- Employment, i.e. The risk of 50 to 100 thousand job losses hardly offset elsewhere in the economy.
- Transmission access and pricing.

Conclusions

It is impossible to predict the future of nuclear power in Germany. The dates for resumption of nuclear transports, shutdown of reactors, etc. are unknown. International co-operation and interaction, however, has been an important corrective mechanism against precipitous decisions. For example, the existence of governmental reprocessing agreements was probably an important reason that reprocessing was not stopped immediately.

The government continues to pursue the long-term goal of an energy supply without nuclear power. Energy conservation, co-generation and renewable energy programmes are already contributing to the attainment of that goal. Clearly there are many issues to be resolved before the goal can be met.

POLICIES AND EVENTS AFFECTING NUCLEAR POWER USE AND INVESTMENT IN THE UNITED STATES

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The opinions expressed here are those of the author and not necessarily the opinions of the Federal Energy Regulatory Commission or the US government.

Introduction

Good morning. I appreciate the opportunity to speak with you about how US energy policy affects nuclear power in the United States.

I am with the Federal Energy Regulatory Commission (FERC).[1] The FERC establishes policies promoting competition in the electric power industry.[2]

US Nuclear Power Forecasts

Nuclear power produces 19% of the electricity generated in the United States.[3] Our 99 gigawatts of generating capacity at 111 operating nuclear units represents 13% of US electric generating capacity. What is the likely future for nuclear power?

US policy is to rely on competition and private sector choices to select the technologies and fuels for generating electricity.[4] Under competition, economic models can forecast future nuclear power use.

The US Energy Information Administration (EIA) is the independent energy forecasting agency of the US government. Its forecasts do not represent US nuclear policy or energy policy. The forecasts are predictions about how the competitive private sector will act. The EIA forecasts that US nuclear fuel use will increase through the year 2000. This is because the recent performance of nuclear power plants has improved substantially, reflecting increased nuclear plant operating availability.

However, no new nuclear units are ordered or under construction now in the United States. Because US nuclear units are ageing, EIA projects that over the next twenty years, about half of the existing US nuclear capacity will be shut down.[5] This is because they will need major new investment to continue after 30 years of operation-investment that for many nuclear units would not be economical compared to building new non-nuclear capacity. EIA expects no new nuclear units to come on line by 2020 because natural gas and coal-fired plants are projected to be more economical. The United States has vast coal reserves, and the United States and Canada have abundant natural gas resources.

US nuclear generation is projected by EIA to decline from about 680 billion kWh a year in the year 2000 to 420 billion kWh in 2015, and to 360 billion kWh in 2020. Because total US generation will grow, the market share of nuclear fuel will decline even more dramatically: from a 19% share of US generation in 2000 to 7% in 2020. The story in these EIA projections is not substantially affected by the level of US economic growth.[6]

It should be emphasised that it is not US policy to phase out nuclear power. Competition is the policy, and competition is forecast to reduce US nuclear use, assuming existing laws, regulations, and policies remain in effect until 2020.

EIA compares its own 1999 forecast with the 1998 forecasts of three private sector groups.[7] All three predict more nuclear power generation than EIA, and one predicts substantially more. However, all three agree that nuclear generation will decline both in absolute kilowatt-hours and as a percent of US generation over the next twenty years.

These forecasts depend on many assumptions about nuclear[8] and non-nuclear costs. A very important factor is the price of other fuels, especially coal and natural gas. For example, EIA projects the average US mine-mouth price of coal to decline from US$18.14 per ton in 1997 to US$12.74 per ton in 2020, as a result of increasing productivity in the industry, more production from lower cost Western mines, and competitive pressures on labour costs. Coal and gas meet most new demand for electricity and replace much of the nuclear generation in the EIA forecast.[9]

The Electric Power Research Institute (EPRI) finds great uncertainty about the forecast costs of generating electricity from coal, gas, wind, and nuclear fuels in the year 2020.[10] (Further, some recent reports indicate that solar energy could also be competitive in 2020.) EPRI considers ranges of capital cost, fuel cost, non-fuel operating and maintenance expenses, financing methods, and taxes for the year 2020. Because the total cost ranges overlap, EPRI concludes that any of these energy sources could be competitive in 2020.

Electric Industry Restructuring and Nuclear Power

The EIA forecasts are based on economic models that balance supply and demand, considering the average annual cost of electricity produced by various fuels. Let us consider several economic factors that will affect nuclear power use but that cannot be easily included in an economic model.

Two fundamental changes in the US electric industry could alter the results of today's best forecasts of nuclear fuel use for electricity generation: [1] electric industry deregulation and [2] new owners of power plants.[11] Some changes would disadvantage nuclear power, and others may work to its advantage.

Electric Industry Deregulation

The FERC greatly expanded competition in the wholesale electricity market through our open access rules in FERC Order No. 888.[12] Unlike Europe's new requirements, FERC's Order does not require open access to retail consumers. Retail competition is not yet national policy. Retail access is being decided by the 50 individual states, but it is increasing rapidly.[13]

Retail competition affects the choice of fuel for new generation and hence affects the future of nuclear power. A US Department of Energy study indicates that retail competition is likely to favour nuclear power a little over the next ten years and then slightly disfavour nuclear power afterward.[14]

Under regulation, utilities had an incentive to favour plants with high capital cost and low fuel cost such as nuclear and hydro. They earned a profit on invested capital not operating expenses. A technology with a high capital cost yielded higher profit. This created an incentive to build a nuclear unit. Another technology with the same life-cycle cost – but with lower capital cost and higher operating cost – would not have been as profitable.[15]

Under competition, investor incentives change. Investors find no advantage in high capital cost technologies. They consider total life cycle cost. However, total life-cycle cost is not the sole – or even the principal – investment criterion. Investors tell us that the time to recover the investment is just as important. Shorter times are preferred, and a lower capital cost investment is favoured. The capital cost of a nuclear plant must not require a very long payback time. That would discourage market investment in a nuclear plant.

Another factor is how the price of electricity varies during the year in a competitive market. US electricity markets may have sustained periods of low electricity prices interrupted by short periods of unusually high prices, sometimes called price "spikes." When the price is low, generators sell when they can recover at least their operating expenses plus a small profit. Greater profits go to those whose cost is significantly below the market price. The "spikes" provide very high profits for a short time.[16] The market responds by building new generation. Investors in new generation try to profit from the capacity shortage before competitors can get their own new generation on line. Therefore, the new plant construction time must be short. (It is not yet clear whether the market will eventually attract merchant investors who invest for the very long run.)

Hence, competition could be favourable to nuclear power – or any other generating resource – if (1) the capital cost is low, (2) construction time is short, and (3) the operating expense is low. It is doubtful that new nuclear units can satisfy these market investment criteria.[17]

An existing nuclear unit, however, may be an attractive purchase if the sales price is low enough. Existing nuclear plants can make good profits not only during price spikes. Some can also profit continuously by operating at a cost well below the market price during the long low-cost periods between spikes.[18]

A few years ago, conventional wisdom held that no one would purchase an existing nuclear power plant.[19] Under competitive markets, however, nuclear plants are being sold to willing buyers – if the price is right. Successful, experienced operators of nuclear units are buying more units from the less successful operators. Therefore, fewer companies now own US nuclear units, and these companies have the nuclear expertise and economies of scale to operate nuclear facilities more safely and at lower cost. This is good for the US nuclear industry. From August 1997 through July 8, 1999 there were willing buyers for 3 716 MW of US nuclear generation.[20] However, the average price of these nuclear assets was only US$79 per kilowatt, a deep discount from the original cost of about a thousand or even several thousand dollars per kilowatt.

This illustrates two things. One is that these plants have a low value in today's competitive market.[21] The other is that, in a competitive market, profit-minded investors will invest in nuclear power despite potential economic and political risks.

New owners of power plants

Consider next another aspect of US electric industry restructuring: changes in who builds power plants. Four parties can own plants or affect what type of power plant is built in the United States: utilities, independent power producers (IPPs),[22] consumers, and governments. Their roles have been changing during the 1990s, and this will affect nuclear power's future.[23]

Utilities

Utilities formerly chose the generation technology and fuel, with some state regulatory oversight. Utilities compared the life-cycle costs of the technologies. The regulatory formula created an incentive for utilities to favour high capital cost investments, as mentioned. In the past, utility decision-making favoured the nuclear option, but more recently state regulation of utility investment generally discouraged the nuclear choice. Utilities are making fewer power plant decisions today.[24]

IPPs

In the early 1990s, IPPs were extremely conservative investors. Such investors would not consider a nuclear investment with its attendant risk.[25]

Now, a new kind of risk-taking IPP is emerging. Dozens of "merchant IPPs" are willing to invest large amounts of equity capital without a regulatory guarantee or a long term contract for cost recovery.[26] Merchant IPPs today are building mostly gas-fired generation. But they are more willing than regulated utilities to take risks if the possible reward is high enough. This could favour nuclear power. For example, a merchant IPPs might invest in an existing nuclear power plant and refurbish it to extend its life. A merchant IPP would be more likely than a regulated utility to invest in a new nuclear facility if the economics of nuclear power improved relative to coal and gas.[27]

Also, those in the nuclear power supply industry with extensive financial resources might create an affiliated merchant IPP to own and operate a new nuclear plant to demonstrate the competitiveness of its new power plant design.[28]

Consumers

Today, many people in the electric power business believe that customer self-generation[29] with distributed generation[30] will soon have a major effect on electric investment decisions.[31] If distributed generation is successful,[32] it would be an important factor not only for large industrial customers but for many small customers as well. The self-generating customer is very unlikely to consider nuclear self-generation.

Government

Governments choose the fuel for their own generation and affect private sector fuel choices. Federal, state, and local governments own a significant amount of generation in the United States. Also, although electric power competition is the main US government policy, other government policies – such as research and development funding and tax policies – can influence the private sector's technology choices.[33] Current US government support for nuclear power is reduced from historically higher levels. However, we cannot reliably say whether future US government support will swing toward or away from nuclear power.

Events that could affect nuclear power

Finally, we must mention briefly four non-economic factors or events that could significantly change the economic forecasts of future US nuclear power use for electricity generation. It is important to emphasise that this is not a prediction of these events but a recognition that unpredictable events could change significantly the US reliance on nuclear power from the purely economic forecast scenarios discussed at the beginning of this paper.

Two events that would decrease reliance on nuclear fuels are:

- **A major nuclear accident**. A major nuclear accident anywhere in the world, but especially in the United States, could significantly reduce future US reliance on nuclear power.

- **Government/industry failure to resolve nuclear waste disposal issues**. The United States continues to struggle to achieve a workable consensus nuclear waste disposal plan. On-site plant storage of spent fuel is filling up, and some utilities may soon be unable or unwilling to create more waste without a dependable government disposal plan.[34]

Two events that would increase reliance on nuclear fuels are:

- **Global climate change**. A new and dramatic demonstration of global climate change effects could significantly change the direction and pace of US energy policy to reduce reliance on coal, and perhaps other fossil fuels.

- **New nuclear technology**. A major improvement in nuclear plant design that lowers the capital cost of a nuclear plant even more than is forecast and that can be licensed for operation would enhance the competitive position of nuclear power.[35]

Conclusion

To conclude, unless major unforeseeable events advantage or disadvantage nuclear power, economic forecasts and increased competition in the electric power business suggest that nuclear power is likely to be an important but declining contributor to US electricity generation over the next twenty years.

Notes:

1. The views expressed here are my own, not those of the FERC or of the US government. FERC is not a nuclear power regulatory commission; that is the US Nuclear Regulatory Commission (NRC). Nor are we the principal US agency for developing energy policies; that is the Department of Energy.

2 The FERC also regulates the siting of natural gas pipelines and the siting, licensing, and safety of hydroelectric facilities, as the NRC does for nuclear facilities.

3. All data are from the US Energy Information Administration, EIA, unless otherwise noted. Many EIA reports are available without charge, and many are available on the Internet.
   See http://www.eia.doe.gov/cneaf/electricity/chg_str_fuel/execsumm.html

4. The policy of competition emerged in several stages. One important step was the Energy Policy Act of 1992. Among other things it created a plan to privatise the US government's uranium enrichment facilities. The board of directors of the United States Enrichment Corporation (USEC) announced on June 29, 1998 that USEC, the US Government-owned enrichment company, would be privatised through an initial public offering of common stock.

5. Many US nuclear plants will reach the end of their operating licenses during the next 20 years. Also, some plants will retire early, according to EIA, because they need major investment to continue after 30 years of operation – investment that would not be economical compared to building new non-nuclear capacity. EIA forecasts that, under the most likely economic assumptions, 51% of current nuclear capacity is expected to be taken out of service by 2020. Of the 99 gigawatts of nuclear capacity available in 1997, 50 gigawatts will be retired. EIA, Annual Energy Outlook 1999. See http://www.eia.doe.gov/oiaf/ aeo99/electricity.html

6. According to an EIA sensitivity analyses, low economic growth accelerates nuclear plant closings somewhat, and high growth delays the closings. *Ibid*.

7. The three private sector groups are The WEFA Group (WEFA), the Gas Research Institute (GRI), and DRI/McGraw-Hill (DRI). While EIA finds that annual US nuclear generation in billions of kilowatt-hours will decline from about 680 (year 2000) to 420 (year 2015) and then to 360 (year 2020), WEFA projects 480 (year 2015) and 370 (year 2020), GRI projects 450 (year 2015; no year 2020 projection), and DRI projects 580 (year 2015) and 550 (year 2020).

8. For example, EIA assumed that nuclear power plants will operate until some major capital investment is required for repair. The decision to repair or retire the unit is based on the relative costs. EIA assumes:

   That a retrofit costing US$150 per kilowatt will be required after 30 years of operation to operate the plant for another 10 years. Plants that have already incurred a major expenditure (such as a steam generator replacement) are assumed not to need additional retrofits and to run for 40 years. For other units, the capital investment is assumed to be recovered over 10 years, and an annual payment is calculated. If the combined operating costs and capital payment costs are cheaper than building new capacity, then the plant is run through its license period. If it is not economical, the plant is retired at 30 years.

It is also assumed that nuclear licenses will be renewed at the end of 40 years, if it is economical to continue running the plant. A more extensive capital investment (US$250 per kilowatt) is assumed to be required to operate a nuclear unit for 20 years past its current license expiration date. If this investment, recovered after 20 years, is less expensive than building new capacity, the unit is assumed to continue operating. Otherwise, it will be retired when it reaches the expiration date on its license. For both of these investment decisions, adjustments are made for new units to capture the improvements in their designs compared with older units.

9. EIA projects the average US mine-mouth price of coal to decline from US$18.14 per ton in 1997 to US$12.74 per ton in 2020, as a result of increasing productivity in the industry, more production from lower-cost western mines, and competitive pressures on labour costs. EIA projects the average wellhead price of natural gas to increase from US$2.23 per thousand cubic feet in 1997 to US$2.68 per thousand cubic feet in 2020. The fuel price projections are themselves the result of model with many assumptions and the results can change from year to year. Last year, EIA projected somewhat higher coal prices for the year 2020 and somewhat lower natural gas prices.

10. EPRI reports that the cost of a kilowatt-hour of electricity from a new coal plant in 2020 could be anywhere from 2.2¢ to 4.0¢ (and as high as 6.0¢ if there were a US$100 per ton carbon tax). Electricity from natural gas in 2020 could cost from 2.1¢ to 4.5¢ (and as much as 5.5¢ with a carbon tax). Electricity from wind energy would be somewhere in the range 2.3¢ to 4.3¢. Nuclear electricity is projected to cost between 3.3¢ and 5.3¢. Electric Technology Roadmap, Volume 2: Electricity Supply, Electric Power Research Institute, Palo Alto, California, USA; January 1999; see the discussion on and near page 2-16.

11. These are related changes but it is clearer to discuss them separately.

12. The wholesale market is the market in which electric utilities buy power from others, including other utilities, other power producers, cogenerators, and marketers.

13. About half the states have chosen a retail competition policy, and half have not. Congress is now considering legislation to make retail competition US national policy. However, it may enact a law that encourages states to have full competition but permits them to choose continuing monopoly utility service to consumers.

14. Competitive market outcomes are fundamentally harder to predict than the actions of monopoly utilities acting under government regulatory oversight. If we could foresee the results of competition, we could direct this outcome without resort to competition. DOE finds retail competition would increase nuclear generation (in billions of kilowatt-hours per year) 678 to 694 in 2000; from 659 to 661 in 2005; from 580 to 581 in 2010; and decrease it from 427 to 420 in 2015. See the US Department of Energy analysis is support President Clinton's electric restructuring legislative proposal. Available on the Internet at http://home.doe.gov/policy/ ceca.htm

15. In the regulated world, invested capital is recovered slowly through depreciation expense over thirty or forty years. In the past, this posed no serious risk to the utility because it would continue to earn a return on the undepreciated part of the investment. Because electricity demand always increased and customers had no choice of electricity suppliers, capital recovery with a profit was practically assured.

16. Spikes signal that capacity is in short supply. The high profits during spikes encourage new generation construction. Markets are cyclic, however. Over-entry by competitors could lead to excess generating capacity in the market for a few years. Short construction times are important.

17. Nevertheless, under retail competition, power consumed will not necessarily be generated locally; it will be purchased instead from the lowest cost source, near or far. This could favour new nuclear plants sited at remote locations away from population centres.

18. Low nuclear fuel cost would make a nuclear plant attractive in a market if nonfuel operating costs can be contained and if a nuclear unit is acquired at

a low capital cost. This is because the market rewards most those who can generate at a price that is most below the market clearing price.

19. Utility purchase of an existing nuclear plant would have been hard to justify to state regulators and would have been seen by captive consumers as an increase in the “stranded cost” that they would have to pay. To investors, a nuclear purchase represented an investment risk not only because of the possibility of an accident but also because of the liability for nuclear fuel disposal and plant decommissioning. Investors do not like risk without a commensurate reward, and the regulated utility could earn no more than a regulated return on its investment.

20. Data from a study by Energy Insight, Bolder, Colorado, a subsidiary of Resources Data International, as reported in “Ten Companies Account for Two-Thirds of All Asset Sales Sold in US since ’97” in *Electric Utility Week*, August 16, 1999.

21. It may also illustrate the size of the decommissioning liability. See “PECO Appeals Tax Fight on Limerick: Sees Little Value in Nuclear Plants,” in *Electric Utility Week*, September 6, 1999 in which an electric company asserts that its nuclear asset has a low market value and possibly a negative value because of a potential US$1 billion decommissioning cost.

22. Independent power producers (IPPs) are power producers that are independent of utilities.

23. For example, this changing role can affect who decides on any future investment in refurbishing an existing nuclear facility or building a new one.

24. In the past, nuclear advocates among utilities could decide to build nuclear plants. This would reward investors. State regulators formerly did not second guess utility technology choices. However, rising nuclear capital and operating cost in the early 1980s reduced the attractiveness of the nuclear option. Further, in the late 1970s and early 1980s, increased state oversight of utility investment decisions followed excess generating capacity and nuclear cost overruns. Not all investments dollars were recovered, and state regulatory oversight of utility technology choices became an additional deterrent to nuclear investment. In the 1990s, utilities’ worries about stranded cost recovery under competition worked against the nuclear option.

25. They chose a generating technology to attract capital and investment minimise risk. A typical IPP build a gas-fired turbine, financed largely with debt, not equity, with risk virtually eliminated through a long-term contract with a utility buyer that practically guaranteed full investment recovery.

26. A merchant IPP will build a plant to sell power into the open market with the intention of making a profit. Natural gas and coal are the main choices of merchant IPPs today.

27. Although a merchant IPP operates with little economic regulatory oversight, it is still subject to environmental and safety oversight.

28. There is already increasing concentration of ownership through mergers in the electric power and equipment supplier businesses.

29. Self-generation by consumers was important early in US electric power industry history, but declined throughout most of this century as utilities exploited economies of scale. Self-generation rose again when utility electricity prices began to rise. Since 1978, US law has encouraged self-generation by requiring utilities to purchase the excess power from cogenerators in certain circumstances.

30. Distributed generation refers to a set of new efficient technologies for generating small amounts of power at or near customer loads. Natural gas turbines, fuel cells, and renewable energy sources are the principal fuels for distributed generation.

31. It is too early to tell if distributed generation will become a major factor in US power generation, but if it does, the effect would be to make nuclear investment relatively less attractive.

32. Congress is considering a "net metering" provision in legislation to allow even small customers to use distributed generation and sell excess power to utilities.

33. Many US federal, state, and local laws, regulations, and policies affect or limit some competitive market choices. These include government tax laws and subsidies; research and development funding; environmental and safety regulations for nuclear, hydroelectric and other generating facilities; government decisions on the siting of electric generating plants and of

electric and natural gas transmission lines; and regulatory decisions about compensation for prior investments in nuclear plants and other electric generating choices. Also, some electric generators are owned by federal, state, and city governments; here government owners choose directly the generating technology and fuel. Except when government-owned utilities are involved, federal and state officials do not interfere directly with investor technology choices. But they can affect these choices indirectly, especially through tax policy (for example, a carbon tax); research, development, and demonstration funding; encouragement of preferred technologies through conferences and other means; and the strictness of interpretation of environmental laws and regulations. The period 1969 through 1999 is a history of changing government "favourite" fuel or technology for electricity generation. Although this list is disputable, it seems to have been oil in 1969, nuclear fuel in 1973, coal in 1978 (if fact, new use of natural gas and oil for electric generation were banned in that year), conservation in 1981, renewable fuels in the mid-1980s, natural gas in 1990, competition among fuels in 1992, non-carbon fuels in 1993, fuel cells in the mid-1990s, and perhaps distributed generation today. None of these policies entirely overcame basic economics, however. Throughout all this time, coal provided more than half of US electricity generation every year, and coal continues to be the "king" today and for the foreseeable future. This year, the Clinton Administration proposed to the Congress a mandatory percentage of generation from renewable energy under retail access; this proposal has been controversial in the Congress.

34. The United States lacks a clear policy for disposal of the high level waste in spent nuclear fuel. Although government, Congress and the courts continue to work toward a solution, most waste remains at the nuclear plant sites.

35. Vendors would have to demonstrate that the new nuclear plant can be constructed and operated at much lower cost than previous nuclear plants and still satisfy nuclear safety regulations.

PHASING OUT NUCLEAR POWER – THE SWEDISH EXPERIENCE

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The first Swedish commercial reactor for power production was put into operation in 1972. Additional nuclear power plants were started in the following few years, but during this period, the nuclear issue started to become politically controversial. After the Three Mile Island accident in 1979, Parliament decided that there should be a referendum on nuclear power.

The consultative referendum, which was held in 1980, resulted in a Parliamentary decision with the following intentions:

- No further expansion of nuclear capacity beyond the twelve reactors in operation or already under construction.
- All nuclear power plants should be decommissioned by the year 2010. The timetable for closure of the reactors should be decided according to safety aspects.

In the spring of 1986, Northern Sweden was one of the regions outside the Soviet Union that was hit hardest by the radioactive fall out from the Chernobyl accident. One conclusion from the numerous investigations that were carried out after Chernobyl was that there were no reasons to bring forward the deadline for the phasing-out of Swedish nuclear power. However, it was found that a long phase-out period would improve the conditions for a step-by-step adaptation to the new situation.

In 1988, Parliament decided that one reactor should be closed down in 1995 and a second in 1996. The reactors chosen were one in Barsebäck, (mainly privately owned), and one in Ringhals, (owned by the state power company Vattenfall). In 1990, a control-station would provide information on the measures required to secure supply of electricity and reasonable electricity prices for Swedish industry, much of which is highly energy intensive.

Also in 1988, Parliament decided that a national preliminary target for CO_2 emissions should be stabilisation at the 1988 level.

The Government initiated a number of investigations on the possibilities of replacing the nuclear capacity and on the economic and social consequences of closure. Broad expert committees produced reports and the results indicated considerable constraints and high costs for closing the reactors. But the results also indicated that some positive results for the future could be expected if policies and measures for renewable energy sources and energy efficiency were developed.

In 1991, an agreement was reached between the Social Democrats and the Liberal and Centre parties on future guidelines for energy policy, and the Parliament decided on a new energy policy programme for a five-year period. The main measures were on the demand side, with a huge financial support scheme for energy efficiency. On the supply side, the programme provided investment support to combined heat and power plants based on biomass, wind power plants and solar heating.

This decision repealed the 1988 decision to close one reactor in 1995 and another 1996 and the decision on stabilisation of CO_2 emissions. Instead, the new guidelines stated that the juncture at which the phasing-out of nuclear power could begin and the rate at which it could proceed should depend on the results of the 1991 Energy Policy Programme and the possibilities of maintaining internationally competitive electricity prices.

In 1993, Parliament made another decision on climate policy: CO_2 emissions should be stabilised at the 1990 level in the year 2000 and should then decrease. Sweden ratified the UN Framework Convention on Climate Change on 23 June 1993 in conjunction with the Swedish Parliaments approval of the Climate Bill.

As well as a national Swedish programme, a proposal was simultaneously approved for pilot programmes aimed at the execution of projects in Sweden's "near region": the Baltic States and Eastern Europe. The objectives of the projects were increased energy efficiency and an increased use of renewable fuels in the district heating sector in this region. The fact that forms for joint implementation had not been finalised at this point was not seen as an obstacle to climate-related initiatives in the Baltic States and Eastern Europe. The pilot programme aimed to contribute to the development of methods for joint implementation according to the terms of the Climate Convention.

The programme is financed from the Government Budget. In the period to 1998, a total of SKr 330 million (about US$ 40 million) had been allocated to the programme.

So, what were the results of 1991 Energy Policy Programme?

A new Parliamentary Commission was appointed in 1994 to prepare for the next phase and took as its starting point assessments and evaluations of the 1991 programme.

Unfortunately, the evaluation of the programme did not show very positive overall results. In particular, the results of the energy efficiency measures were rather poor. A number of bio-fuel based CHP-plants had been constructed, but few of them were in operation because of their high relative costs compared to traditional plants. For wind power plants, there was a positive ongoing trend of decreasing production costs, but for solar heating, there was no sign of rationalisation and technological development. It was obvious from the results that the programme would have to be changed before coming to an end in 1998.

The Commission presented a number of possible measures for future actions, but could not agree on which of them to favour. The Commission recommended further detailed analyses. However, the Commission stated that the reorganisation of the energy system towards sustainability should take place over a sufficiently long period to fulfil the objectives of the 1991 energy policy agreement.

The Commission considered that a number of conflicts of objectives remained unresolved – the climate issue, problems for employment, welfare and competitiveness if all nuclear power generation should be phased out by 2010. A final year for taking the last nuclear reactor out of service should not be specified. In other words, the generation and use of nuclear power could continue beyond 2010.

However, the Commission also considered it important to start the phasing-out process at an early stage and stated that one nuclear power reactor could be closed down without noticeably affecting the power balance.

The report from the Energy Commission was published in December 1995. Shortly afterwards, the Government initiated deliberations between the political parties aimed at formulating the foundations on which to base sustainable long-term energy policy decisions. Three of the parties left the deliberations before their conclusion on 4 February 1997. The result was an agreement between the

Social Democrats, the Centre Party and the Left Party, the main content of which was:

- The 1991 energy policy guidelines should be maintained.

- No final year should be set for the closure of the last nuclear reactor.

- The two nuclear reactors at Barsebäck should be closed:
  - The first reactor before 1 July 1998.
  - The second reactor before 1 July 2001 – if the electricity production loss could be compensated by new production and a decrease in electricity consumption.

- A 5-year programme should be initiated which would consist of measures for reducing the use of electricity heating in buildings and for connecting buildings to district heating systems as well as investment support to new electricity production from renewable energy sources.

- An extensive 7-year programme of investment consisting of over SKr 5 billion (€40 billion) should be initiated for research into, and technological development and demonstration of, new technology aimed at reducing costs for energy efficiency measures and production costs for new electricity generation.

The agreement and the programme were approved by Parliament. Parliament also passed a new Act on the Phasing-out of Nuclear Power authorising the Government to decide on the closure of nuclear power plants according to the provisions of the Act. This act was applied for the first time in February 1998, when the Government formally decided that the reactor Barsebäck 1 should be taken out of service from 1 July 1998.

Sydkraft AB, the owner of Barsebäck, appealed against this decision to the Supreme Administrative Court invoking both national and EC law for a claim that the decision was unlawful. The court decided in May 1998 that the closure of the reactor should not take place before the court had settled the case.

So far, the following has taken place:

For the nuclear plants:

- In June 1999, the Supreme Administrative Court arrived at the conclusion that the Government decision of February 1998 was legal and that the first reactor should be closed no later than 30 November 1999.

- A negotiation process on the level of financial compensation is currently taking place between the owners of the Barsebäck plant and the state.

- Sydkraft has also complained to the European Commission, contending that the Government decision violates EC law, mainly by distorting competition in the Swedish electricity market. The European Commission has so far made no decision regarding the complaint.

- On 6 October, Sydkraft appealed to the Stockholm District Court to set aside the Government decision to close Barsebäck 1 until the EU Commission has tried the competition case.

For the 1997 Energy Policy Programme:

- An evaluation of the results of the first year has shown that the results will probably not be sufficient to compensate for the electricity loss from the Barsebäck power plant. However, it is evident that the programme is going to achieve some positive results.

- Even with substantial subsidies, the costs of connecting single family houses to district heating systems or converting from electric heating to other fuels are still too high to interest households in such investments.

- Interest in investing in high cost new electricity production capacity is low, mainly due to the low electricity prices and the forecast price levels and demand for electricity.

Electricity Market Reform

Finally, here are some conclusions on the effects of the electricity market reform on the restructuring of the energy system.

The reform came into force on 1 January 1996. The experiences have mainly been positive. Prices have fallen rapidly, especially on the wholesale market and for large consumers. The initial process was designed to be rather slow, since Sweden has had a system where an advanced metering system was required for access to the market. The cost for such metering imposed a certain inertia on the market. On the other hand local grid companies had to buy electricity from small-scale electricity production, such as wind or hydroelectric power.

Now this initial period is over. From 1 November 1999, all actors on the market are free to buy electricity without constraints from whichever supplier they choose. It is proposed that a tax be imposed on electricity transmission to finance a transitional support to small-scale electricity production.

Electricity prices in general have fallen substantially and during the autumn of 1999, prices for household consumers have fallen drastically. The price trend is projected to be very positive for consumers and prices are expected to fall for small consumers as well as large. Since there was a substantial over capacity in the Nordic market when the reform started, the low prices combined with the promotion of trade have made the 1997 Energy Policy Programme less attractive than expected.

The electricity market reform and the increased inter-Nordic electricity trade will of course contribute to security of supply after the closure of Barsebäck. This is especially important for us in Sweden during years with cold winters and very dry and warm summers. Normally, our hydro power plants supply some 63 TWh, but the difference between a "wet year" and a "dry year" may amount to 25 TWh. The ability to trade with other production systems is essential in such situations.

But of course, the most important matter is that there is a real production capacity behind the trade options. What happens if the Danish climate programme really results in the closure of a substantial proportion of their coal-fired electricity production? In the last few years, unprofitable production capacity amounting to some 5-6 TWh has been closed in the Nordic region. About half of this capacity was Swedish fossil reserve capacity that could not compete with imported coal based electricity production because of relatively high costs due to Swedish taxation and environmental regulations.

Since the production costs for new capacity from renewable energy sources are so high, the first choice, especially for countries with electricity production from coal and oil, is natural gas. For Sweden, with an almost fossil-free electricity sector, the building of new gas-fired capacity would lead to an increase in CO_2 emissions. On the other hand, increased import would cause increased emissions in other countries.

But for the climate impact, the place where emissions are generated is irrelevant. Nevertheless, the Barsebäck reactor is to be closed before the end of November this year.

NUCLEAR POWER DEVELOPMENT IN JAPAN

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Energy Situation in Japan

The degree of energy self-sufficiency in Japan which 50 years ago was around 80%, had declined to 10% in 1973, while the oil demand increased dramatically during the high economic growth period of the 1950-1960s. Oil crises that occurred in the 1970s did substantial damage to the Japanese economy and proved that Japan's energy supply-demand structure was vulnerable to supply disruption. Since then, Japan has made efforts to improve energy efficiency as well as to promote energy diversification. Owing to such efforts, the degree of self-sufficiency in Japan has increased to 20% which still is the lowest among OECD countries. In particular, oil is 99.7% dependent on imports, more than 80% of which comes from the Middle East. Therefore, the energy supply-demand structure in Japan remains much weaker than that of other OECD countries.

In 1997, the composition of the total primary energy supply (TPES) in Japan was oil 52.7%, coal 16.8%, nuclear 16.1% and natural gas 10.7%. Many people erroneously think that the share of nuclear in TPES is substantially higher in Japan than in other countries; however, it should be noted that this share is smaller, though only slightly, than in OECD Europe. On the other hand, the share of natural gas in power generation in Japan is 20.5%, which is higher than that of OECD Europe (12.4%) and OECD North America (12.5%), though the share in TPES in Japan is lower than the OECD average.

Significance of Nuclear Power from the Energy Policy Perspective

The fundamentals of Japanese energy policy can be summarised as the 3Es: energy security, economic growth and environmental protection, which are to be accomplished simultaneously and in a balanced manner. Nuclear power has a significant role to play in achieving each of the 3Es as follows.

Energy Security

As for nuclear power, a stable supply of uranium fuel can be expected, in spite of dependence on import from abroad. Moreover, nuclear power plants need less fuel than do fossil fuel fired plants. For example, to operate a 1 GW plant for one year, an oil-fuelled power plant needs 1.4 million tonnes of oil, while a nuclear power plant needs only 30 tonnes of enriched uranium and can operate more than one year without refuelling. For this reason, nuclear power, as a semi-domestic energy, is increasingly important for ensuring energy security.

Economic growth

It is very important to reduce energy costs in achieving sustainable economic development. Nuclear power is sometimes said to be unfavourable in costs; however, it, in fact, has some advantages in comparison to thermal power generation. As nuclear power is capital-intensive, the power generation cost is less affected by the fuel cost. Therefore, nuclear power can realise low cost with high capacity utilisation factor. In the longer term, after depreciation is finished, much lower cost operation than thermal power generation is possible. In this way, nuclear power can be labelled as “technology fuelled” power generation and is a valuable energy source for coping with long-term energy issues.

Environmental protection

Energy use is closely related to environmental problems and, in particular, fossil fuels have substantial influence, such as global warming and acid rain. Therefore, increasing energy efficiency, reducing consumption of fossil energy and increasing less carbon intensive energy such as nuclear power and renewables (including hydropower) are essential. In the case of Japan, the employment of nuclear power, together with the development of renewables and increase of energy efficiency (energy conservation) has substantial advantages in decreasing CO_2 emissions, in the long term.

How Japan has promoted nuclear power

During the 1960s and 70s, many countries introduced nuclear power as a promising energy source to meet their increasing energy demand. This was accelerated by the two oil crises of the 1970s. However, since the 1979 Three-Mile Island and the 1986 Chernobyl accidents, concerns have been raised about the safety of nuclear power and reliance on nuclear power itself. Generally speaking, concerns about nuclear power can be summarised as the following three points. (1) safety of nuclear power and public acceptance, (2) economics of nuclear power and (3) waste disposal.

Not only because of these points but also because of the availability of alternative energy sources, some countries slowed the pace of development or took negative decisions on nuclear power employment. For Japan, however, there is no usable alternative energy to fill the breach, should nuclear power be discarded as an option. Of course, renewable energy is expected to increase as a domestic and environmentally friendly energy source in Japan. However, even if the introduction of such energy were to be promoted to the maximum extent, one could not expect a contribution equal to that of nuclear power. In fact, the introduction target of renewable energy in 2010 is 19.1 Mtoe, which would not amount to more than 3% of Japan’s total energy supply.

Accordingly, nuclear power is indispensable for ensuring energy supply in Japan and at the same time a major option for meeting the Kyoto target. Continued efforts have been and are being made for promoting nuclear power in Japan by both government and electric companies.

Safety of Nuclear Power and Public Acceptance

In a public-opinion poll conducted by the government in February this year, 70% of respondents expressed the view that nuclear power should be “increased” or “maintained at current levels”. At the same time, 70% of them expressed concern over the safety of nuclear power generation.

In order to gain public acceptance for the development of nuclear power, it is essential to decrease the number of incidents and to accumulate a history of safe operation. The number of unscheduled shutdowns in Japan is the lowest in the world and the average capacity utilisation factor of nuclear plants is steadily increasing. The capacity utilisation factor of nuclear power plants, which was only some 40% during the 1970s because of many technical troubles, has stayed at more than 70% since 1983 and recently has been more than 80%. These are the results of the safety-culture initiatives that put the priority on this factor.

Maintaining transparency in information related to nuclear power is another prerequisite to gain public acceptance. Documents on authorisations issued by the government as well as information about incidents have been made public.

Economic development of areas surrounding nuclear power plants is also important to promote the construction of new plants. The central government, local governments and electric companies are co-operating on all measures for vitalising local communities.

Economics of nuclear power

The power generation cost of nuclear power in Japan is one of the lowest compared with other resources, even if one includes the cost of plant decommissioning and waste disposal. As the cost is less-dependent on fuel compared with fossil energy, nuclear power will provide long-term stability of generation cost and lower cost after the depreciation period.

Radioactive waste disposal and decommissioning

In order to promote the development of high level nuclear waste disposal, a report by the relevant advisory committee has been published recently. This report describes the responsibilities of the public and private sectors, the establishment of basic plans, the necessary funding scheme for the disposal and the establishment of a waste disposal implementation body.

The disposal of high level nuclear waste is a difficult task to pursue, but it is at least technologically possible. On the other hand, with regard to the CO_2 emitted by fossil fuels, no measures can be taken, once CO_2 is emitted.

The first commercial nuclear power reactor, which is the only gas-cooled reactor in Japan, was shut down in 1998 after 31 years and 8 months of operation, and its decommissioning is now under preparation.

The future of nuclear power

The Japanese government has been providing periodically (each 4-5 years) a long-term energy supply and demand outlook and the most recent revision was made in June 1998 after long deliberation in order to incorporate the results of the COP3 Meeting in Kyoto. This outlook, which is a guideline to the future energy policy, points out that the introduction of nuclear power should be promoted, in addition to the improvement of energy efficiency and the use of renewables. In 2010, nuclear power is expected to reach capacity of 66-70 GW and to provide 480 billion kWh of electricity with a (17% of TPES and 45% of electricity generated).

With regard to which energy source will be developed as the primary one, it is natural that the answer may differ from country to country. It is noteworthy that even the energy resource situation might be different in each country. For example, countries in OECD Europe or in OECD North America show rather diversified energy sources. In the same way, Japan, as a country with no international electricity and gas grids, has to achieve such diversification.

Fossil fuels are limited resources. It is said that the world population may reach more than 9.4 billion by 2050. This population increase and economic development will bring about a dramatic increase of energy demand in developing countries, especially in the Asian region. The world may run short of fossil fuels, in particular of oil. The protection of the global environment including the reduction of the CO_2 emissions, will be an important issue also.

It is opportune to consider how to provide the energy necessary for sustainable development at a global level. A power plant can operate for several decades, sometimes for more than 50 years, and energy policy requires long-term perspective on directions that should be pursued. At the same time, we should not forget to take measures on energy use at a time when the industrialised countries are consuming so profligately. Perhaps it is time to change our consciousness and consider an “energy diet”.

THE AUSTRIAN EXPERIENCE

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Austria's nuclear policy is determined by past experience and has been repeatedly confirmed, also by recent events. This policy aiming at promoting a phase-out of nuclear power comprises three strategic elements, namely risk reduction, co-operation with economies in transition in the energy sector and further development of international law. Referring to Austria's co-operation with economies in transition the main features of Austria's energy policy and Austria's experience in doing without nuclear power are presented.

What do the city of Gomel in Ukraine – some 120 km north-east of Chernobyl – and the city of Wels in Upper Austria – some 1 200 km from Chernobyl – have in common? Both areas show a total Caesium-137 deposition of more than 40 kbq/m². Indeed, Austria is certainly among those countries in Central Europe which were most affected by the Chernobyl disaster of 1986. We even find areas with a total Caesium-137 deposition of more than 100 kbq/m² and up to 185 kbq/m² in Austria The "Atlas of Caesium Deposition on Europe after the Chernobyl Accident" published by the European Commission in 1998 is a clear proof of the far ranging impacts of this accident.

The recent accident in Japan indicates that even highly industrialised societies may not be capable of managing nuclear power safely. And this may become worse: As has been repeatedly stressed by the present Director General of the IAEA, we need provisions to prevent the new imperative of competitiveness to deteriorate the safety of nuclear power[1].

Also, the limited effectiveness of existing non-proliferation regimes, as demonstrated for example by Iraq or the Peoples Republic of Korea reminds us that proliferation has not ceased to be a Siamese twin of nuclear power. The call for proliferation resistant – "safeguards friendly"[2] – nuclear power plants and fuel cycles by IAEA's Director General, as a condition *sine qua non* for nuclear power to have a future, points to the direction to go, but is far from what nuclear power has presently to offer.

As Austria is neither running nor intending to run a nuclear power plant nuclear power is primarily a matter of environmental concerns and concerns about health and safety impacts on Austria, with proliferation as an additional threat. This fact includes the notion of virtually no benefits at possibly high costs, at least for Austria. So while respecting national sovereignty and international law we feel entitled an obliged to voice our concerns. Consequently, Austria has made nuclear safety a priority issue of the enlargement process of the European Union and will continue to do so.

It may be recalled that already in 1978 the Austrian electorate decided in a referendum not to start the operation of the NPP Zwentendorf. After the catastrophic events in Chernobyl in 1986 and again following the increasing number of reports indicating a less than sufficient safety standard of nuclear power plants in Economies in Transition the opposition to and the concerns about nuclear power became deeply rooted in the Austrian population; at all levels of society.

This is one reason for the Austrian Government to promote a nuclear phase-out in general and to advocate a nuclear power free Central Europe in particular.

The second reason is the concept of sustainable development. In addressing the IAEA General Conference in 1997 Federal Chancellor Viktor Klima stated:

"I do not consider nuclear power as compatible with the concept of sustainable development. In my view, reliance on nuclear power can therefore not be a viable option to combat the greenhouse effect. I have to add, that this position is shared by all the political parties represented in the Austrian Parliament. Sustainable development, if fully applied to the energy sector, would require substantial increases in energy efficiency and energy saving as well as a switch to renewable sources of energy with the ultimate goal of meeting the demand for energy services by customers in the industrial world and in developing countries alike."[3]

Consequently the Austrian Government pursues a three fold strategy:

1. Activities to reduce the potential risks from nuclear installations close to or in the vicinity of the Austrian borders. In this context a constant exchange of adequate and timely information which is one of the key features of a number of bilateral "Nuclear Information Agreements" is of great relevance to Austria.

2. High priority is also given to the co-operation in the energy sector with Economies in Transition. In the spirit of good neighbourhood Austria has offered comprehensive co-operation to a number of countries aiming at increasing energy efficiency as well as developing new sources of energy using environmentally sound technologies. Encouraging progress has been achieved in setting up appropriate mechanisms and defining collaborative projects of mutual interest. In doing so the Austrian Government also contributes to creating the necessary preconditions for a phase-out of nuclear power programmes.

3. Austria welcomes the fact that the international community more and more subscribes to the notion that due the enormous potential risks nuclear installations – among others – are not exclusively a matter of national sovereignty but that countries which might be affected have a legitimate interest in these installations. To put it in the words of the Director General of the IAEA: “Nuclear Safety is a national responsibility but a global concern”.[4] Consequently Austria is in favour of applying the highest standards of design and operational safety as well as establishing a strong and independent regulatory framework and practice. Austria is thus playing an active role in the development and improvement of pertinent instruments of international law.

As mentioned, co-operation in the energy sector with economies in transition, is one of the major elements of Austria’s nuclear policy. In this context its legitimate to ask what kind of experience has Austria to offer in “going non-nuclear”; in doing well without nuclear power? Why does Austria feel comfortable when offering co-operation to and with neighbouring countries, aiming at creating trust in non-nuclear alternatives to the present nuclear paradigm, which is a heritage of the one-dimensional energy policy of the former centrally planned economies?

I start with the observation that it has been taken for granted that economic and social prosperity invariably goes with increasing demand for energy. This common wisdom has been challenged in the seventies and eighties, when the so-called “decoupling” of economic growth and energy demand was observed in market economies, as a result of the expectation that oil will continue to be a scarce and expensive commodity. This development made it clear that increasing demand for energy services (such as mobility, warm homes, process heat, motor power etc.) has always been met by a mix of additional use of primary energy resources and by the reduction of the energy intensity of goods and services.

In the past, these two sources for economic growth made a comparable contribution, i.e. about half of the additional demand for energy services was met by additional energy resources (almost exclusively fossil), the other half by exploiting energy efficiency potentials. If the sum of these two contributions during the 1970-1995 period is taken to be 100%, then nuclear energy makes a marginal contribution of about 3% (in primary energy equivalents, IEA accounting, or 2% WEC accounting) to meet the demand for additional energy services.

There is a second lesson to be learned from the various scenario studies about future energy demand, such as those by IEA, the World Energy Council (WEC/IIASA), the European Commission and others.[5] The analysis of these "possible futures", which all assume the same economic and population growth, tells us that the range within which the development of total energy consumption varies, as a result of demand-side or supply-side oriented energy policies, is an order of magnitude larger than the most optimistic estimate of a nuclear or renewable energy contribution on the supply side.

But already by the time of the Austrian decision to abandon nuclear power, there were clear indications that demand-side policy is what matters. To give just one example, I would like to recall a publication by the International Institute for Applied Systems Analysis based in Laxenburg, Austria, near Vienna, called "Assessment of Alternative Energy/Environment Futures for Austria: 1977-2015" by Foell and others. Although published as late as October 1979, the main results of this assessment have been presented in a workshop already in June 1977, that is before the referendum. The main finding is that the amount of additional fossil fuel is mainly determined by the extent to which total energy demand is allowed to grow, with nuclear energy appearing as an indicator of the supply-side bias of the underlying energy strategy.

This fundamental theory has been validated by reality: As a result of the oil price shock, the decrease of the energy intensity of the Austrian economy has been increased, from the traditional 0.6% per annum (up to 1972), to almost 2%. Not surprisingly, the recent decay of energy prices and the expected stability of this situation brought this figure back to roughly 1%.[6] This effect is also observable in other countries of the European Union which chose not to stabilise real prices by e.g. means of taxes.[7] This reduction of energy intensity happened as a result of technical progress and, in the seventies and eighties, also as a result of dedicated policies.

All this puts the nuclear option in an unconventional, but policy relevant perspective. It led and leads Austria to conclude that the main policy option is not to choose among various supply-side options, thus varying the mix between the dominant fossil contribution and additional sources such as nuclear or renewable. The real policy decision is to what extent the energy intensity is made the target of energy policy.

Consequently the first element of the Austrian energy strategy is focusing on an increase in energy efficiency or, in other words, on the decrease of the energy intensity of the production of goods and services in the various sectors of the Austrian economy. It can be frankly admitted that efficiency oriented energy policy is not a simple modification of traditional policy patterns, but a major redirection. It implies a totally new field of policy fields and activities, dealing with different and more numerous actors, and using very different policy instruments and approaches

The second element of the Austrian energy strategy complies with the concept of sustainable development by focusing on renewable sources of energy when dealing with supply-side options. This reflects the consensual policy to exploit Austria’s natural resources such as hydro and biomass. As an evolution from the first decades after World War II, the focus now is on increasing the technical and managerial efficiency of existing hydro installations, rather than on the construction of new ones, and on the use of biomass in an environmentally friendly way. Recently, triggered by a new element in the Austrian legislation requiring 3% of the electricity to be generated by “new renewable” sources, electric power from wind, landfill gas, straw and other hitherto unexploited resources is gaining importance.

With these two main strategic elements the Austrian Government pursues four energy policy objectives namely:

- Security of energy supply, including diversification of imports.
- Cost effective energy supply.
- Environmentally sound energy supply and minimising resource depletion.
- Social acceptability of the energy system.

It should be noted that Austria has a federal structure where the main responsibilities in the energy sector rest with the provinces (Länder). So from an external point of view consistency of various energy policies on provincial and federal level sometimes might look less than optimal. Nevertheless several indicators show that Austria’s energy policy has been quite successful.

Energy consumption per unit GNP is well below OECD average (0.15 toe per US$ 1 000 in 1996 – at 1990 prices and exchange rates – as compared to the 0.26 toe average).[8]

Also with respect to CO_2 emissions – be it per capita or per unit GNP – Austria is well below OECD average in 1996:

	Austria	EU	OECD
Tonne per US$ 1000	0.35	0.45	0.63
Tonne per capita	7.68	8.77	11.14

The share of renewable sources of energy in Austria's total energy supply amounts to some 25% with Austria ranking third among IEA Member States.[9] It should be noted that the EU-average is as low as 5%.[10]

Annual expenditures for renewable sources of energy in Austria amount to 29.7 €/capita, being second only to Denmark with 35.9 €/capita and substantially above the average of 8.3 €/capita in the European Union.[11]

We are fully aware, that market liberalisation and declining energy prices – in real terms – as well as the obligations of the Kyoto protocol are posing major new challenges. Nevertheless, we are confident that – keeping in mind that demand-side strategies make most of the difference – we will master these challenges as we have done in the past, and that Austria can provide a wealth of examples for "best practice" in the fields of energy efficiency and the use of renewable sources of energy.

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AFTER-DINNER SPEECH

by Mr. Dominique Maillard

FRENCH NUCLEAR INDUSTRY POLICY AND LATEST GOVERNMENTAL DECISIONS

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Due to the limited resources of energy and fossil fuels in France, energy policy has been guided by the following three main objectives and orientations : long-term energy supply security, sustainable development which incorporates protection of the environment, and increased energy competitiveness.

In the wake of the first oil shock, France introduced an **energy policy** aimed at **strengthening the long-term security of its supplies**. A massive programme of electro-nuclear development, energy saving, renewable energies and diversification of external supplies was initiated.

Today, thanks to a major investment effort of approximately FF800 billion in the nuclear power sector, France has a standardised network of 57 reactors with an installed power of 61.5 GWe. This network accounted for 76% of national electricity production in 1998. A 1450 MWe "N4 series" reactor will be commissioned in 1999.

This ambitious programme has substantially increased the security of French supplies, multiplying domestic power production by 2.5, and raising the energy independence ratio from 22% in 1973 to nearly 50% today (48.9% in 1998).

The nuclear electricity industry has also made a major contribution **to the protection of the environment**, as it does not produce greenhouse gases, acid gas pollution, or dust.

In energy savings, the effort may be, in real terms, a little less significant, nevertheless it provides also the equivalent of 35 Mtoe/year of savings as compared to the previous trend.

Emissions of nitrogen oxides and sulphur have fallen by more than 60% over the past twenty years in France, thanks mainly to nuclear power. Similarly, CO_2 emissions are down by more than 20% in volume, and by a factor of 9 per kWh produced. Sixty percent of this positive trend is attributable to nuclear power, with the remainder being due to energy conservation.

France now has one of the lowest levels of CO_2 emissions among OECD countries. However, nuclear and hydroelectric production have reached capacity, and our margins for manoeuvre are becoming more restricted. Under the European Union's commitments made at the Kyoto Summit, France needs to stabilise CO_2 emissions by 2008-2012. To achieve this goal, we now need to focus on transportation, which accounts for the majority of France's oil requirements. Electric heating and new renewable energy sources also require attention.

The third orientation of French energy policy is to increase energy **competitiveness,** and, at the same time, comply with the public service mission to guarantee the notion of an essential service.

In conformity with the European directives that provide for the opening up of domestic electricity and gas markets, France will be opening up its network monopolies, Electricité de France and Gaz de France, to outside competition.

Despite the progress that has already been made, the potential benefits of nuclear power will only be realised if the challenges currently facing the industry are met.

The major challenges are:

- Completing the downstream cycle, and especially solving the problem of waste management.

- Implementing more transparent control and expert appraisal procedures to ensure nuclear safety and protection against radiation.

- Preserving our nuclear skills and competitiveness after 2010, when the oldest nuclear plants in France should be renewed.

Public acceptance of nuclear power depends on appropriate responses to these issues.

Handling of spent fuel and nuclear wastes

France's policy regarding the back-end of the nuclear fuel cycle is based on two fundamental aspects: the choice of the reprocessing-recycling of the spent fuels and the current elaboration of a long-life radioactive wastes management strategy in accordance with the 1991 Act voted by the French parliament.

First of all, France opted for the **reprocessing-recycling** approach and is equipped with the required industrial capacity. The reprocessing plants in The Hague are in operation. The Melox plant produces MOX fuel with recycled nuclear elements coming from the reprocessing of spent fuel unloaded from domestic and foreign nuclear power plants.

To date, use of this fuel has been authorised for use in twenty 900 MWe reactors in France.

Secondly, the Act of December 30, 1991, which **covers the management of highly radioactive long-life waste**, instituted three separate avenues of research to be conducted over the next 15 years, so that the French Parliament can come to an appropriate decision in 2006 based on the findings of these research programmes.

With regard to the first area of research **– the partitioning and transmutation of long life elements –** although, as you know, the French Government decided to stop the fast neutron reactor Superphénix., research in this area will continue with the Phénix reactor, and through international co-operation.

Although there are no plans to use the fast neutron technology to generate electricity in the immediate future, owing to the low cost of uranium and of energy in general, fast neutron reactors may prove to be of interest in the long term. Therefore, France intends to maintain research in this area, especially through international co-operation.

With regard to the second area of research to **test geological disposal of nuclear wastes**, in December 1998, the French Government decided to build two types of laboratories. One is in clay, and is located in the department of Meuse in the east France, and the other will be constructed in granite, as soon as a suitable location has been found.

ANDRA, the French National Radioactive Waste Management Agency is in charge of the project management of this research.

As for the third area of research **– long-term storage and associated conditioning** – the Government has asked the Commissariat à l'Énergie Atomique to strengthen its effort, and has ordered an in-depth study of subsurface long-term interim storage.

Transparency of safety regulation and information

The future of the nuclear industry depends on ensuring the independence and transparency of safety regulation and providing open access to information.

To date, the overall nuclear safety policy for all civil nuclear sites is entrusted to the Nuclear Regulatory Directorate (DSIN), which is under the authority of the Ministers of Environment and Economy, Finance and Industry.

The French Government has decided to modify the nuclear safety organisation and a bill will be presented within a few months to the Parliament.

The Government also considers it particularly important to increase the means for monitoring and regulation of radioprotection. Attention will be focused on radioprotection because workers and surrounding populations health are a major public concern. The resources of the Office for Protection against Ionising Radiation (OPRI, Office de Protection contre les Rayons Ionisants), will be increased to enhance its scientific and medical capabilities.

Local information commissions are already established near nuclear sites. Representatives of nuclear facilities, local authorities, trade unions, conservationist associations and public authorities sit on these commissions whose role will be reinforced.

These measures will allow citizens to be thoroughly informed and therefore facilitate public acceptance of nuclear energy.

Need for competitiveness in the electro-nuclear industry

Although current supply meets demand, and no further orders for reactors will be needed in France before 2010, it would be irresponsible not to prepare for the future. We expect our energy options to remain open between now and 2010, and nuclear power will play a role in meeting the imperatives of competitiveness with respect to the environment.

This was highlighted in a comparative study of electricity production costs associated with various energy sources in 1997, which was conducted by the General Directorate for Energy and Raw Materials.

This study confirmed the strong competitiveness of nuclear power in France as a means of base load generation.

I would like to point out that the costs considered in this study comprised all nuclear-related costs, including upstream research and development, and dismantling and waste disposal costs.

But, maintaining competitiveness in the electro-nuclear sector means developing ever more efficient facilities in order to keep pace with the increasing competitiveness of other energy sources, especially gas.

Consequently, in 1989 French and German industry leaders decided to pool their know-how and experience to design the reactor of the future, the EPR (European pressurised water reactor).

This new generation of reactors should meet three objectives. Firstly, they will increase safety, secondly, they will maintain the competitiveness of the nuclear energy sector by increasing the availability and working life of facilities; and thirdly, they will have a positive impact on the environment by reducing the amount of emissions and waste produced, and by increasing fuel recycling capacity.

So far no decision has been taken on this programme, but the aim of the French government is to go on with a scientific and democratic debate on nuclear. It is too early for me to give you information about the modalities and the schedule of this debate.

Conclusion

To sum up then, the French Government has confirmed the continuation of the nuclear power option as an essential component of French energy policy in the interests of energy self-sufficiency and environmental concerns. It has also reaffirmed its desire to promote open access to information about energy options.

The Government is also ready to work actively and seriously on diversifying France's electricity supply. Great attention will be paid to European and international developments in energy choices in order to meet our international commitments to fight the greenhouse effect.

Session 3

NUCLEAR POWER POLICY IMPLICATIONS OF BUSINESS AS USUAL: COUNTRY VIEWS

Chairman:

Mr. Mikko Kara
Research Director, Technical Research Centre of Finland

INFRASTRUCTURE NEEDS FOR NUCLEAR POWER

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Introduction

Nuclear power is a significant component of electricity systems world-wide and in OECD countries as a whole, it accounts for about one fourth of the electricity supply. Questions arise as to whether special measures are needed to ensure that the nuclear option will be available when wanted, and if so, who should take these measures. These questions have been put on the agenda because there are concerns that in the future the nuclear option will not be as flexibly available as governments might wish given the stagnation in orders for new nuclear power plants in many OECD Member countries.

The stagnation in orders has led to adverse effects in many sectors of the nuclear infrastructure. Nuclear industries are finding it difficult to keep appropriate supporting production facilities, business organisations and, more importantly, qualified human resources. Research institutes are losing financial support for facilities and there is also some reduced willingness among students to follow educational paths that lead to careers in the nuclear field.

The NEA is contributing to monitoring the infrastructure status with some studies completed in the last several years[1-4] and with others that are currently in progress. The distinctive characteristics of the nuclear power industry were outlined in a paper[5] presented at the 1996 NEA workshop on the "Infrastructure for Nuclear Energy Deployment". These characteristics result from the introduction of:

- Legal requirements with which the manufacturer of nuclear systems must comply, including safety regulations and obligations regarding the quality of products.

- Special rules for the design and construction of components.
- A "quality system" for design and construction which was a forerunner of a system type now commonly used in other industrial sectors; this system was first introduced in the early 1970s.

The requirements and rules under which nuclear power operates are enormous compared to other industries. This results in a unique situation that requires maintaining a minimum supporting infrastructure.

This paper provides at first an attempt to define what can be considered as "structure" and "infrastructure" and then a review of relevant issues related to industrial and governmental supporting infrastructure. In particular, the manpower availability and educational implications are examined.

Structure and Infrastructure

Although it is difficult to define boundaries within the general structure of nuclear energy activities, elements can be placed in one of the following categories:

Structure or core nuclear activities. These correspond to the essential nuclear activities. The structure includes the nuclear power plants, together with the organisations that operate them, including those that mine uranium and provide the fuel, that manage the waste products and that ensure compliance with safety and radiation protection regulations. This is the structure that the "infrastructure" is there to support.

Infrastructure of nuclear activities. These are the areas surrounding the nuclear core activities. The boundaries between the nuclear structure and infrastructure depend upon how important the activities are for nuclear power generation. Criteria for the setting of boundaries are yet to be universally determined; nevertheless, infrastructure activities could be defined as those activities which are necessary for supporting and maintaining the core parts of nuclear activities, and which cannot be expected to be supplied by general industrial, educational or research and development programmes. Facilities for nuclear research, such as research reactors, accelerators and hot-cells, can be considered important elements of the nuclear infrastructure. Governments' regulatory activities are, in this concept, examples of infrastructure which consist of expertise and experience on nuclear safety as well as country-specific nature of regulations. The training of operators and engineers, which could be provided by companies' in-house system, is a subset of infrastructure for industrial activities and power plant operation. Sub-contractors for larger manufactures or equipment as part of a nuclear support system could also be seen as a subset of infrastructure.

Peripheral areas of nuclear activities. These are areas which support the nuclear activities specified in the two categories above. This type of support can be obtained elsewhere in general industrial and public activities irrespective of the existence of nuclear power. Financing and general administrative management are examples of this category. Engineering and consulting activities are necessary expertise for construction and manufacturing of nuclear plants, but much of them may be obtained from other industrial activities in similar areas such as large chemical plants and fossil fuel power plants. The general education programme for engineering is also in this peripheral area.

Industrial supporting infrastructure

In addition to the general characteristics that were previously outlined, the nuclear industry has many other distinctive features which set it apart as a unique sector requiring quite original types of skills and manufacturing facilities. For instance, the operating environment of pressurised water reactor systems and the levels of pressure they must withstand have made it necessary to develop components unlike any other in terms of their size, weight, constituent materials and the type of non-destructive testing they must undergo.

The staff working in design engineering departments, workshops and the construction sites need to be highly specialised and their skills need to be maintained through major training and certification programmes.

Testing the operation of many different components under normal or accident conditions in accordance with stringent specifications entails developing and implementing major qualification programmes in terms of both experimental development and the problems which the design of such components poses. For instance, the electrical components such as meters, sensors, electrical cables, and electrical motors for safety systems are all designed and qualified to operate under conditions, particularly accident conditions, which are only found in nuclear power plants.

A special effort is needed to maintain a limited volume of production by nuclear related firms, given the massive qualification programmes required in order to develop such components. Maintenance activities alone are not enough to generate a sufficient order book for firms. These firms can make a significant contribution, however, to helping preserve the skills and quality levels needed for nuclear engineering activities. Long-term commitment to service suppliers can provide stable employment and encourage investment in skill-enhancement programmes, production plant, tools, and research and innovation in general.

The importance of the experience that is gained by the component suppliers while servicing operating power plants was stressed in a paper presented by Siemens at the 1996 NEA Workshop on Infrastructure.[6] The paper outlined the specific problems faced in the manufacturing of new components and in particular the importance of quality assurance aspects.

In general, the costs of maintaining a quality assurance system in engineering can be considered moderate. This is especially true as the advantages of such a quality assurance system are effective also for non-nuclear components without having an unacceptable impact on the costs of such components. On the other hand, maintaining quality assurance systems for the design and manufacture of nuclear components may be costly. In manufacture, in addition to the proof of adherence to a quality assurance system, the qualification of personnel, manufacturing equipment and fabrication processes have to be demonstrated at very short intervals.

An increasing number of manufacturers have therefore decided not to maintain their qualifications for the manufacture of nuclear components because of the absence of new power plant projects and the resulting declining need for components. The fact that, at workshops with nuclear and conventional quality assurance systems, the manufacturing costs of conventional components are affected by the presence of a nuclear quality assurance system may be a factor that leads to a decision to abandon the nuclear quality assurance systems.

In the late seventies, when the majority of the power plants operating today were being constructed or planned, there were in Western Europe twelve manufacturers of heavy components such as reactor pressure vessels, steam generators, pressurisers or core internals. Four of these manufacturers were located in Germany. In 1996 there were only three manufacturers left in Western Europe, none of them in Germany. Also in the late seventies, there were six forges in Western Europe, three of them in Germany, providing heavy forgings. In 1996 in Western Europe only two of them could provide forgings for heavy nuclear components.

Governmental supporting infrastructure

In addition to an adequate industrial infrastructure, nuclear programmes need the support of governmental infrastructure. This is a major component of the nuclear infrastructure and a subject of great interest to governments. The government support is particularly important in the areas of research and development and regulation.

In the past, governments have played an indispensable role in the development of the nuclear technology and in the performance of fundamental research. In several countries, the public sector still owns and operates research facilities such as research reactors, accelerators and hot-cells. Although the overall impact of deregulation and privatisation of the electricity markets on nuclear power is yet to be defined, a further reduction in state and government R&D is expected. Maintaining government research activities may be particularly important in the areas of safety, waste management and efficiency.

With respect to nuclear regulatory activities, the role of governments cannot be diminished even under shrinking nuclear programmes. Governments are committed to define and maintain standards, guidelines and criteria in relation to the handling of radioactive material and the operation of nuclear power plants. Even if fully competitive markets evolve in countries and all over the world, governments will have to maintain regulatory bodies to ensure the safe operation of nuclear reactors and the proper handling of waste.

Manpower availability and educational implications

The 1993 NEA report on "Qualified Manpower for the Nuclear Industry",[1] contains relevant information in different countries and in selected nuclear sectors including: front-end, back-end nuclear power plant operation, manufacturing, construction, R&D, education and regulation. The report identified several characteristics specific to nuclear manpower, namely that: engineers are the dominant figure in the distribution of total qualified manpower; the ratio of engineers (with respect to other professionals) working in nuclear power plant operation and in engineering, manufacturing and construction is higher than that in other sectors; and also that the ratio of scientists in R&D and education is higher than in any other sector.

The age distribution in the different sectors and countries was also investigated and in general, a top-heavy age group distribution was seen in each sector of each country. Particularly, in the US higher ratios were indicated in the "over 60 years" age group for education, and in the "over 50 years of age" groups for engineering, manufacturing and construction.

In relation to education, the NEA has initiated a study[7] aiming to assess some important aspects. The study includes a survey of about 120 educational institutions in 16 countries. Information is sought about nuclear programmes, numbers of students, number and age structures of teaching staff, status of the experimental facilities, occupational distribution of students and recent changes in nuclear related courses.

Preliminary data on universities show as a main concern that only a few new faculties are offering nuclear programmes. When many of the experienced professors have retired, the expectation is that there will be a significant drop in the number of faculties. The inevitable outcome will be a reduction in the number and choice of courses which in turn will dramatically affect the quantity and quality of graduates.

Conclusions

Maintaining the nuclear infrastructure is a concern in a number of Member countries. The perception is that the nuclear option needs to be maintained in the long-term for several reasons including future electricity demand and environmental and security concerns.

Many countries, for instance, were going to close down parts of their nuclear infrastructure because they assumed that other countries would maintain theirs, but the impression is that what is left is inadequate. Certainly maintaining nuclear infrastructure can be costly but it is possible to reduce the cost by sharing facilities such as those supported by governments. However, doing so requires that infrastructure needs for all countries be identified, those needs that are to be met by governments be determined, and then a mechanism for intergovernmental co-ordination to maintain this infrastructure be established.

A similar approach can be followed in sharing infrastructure for other applications that are not in nuclear energy, but which might relate to it. A good illustration is the use of test reactors for more general research and development of materials. The radioisotope business that supports a number of reactors and hot cells is another example.

In summary, the current stagnation in nuclear orders and the expectation of diminishing nuclear programmes in several countries are factors affecting the world industrial and governmental supporting infrastructures for nuclear power. Therefore, policy makers may need to consider the aspects of the infrastructure that would need to be maintained, and the specific knowledge, know-how and framework that need to be retained. The sharing of knowledge, experience and research facilities is a way for the industry and governments to maintain the infrastructure while reducing its cost.

It is important to recognise the role that international organisations can play by facilitating the sharing of knowledge and by fostering initiatives for the multinational use of facilities that would help to maintain the nuclear infrastructure at an adequate level.

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WORLD-WIDE COOPERATION IN NUCLEAR POWER: A CANADIAN PERSPECTIVE

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Canada's perspective on world-wide co-operation in nuclear power is based on more than 50 years of experience in full fuel cycle nuclear activities and on its role as a leading nuclear exporter of power reactors and related materials and technology.

This paper will briefly review the international market for nuclear power reactors with emphasis on the nature and implications of market trends in nuclear power programme development. Generally speaking, OECD countries will be focusing their efforts on plant refurbishment and life extension while non-OECD countries will be facing capacity expansion needs. Countries with mature nuclear programmes face different needs than those at the beginning of nuclear programmes. However, there are important technological synergies making it logical and mutually beneficial to enhance collaboration in the nuclear field between OECD and developing countries.

The development of nuclear power programmes in non-OECD countries and the transfer of technology to these countries provide a unique opportunity to address on a global scale nuclear matters which are truly global in nature and require enhanced co-operative efforts. While much can be done on a bilateral as well as commercial basis, much can also be accomplished on a multilateral basis, especially on issues that transcend national boundaries. Key areas for enhanced co-operation are: nuclear technology, nuclear safety/regulation, waste management, non-proliferation and economics/financing.

Many of the new, advanced power reactor designs will be built in the non-OECD countries; the need to have the highest safety standards will continue to be a priority for OECD and non-OECD countries; over and above instruments such as the Nuclear Safety Convention which set forth common practices and codes of conduct in the safety area, further linkages/information exchanges among regulators need to be enhanced; joint international sponsorship of research, development, demonstration and deployment also make considerable sense; technical and information exchange on matters relating to nuclear fuel waste management would be particularly helpful; economics and financing continue to be a challenge for both developed and developing countries.

We have long witnessed the benefits of multilateral co-operative technical and information exchange programmes spearheaded by the NEA, the IEA and the IAEA. This paper will explore ways and means to improve international linkages through an array of suggestions.

REGULATORY CONTROL, NUCLEAR SAFETY REGULATION AND WASTE MANAGEMENT IN SPAIN

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Good morning ladies and gentlemen.

I am the only safety regulator speaking to you at this meeting. Nuclear energy may or may not be a significant contributor to meet future energy demands, but as long as it is or will continue to be a reality it has to operate with adequate and acceptable levels of safety.

A changing and challenging scenario

Maturity of nuclear safety regulation is nowadays a broadly accepted idea. Basic fundamentals are clearly established and an overall regulatory structure can be perceived. But when closely observing reality one can appreciate a changing and challenging environment that nuclear regulation is facing and will continue to face.

The absence of new orders or the stagnant market, in most countries, for domestic nuclear power development represents only part of the present energy scenario. Other features of this scenario would include, most importantly, deregulation of the electricity industry to provide increased value to the kWh user by enhancing the role of the market forces. This fact is imposing severe changes in nuclear power economics and forcing nuclear power to compete with other sources of electricity supply, generating pressure to minimise the cost of production. In parallel, a pressure is perceived for regulatory effectiveness, primarily since the cost of regulation is a component of the cost of the product. Within OECD countries there is a pressure to reduce the cost and increase the effectiveness of public administration. Evolution of risk perception and socio-economic environment are causing public acceptance to change, and growing environmental concerns put pressure on regulation, while new policies tend to allow stakeholders to play larger roles in the licensing and control activities. The trend for globalisation is also affecting nuclear operations in different ways

The regulatory process

The objective of nuclear regulation is to define adequate levels of safety and assure their achievement. In practice regulation has proven to be a dynamic process, an active and alive process in which analysis, decisions, implementation, experience gathering and feed back take a key role. Pressure for optimisation affects the potentially different approaches of the regulatory process.

The regulatory process is responding to the changing challenges posed by the evolving scenarios and it becomes convenient to consider holistic approaches to assure the overall effectiveness of regulation at any time.

Nuclear regulatory dynamics in Spain

The regulatory authority of Spain (Nuclear Safety Council, CSN) is facing these challenges. The Nuclear Act (15/1980) establishing CSN defines the responsibilities that are assigned to the regulatory authority. Basic responsibilities remain constant but challenges have been changing over time, from the construction phase of the nuclear programme, to the initial operation of the different plants and to today's mature phase.

The present Council, whose membership is renewed every six years, decided back in 1995 to perform an analysis of regulatory challenges as perceived in Spain, and produced a Strategic Guidelines Document (POE) for the period 1995-2000. This document, updated in 1998, emphasises those aspects considered as relevant, to provide the Council with adequate information for decision processes in the yearly programmes of work, thereby facilitating the CSN to meet its established responsibilities.

The POE pointed out the need to improve the set of regulations or regulatory pyramid, the regulatory process and the inspection system. It identified goals to improve the operating licenses system, the need to further develop capabilities and applications of probabilistic risk assessment, improvements in severe accident policies and operating experience analysis, plant life management, decommissioning and dismantling. It emphasised the need to face the nuclear fuel cycle challenges including waste. It also identified challenges and gave some indications related to radioactive installations, radiological protection and the need to improve emergency preparedness. The document also highlighted the need for more efficient research and development programmes and also identified challenges to improve management and information processes.

Experience shows that a strategic analysis of the short term (i.e. five years) challenges and trends, providing guideline and objectives to be complementarily developed in the yearly programmes of work, is a good procedure to gain in effectiveness for safety. A similar practice has also been followed by the licensees and both parties had informed each other on the results of their respective analysis and plans. In this way regulation can be made more predictable and there will be gains in safety level, safety culture and regulatory effectiveness.

On present nuclear regulatory challenges

There is today, in my view, whatever the circumstances are, an international trend to gain effectiveness in regulatory control, through systematic strategic analysis, formulation and implementation. Within the NEA framework, I have to make reference to the Strategic Plan for the Agency recently approved by the Steering Committee, and also I would like to refer for a more detailed view on regulation, to the document "Future Nuclear Regulatory Challenges" issued by the Committee on Nuclear Regulatory Activities of the Agency.

The following is an enunciation of regulatory concerns and challenges to the nuclear regulators as contemplated in this document:

- Technical issues: Plant ageing; plant backfitting and requests for plant life extension; maximising output from existing reactors; and decommissioning plants.
- Socio-economic issues: Economic deregulation of the electricity market; privatisation of national companies, mergers between utilities and restructuring of the electricity supply industries; and risk-informed/performance based regulation.
- Organisational, management and human issues: Regulatory effectiveness; licensee responsibility; operator response and self-assessment; maintaining expertise; and the interface between regulatory authorities and the public.
- International issues: Development of co-operation between safety authorities; and co-operation with, and assistance to, safety authorities in countries where regulatory organisations need to be strengthened.

- And perhaps the most relevant: the management, storage and disposal of high-level radioactive waste and spent fuel, or more generally the closure of the fuel cycle, are prerequisites to the general acceptance of the continued and future use of nuclear power.

I think that two years after their formulation, they still maintain their freshness.

How these exercises for strategy setting and updating are performed may vary. My opinion is that they are necessary to conduct regulatory tasks on more systematic and rigorous bases. We are starting to see how different regulators and international organisations pay attention to this methodology and consider it necessary to better meet their functions. In my view also, we will see much improvement in the future in the use of methodologies and tools for strategy setting and planning.

Plant life management

Let me now share with you some views of plant operational safety. Nuclear operators are challenged to generate more value out of the existing plants and will try to take action on every element they have on hand. Essentially they will try to improve operating performance, life management and enhance the value of their assets. This will imply actions like refuelling outage time reductions, manpower cost reductions, longer operating cycles, improvements in fuel efficiency and reliability, scram reductions, implementation of programmes for reactor materials protection, programmes for plant modernisation and power up-rates.

Combining all those efforts certainly will offer a more effective and productive source of electricity, but it is the task of the nuclear regulator to assure that the level of safety of the plant and the safety culture of the organisation is not reduced, but increased in this process.

When nuclear operations are conducted with an adequate level of innovative and quality management it goes without saying that efficiency, economy and safety are not conflicting objectives. Nevertheless these challenges generate a considerable additional pressure on the regulatory system and on the regulator, that must be very well prepared to face them, in particular for all the scientific and technical knowledge involved.

One of the aspects mentioned is life management, and I would like to offer some key features in regulating this aspect in Spain:

- If the level of nuclear safety is adequate, the specific life span of a nuclear facility is not a nuclear regulator's matter, it is rather an economical, business or policy matter.
- The level of nuclear safety of any plant looking for an extension of its operating licence is formally considered through a periodic safety review evaluation that includes the analysis of operational experience, probabilistic safety assessment up to level 2, and analysis of compliance to applicable codes and standards.
- Closure of a facility should be preceded by the satisfactory evaluation of a closure plan including spent fuel disposal and a dismantling plan.
- A proposed new Regulation for Nuclear Installations (RINR) is expected to be approved soon and develops new specific provisions to deal with the administrative aspects of closure and dismantling.
- The safety evaluation leads the regulator to gain knowledge on the behaviour or ageing materials, structures, systems and components. The role of research programmes becomes of paramount importance in this regard. In the case of Spain, international co-operation in this aspect is relevant.

Waste management

The main guidelines related to waste management in Spain could be delineated as follows:

- The institutional and regulatory framework is well in place. In particular Royal Decree 1522/1984 established ENRESA as the public Agency for waste management. ENRESA is compelled to seek government approval of the National Radioactive Waste General Plan and its associated annual revision. Financial provisions to support implementation of the plan are also in place.
- Intermediate- and low-level wastes are conditioned at the nuclear plants and finally disposed of at El Cabril facility.
- Very low-level wastes may be cleared after demonstrating that the associated radiological risk is trivial. Waste from milling are disposed of in situ.

- ENRESA is also in charge of decommissioning Vandellós I. This gas-cooled reactor is being dismantled now. ENRESA took over site authority after government and regulatory approval in February 1998 and began activities under its responsibility thereafter. ENRESA is expected to finish present level II activities by 2003.
- Spent fuel is being stored at each plant. Considerable extension of spent fuel pools capacity by reracking has been carried out. In the case of Trillo I where capacity will be saturated in 2003, the Government has approved last July 31 the possibility for outdoors storage at site in dry dual-purpose casks.

Among the regulatory developments that have taken place, it is worth mentioning that the Senate (High Chamber of Spanish Parliament) established in 1996 an Inquiry Commission "to study the problem of radioactive waste". This Inquiry Commission has finished its activity in 1999. The main conclusion confirms the present short and medium term policy and the need to continue the involvement in the international activities regarding direct disposal and research activities to this end. The Inquiry Commission recommends to increase research and development and follow up activities facing other alternatives to deep disposal in particular separation and transmutation.

Then, spent fuel storage is not expected to pose any special problem for the immediate future. Nevertheless, Spain must remain active in the research aspects of direct disposal and other alternative of handling the fuel cycle back end along with its international collaboration in the safety and regulatory aspects of long-term management, not risking the timetable available. As a good example Spain will continue favouring initiatives like the joint seminar on long-term safety, held in Córdoba back in January 1997.

In regards to the Joint Convention on Spent Fuel and Nuclear Waste, Spain after having actively participated in promoting and drafting the legal instrument, signed and ratified the Convention last May.

International co-operation

It is a well accepted fact that public safety, as the highest value on which to base nuclear operations, has been achieved and reinforced through a complex set of bilateral and multilateral relations both at the industry and regulatory levels. Three Mile Island reinforced the significance of international co-operation. Chernobyl clearly demonstrated the international and world-wide implications of safety. Today's trends toward electricity market deregulation, globalisation and stagnation in new plant construction, are facts that clearly contribute to reinforcing international links.

In today's world, the global village concept is affecting almost every aspect of human activity: any subject arising at any point in the world becomes very rapidly a global issue and creates a need for government response, in particular to the most developed countries. Nuclear safety is no exception.

Much progress is being achieved through the implementation of the Nuclear Safety Convention, and the Joint Convention on Spent Fuel and Nuclear Waste will likewise be the legally binding instrument in its field. The peer review process is a remarkable feature contributing to enhance the level of nuclear safety.

With regard to CSN, we fully share and support the importance of international co-operation. We have been active basically in the IAEA, NEA and EU and we support and continue to programmes relating to East Europe within these international organisations.

The Assistance Programmes to improve the safety of soviet designed reactors is a major undertaking that have consumed significant resources within multilateral and bilateral frames. The evolution of the assistance programmes to transfer of Western practices is an ongoing process that should evolve further towards greater co-operation and interchange.

In general, I hope we can share the idea that the activity of international institutions is evolving as a function of new realities. This transformation is necessary to better serve the purpose of these institutions. We have recently seen consistent efforts to increase effectiveness at IAEA and at the OECD/NEA.

Likewise, in the sphere of international co-operation, CSN considers the importance of maintaining and developing bilateral agreements, particularly with the regulatory bodies of the countries where the technology of our plants originates.

Our role in the Western European Nuclear Regulators Association (WENRA), in the International Nuclear Regulators Association (INRA) and in the Ibero American Regulatory Agencies completes our sphere of active international co-operation.

Final words

I hope to have offered some sort of snapshot of what is going on at this moment in the field of nuclear regulation in my country. In summary I would like to underline the following ideas:

- Regulation is a mature activity, it remains aware of changes in the scenario and strives for continuing to provide adequate responses to emerging challenges.

- Nuclear safety is a global concept and as our most important value, it makes international co-operation a paramount contributor to address and solve regulatory challenges.

In the case of Spain, behind nuclear regulation there is a good team of knowledgeable, able and motivated specialists and professionals to maintain an efficient system to achieve acceptable levels of nuclear safety.

Session 4

IMPLICATIONS OF BUSINESS AS USUAL: INDUSTRY VIEWS

Chairman:

Mr. Georges Cornet
Director General, Belgonucléaire

EDF'S NUCLEAR STRATEGY:
NEW MARKETS AND SKILLED PLAYERS

Mr. Hervé Machenaud
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Today, the success story in generating electricity seems to be gas combined-cycle power plants. I would first like to demonstrate that nuclear energy is still a success story for EDF, and will continue to be so for a long time. Then, we will discuss the future economic and ecological trends, and point out some positive aspects for nuclear energy. New markets need skilled players, and EDF has harnessed its expertise to its industrial and commercial approach.

Existing French nuclear power plants are very competitive, it will prove true when opening the European market

French nuclear power is very competitive today. In fact, it has already been paid off: capital costs, 2/3 of which currently are depreciated, now account for only 28% of generation costs. Capital costs will continue to fall and will be reduced to about half of present levels by the year 2005. The resulting enhanced competitiveness will allow EDF to face heavy erosion of electricity prices for several years, by offering prices which are nearing mere fuel and operation costs. The installed capacity margins, the diversified structure of EDF's generating capacity, a constant and drastic effort to reduce operating costs and the use of trading on the European market, provide additional possibilities.

If electricity prices go down, nuclear power generation with its stable costs will go up

To continue to earn money in a period when profits are subjected to price erosion, one has to sell as much as the European market and the transmission capacities allow. This possibility is open to EDF, since the company has a slight excess in generating capacities.

To maintain profitability in a period of price erosion, an operator may use different tools: cost reduction, MWh output adjustment, generation adaptation to market conditions and power plant lifetime extension. Of course, the broader the choice of tools for an operator, the more profitable are the opportunities

With a generating capacity which is 80% nuclear, topped up with 13% hydroelectric, EDF is able to sell electricity at a stable price for long periods. Nuclear power plants in France are able to follow the load. They are already a set of energy “reservoirs”. The European electricity market will allow EDF to extend its “reservoirs” management policy and fine tune through trading.

This means generation programming and outage scheduling must be constantly adapted to the opportunities foreseeable in the medium-term on the market. If, for some part of the European network, EDF is able to forecast an exceptional need in energy within three months’ time, EDF must then get ready to supply, and at a good price, because of this exceptional situation. On the other hand, when electricity is less expensive in the surrounding pools (for example the English pool), or when our neighbours produce surpluses at a low price (for example, high output of hydro-electricity in Switzerland or Spain), there is less call on nuclear power in France and this opportunity is seized for an optimised fuel management programme.

Our nuclear power plants can keep on producing for a further twenty-five-year period. As long as maintenance costs do not become too high, each year of lifetime extension gained for a 900 MW unit should save around □80 million per year on the financial costs resulting from a new investment. This fact highlights the stakes for technical upkeep and safety, as well as the importance of public acceptance of nuclear power.

Moreover, as shown by all the international comparisons, the availability of nuclear power plant is improving, It is therefore possible for EDF to do even better than today, and generate more electricity, at lower cost.

Reducing fuel and operating costs

In ten years’ time, when the capital costs will have been paid off, the cost of generating nuclear power will mainly be made up of operating and fuel expenses. Today, these costs are very competitive, still, they can and will drop.

We still have room for improvement in these two fields, and we will seize all opportunities.

In the fuel field, by taking action upstream (purchasing, optimising the inventory management, improving the management of the fuel cycle, increasing the burn-up of nuclear fuel) and downstream (reprocessing), costs will decrease.

In terms of operating costs, logistics and routine maintenance expenditures are also the objects of ambitious planned cost reduction programmes.

Finally, the evolution of the European market provides a real opportunity for EDF. By adapting our methods and management, we aim to renew the momentum for evolution in our nuclear power plants. A sophisticated and "all-is-always-planned" technology like nuclear energy needs the inputs and implications of personnel in the field, their ideas and proposals. There are also some added-value possibilities, as recent evolutions in some US nuclear power plants have shown.

The "nuclear" kWh is carbon-free and its costs include all waste treatment

EDF's price structure for the nuclear kWh covers future costs: decommissioning is covered by the 15% provision included in plant construction costs, and the back end of the fuel cycle is taken care of through reprocessing and storage costs. This is not the case for gas- and coal-fired power stations: in a sustainable development perspective, we should take into account the fact that CO_2 has a 142-year lifetime, and that there is no technology today that can guarantee its capture and storage.

EDF is dedicating considerable effort to limit and process nuclear waste, and to prepare the decommissioning of its facilities. As a result, the average volume of short-life, low- or medium-level radioactive waste has been halved in ten years; emissions from nuclear power plants are constantly decreasing and are by far below the increasingly stringent limits. As far as decommissioning issues are concerned, the dismantling of the Chinon A3 nuclear island (Loire area) is well underway, and that of Brennilis, in Brittany, is making smooth progress. It is a question of responsibility: solving the problem of waste, and planning and dealing with the issue of decommissioning are aspects of generation which are closely linked to the continuation of nuclear power plant operation.

As far as the environment is concerned, nuclear power has advantages but also drawbacks, the most important of which – in the eyes of the public – is waste management. EDF assumes the responsibility and bears the entire financial expense for the disposal of nuclear wastes. It actively participates in research provided for in the December 1991 Act, which decides that three possible ways for disposal of nuclear wastes shall be explored for a choice in the year 2006. In this regard, the decision by the French government, taken in July this year, about the underground laboratory in the Meuse area of France has been a very positive step.

We all know that radioactivity is a natural phenomenon. The radioactive sources used in medicine and industry (for example, in the food industry and in non-destructive gamma testing) will always need safe storage. The principles of preservation and prudence lead us to design adequate solutions.

The nuclear waste issue seems to me a rather subjective issue: it tends to disappear suddenly from political debates when it comes to ending a nuclear programme, yet it rises to become the most important problem for the sake of future generations, when debate rages over new nuclear investments.

Gas and nuclear: trends for the future

The success with gas-fired power stations results mainly from a drop in the delivery price of natural gas triggered by the discovery of major gas fields and the subsequent progress in exploiting them. Prices have dropped by half, over the past ten years. Technological progress (efficiency improvements) and industrial progress (a drop in investment costs) have further accelerated the downward trend of natural gas power generation cost. For future plants, gas combined-cycle plants are now as competitive as nuclear power units. The question is “For how long?” Two obvious factors have to be taken into account:

The development of gas combined-cycle plants is not without limits.

The multiplication of combined cycle power plants would require huge infrastructure investment: Liquefied natural gas terminals, port installations, pipelines, compressors.

Had we to replace the French nuclear power plants by gas combined-cycle plants, the existing gas infrastructure would need to be tripled! These investments would of course contribute towards a rise in gas delivery prices.

On the contrary, even though nuclear energy represents a large capital investment, variable costs (essentially fuel) represent only a third of its cost per kWh and are little affected by price fluctuations in raw materials or foreign currencies, since uranium itself represents only 5% of the total production cost of the kWh.

Gas combined-cycle technology is the opposite: investment and operating costs are low. It is an easy bet to newcomers. But risks lie ahead: with prevailing gas prices, the fuel cost accounts for around two-thirds of the overall generation cost. Hence, there is considerable uncertainty, after a lapse of ten years, or perhaps less, according to certain scenarios. And these turbine are designed to last 25 years.

Today, risks taken have to be paid for, or to be covered by financial instruments. To be able to offer long-term fixed prices, operators of gas-fired plants have, therefore, to take and cover significant profit margin risks.

What remains at stake is to assess the proportion of risk which is linked to the different kinds of energy, and what customers will be willing to pay for this.

Carbon emission permit markets would further enhance nuclear energy

The greenhouse gas effect on global warming having been confirmed by observations during recent years, something will have to be done, and the sooner, the better. The turning point will be, without any doubt, the ratification of the Kyoto agreements by the United States.

Today, 93% of French power is generated with nuclear and hydroelectric energy. These generation technologies release neither carbon dioxide, sulphur dioxide, nor nitrogen oxides.

This means that the French economy benefits from the second lowest carbon-intensity (kilogrammes of CO_2 per GDP using purchasing power parities) after Switzerland of all developed countries.

In fact, fossil-based energy is held responsible for the greenhouse gas effect. International opinion is becoming aware of it and developed countries are committed to limit CO_2 emissions.

Nuclear power is CO_2 free. In order to fulfil their commitments to limit CO_2 emissions European countries will no longer be able to play extensively the "gas card".

At this stage, a new market will appear: carbon emission permits.

The Massachussets Institute of Technology (MIT) has estimated emission permit prices as high as US$ 125 per tonne of carbon, if the market were limited to the developed countries involved in the Kyoto agreements, and as low as US$ 25 per tonne of carbon, for a world-wide market.

Economic projections show that, if these permits reach □50 per tonne of carbon, natural gas will no longer be economically competitive with nuclear and possibly wind power. Inevitably, nuclear energy will then have even more added value in the eyes of investors.

The emergence of an international market for carbon emissions permits, involving the developing countries, should facilitate and secure financial flows for efficient and environmentally friendly investments in the energy sector. With no carbon emission permits market, respecting their commitments would cost US$ 34 billion to Japan, US$ 30 billion to Europe, and US$ 38 billion to the United States. With the carbon emission permits market open to the developed countries listed in the Kyoto protocol, the costs would be respectively US$ 15 billion for Japan, US$ 23 billion for Europe, and US$ 35 billion for the United States

Some economic projections show that, with a price of US$ 166 per tonne attained for the carbon emission permits, the additional cost for gas would be 2 US cents/kWh, and for coal 5 US cents/kWh.

My opinion is that, starting from the emergence of a market for carbon emission permits, nuclear energy will then be the “market’s darling” within the following 5 years.

Future design of nuclear power plants

EDF’s industrial strategy is to use a mix of competitive energy options, including gas combined cycle, with a significant portion of nuclear power used for base-load generation.

As regard to the three Es: Energy Security, Economic Efficiency and Environmental Sustainability considered by the International Energy Agency (IEA), French nuclear power has been and will surely be a long-lasting success. Therefore, the nuclear option must be kept open for the future. It is up to EDF to sustain this profitable option for the future by building on the experience and skills already gained. This includes technical expertise and, as competition develops, cost minimisation both during present and future plant construction and operation, while strictly adhering to the ISO 14001 programme for better processes in the environment.

In 2020, a cost-competitive nuclear power plant design will have to be commercially available in order to replace the existing nuclear power plants, it should last until 2060-2070. Such a period of time implies, from the engineers’ point of view, that this new generation of nuclear power plant will have to take into account, in addition to further enhanced safety and availability features, the experience and knowledge we now have about equipment ageing, waste processing and storage.

In this perspective, taking advantage of the momentum of the nuclear industry in the development of new nuclear designs, Framatome, Siemens and EDF, associated with five German utilities, put forward the evolutionary design of the European Pressurised Reactor (EPR), a synthesis of the best features of the N4 and Konvoy series.

Moreover, in such a changing market as described above, any generation technology industry needs an industrial reference for the future, one that operates and is not just a "paper project". Investing in the EPR is therefore a logical move for EDF.

The driving force of a high-tech industry is not the mere market, but profitable technical innovation. This has proved true for gas turbines recently, and will be true for renewable energies, combustion cells, and nuclear energy. The dramatic progress of EDF's N4 series, especially computer-aided operation using sophisticated computer data bases including operating procedures and operating feedback would not have been accomplished otherwise.

Nowadays, countries willing and able to invest in nuclear energy are rather scarce: China, France, Finland, South Korea and Japan. As very few countries have a power system big enough to make their national nuclear industry benefit from series effect. Instead, most nuclear power plants are based upon individual turnkey contracts with domestic equipment vendors. Figures from the most-recent new reactors put on the grid show that EDF investment in a new series is between half and two thirds the investment needed on a turn key basis for Kashiwazaki Kariwa (Advanced Boiling Water Reactor) and Sizewell B (PWR, including computerised control room). We all have seen these last years vendors suddenly and strongly advising Chinese experts and officials to build a fully standardised programme. This consensus is based upon EDF's facts and figures.

Nuclear operators are now aware that they need to exchange their information on operation and maintenance, and share progress fuelled by experience. EDF has the equivalent of 800 reactor-years of experience. The resulting mass of data is reaped and processed through EDF's integrated engineering system, and allows a true industrial policy to be established for the new competition framework. The experience gained about the efficiency of design choices and competition between different equipment suppliers, allow EDF to identify margin possibilities, and in turn, to reduce sharply the price of nuclear equipment.

Through Daya Bay, and now Ling Ao, China has understood and taken full benefit from all these advantages. The PWR nuclear power plants built there have access to EDF's operating feedback and spare parts logistics. This is important, because the nuclear power plants now operating are no longer the plants that were built in the past: our 900 MWe series have evolved greatly, thanks to nuclear engineering services and to comply with lifetime extension programmes. Every year, China Guangdong Nuclear Power Company knows about the modifications that are planned to improve our plants.

The results of the Daya Bay nuclear power plant speak for themselves: today, Guangdong Nuclear Power Company has reimbursed half of its debt.

Mergers and acquisitions, already started in the United States, will drive nuclear generation towards a global market, based on the nuclear power plant standardisation approach. Still, design differences put a stringent limit on this approach. From this point of view, our own standardisation culture leads us to a very prudent and selective attitude. Anyway, this trend of mergers and acquisitions fostered by the United States move towards competition will likely result in the emergence of a few actors big enough to meet the financial critical mass and operating and designing experience for a cost competitive and successful nuclear standardised programme.

Conclusion

French nuclear power has a bright future ahead, as a major contributor to the limitation of CO_2 emissions in the European Union, and as a cheap way of balancing the electricity supply. Of course, this future could be called into question if public no longer trusted us. This means we need to be stringent on the issues of safety, radiological protection of workers and maintenance.

EDF will follow the debate raised by the French government on nuclear energy, through an attitude of openness and constant exchange of viewpoints, in order to give an objectively elaborated and clear answers to the questions raised by our industrial activities, and their future.

EDF wants to answer these questions not only in technical, economic and scientific terms, but also by taking into account people's specific concerns, their expectations and their opinions. Citizens and customers should see a consistency in high standards between our ecological, technological, and commercial activities. It is only on this condition that EDF, and nuclear energy, can keep the confidence they have earned in France.

IMPLICATIONS FOR PROVIDERS OF NUCLEAR POWER PLANTS, MATERIALS AND SERVICES

Mr. Derek May
Executive Director of Corporate Strategy, British Nuclear Fuels plc,
United Kingdom

Introduction

The BNFL Group, following its acquisition of Westinghouse, participates in most areas of the nuclear industry including reactor design and services, enrichment, fabrication of both uranium oxide and MOX fuel, reprocessing and spent fuel management, transport, waste management and decommissioning and engineering services. In addition BNFL generates 8% of the UK's electricity with it Magnox reactors.

BNFL does not agree with the IEA business-as-usual scenario showing a decline in the share of electricity generated by nuclear power over the next 20 years. Indeed the IEA itself expects that the future for world energy will be quite different from that described in the business-as-usual scenario, not least because of governmental action in developed countries to reduce greenhouse gas emissions. BNFL believe that lifetime extensions and continued new build will help maintain or even increase the share of electricity generated by nuclear power.

However, for this conference it is worthwhile considering the impact the IEA business-as-usual scenario could have. Companies providing services in the nuclear industry need to assess the implications of both a continued reduced level of reactor construction over the next few years and the likelihood of resurgence in the longer term.

The impact on reactor design programmes

A slow-down in international reactor construction will obviously have a significant impact on reactor design programmes. New reactor designs are reaching the market at a time when that market is contracting. Historically, reactor vendors could rely on their domestic reactor build programme to provide a captive market for reactor orders. Now that is no longer the case, apart possibly from Japan and to a lesser extent Korea.

It is in the reactor design sector where the first signs of consolidation and co-operation have taken place. Framatome and Siemens are developing the European Pressurised Water reactor (EPR) through their NPI venture. The EPR could be ready for deployment in a few years. However, the probability of large-scale deployment in France or Germany in the near future is judged by many commentators to be slim, if for no other reason than the fact that the existing nuclear reactors in the two countries have, potentially, many years of operation ahead of them and there is no market demand for this type of capacity.

For this reason there are calls for a first of a series EPR to be built ahead of any market-driven requirement. This is a prudent strategy; skills can be maintained and developed within the organisation while the cost reduction exercises explored with a first of a series reactor can be carried out ahead of any eventual series build programme.

It is the same with an even more advanced and competitive new reactor design, namely the AP600 developed under Westinghouse's leadership and involving a contribution from over fifty companies in twenty countries.

Further consolidation and co-operation is likely if the market for new reactors does not pick up. A prolonged hiatus in reactor construction programmes could lead to the skills required for such programmes being lost from some companies. Collaboration between companies in Western Europe and the US, where reactor build programmes are static and companies in the Far East, where continued new build programmes are probable.

Opportunities from lifetime extension programmes

One reason why new nuclear build programmes have been reduced is because existing reactors are operating for longer and at higher performances than ever before. For example the output from all the nuclear reactors in the United Kingdom has increased by 50% since 1990, despite the fact that there has been almost no increase in total operating capacity. Elsewhere around the world reduced outage times and improved operating performances are helping to increase the competitiveness of existing reactors.

For the foreseeable future lifetime extension programmes could provide significant additional nuclear generation capacity. Projections for operating lifetimes of nuclear reactors have increased from 30-40 years to 60 years or even higher as operators seek to maximise the returns from the capital investment made in their plants.

As reactor lifetimes are extended new business opportunities will emerge. The market for upgrading nuclear control systems will increase as older stations are refitted with modern systems. Demand for refits of other systems will also increase, for example upgrades to steam turbines. This market for upgrading Western reactors is of course complementary to the market for upgrading reactors of Soviet design to Western standards.

Impact on supply side strategy and globalisation

For most of the sector of the nuclear industry involved in fuel supply the scaling down of reactor build programmes will have a minimal impact on strategic decisions in the medium term. This section of the industry is already adjusting to reduce significant over-capacity. Over the next twenty years significant consolidation is likely. This process of consolidation will also be driven by the increasing globalisation of the nuclear industry.

However, not all acquisitions necessitate extensive rationalisation. BNFL's acquisition of Westinghouse, a company with a renowned reputation for its expertise in reactor design and services, clearly demonstrates that some acquisitions can be driven by a desire to grow and diversify where it is strategically advantageous to expand a company's portfolio of services.

Liabilities, risks and the future of the industry

In contrast to popular perception nuclear liabilities are well managed within an industry that is still thriving and moving forwards, however some challenges remain for the industry to resolve. The final disposal of waste and treatment of military nuclear materials have not been fully addressed yet. Many of the technical issues are well resolved; the problem lies principally with implementing those solutions.

The issues of liabilities and waste disposal will be best dealt with within a nuclear industry that has a long-term global future. If the industry should fall into decline it will be hard to attract the best people into the industry to deal with the challenges ahead.

At present nuclear build has stagnated in Western Europe and the United States whilst it continues in the Far East and Eastern Europe. If this eventually leads to a regionalisation of the nuclear industry the impact on regulation and safety standards could be dramatic. Western Europe and the United States currently have a strong influence on the management of the global nuclear industry. However, if the nuclear industry declines in these areas the nuclear industries in Russia and in developing countries may seek to minimise the influence of the West on the future direction of the industry and the design and operating standards. Western governments would have to accept that their influence on the nuclear industry would be reduced if they fail to support their nuclear industries. If Chernobyl taught us nothing else it is that nuclear standards anywhere in the world are important to everyone.

Dealing with military materials

The civil nuclear industry offers a solution to dealing with the stocks of military highly enriched uranium and plutonium. The military materials can be used as fuel in reactors. This degrades the military material and provides electricity. However a reducing nuclear programme will drive fuel suppliers to simplified and standardised fuel supply systems in order to maximise the cost reductions necessary for economic survival. As a consequence there will be a reduced incentive to take on the potential complications of recycling military plutonium. There will also be a reduction in the financial return from introducing ex-weapons highly enriched uranium into the civil fuel cycle.

Any reduction in the use of military highly enriched uranium could have a significant negative impact on the ability of countries to deal with their military stockpiles. The enormous value locked up in the Russian ex-weapons highly enriched uranium (in excess of US$ 20 billion at today’s prices) could be a significant driver in both stimulating the Russian economy and ensuring sufficient resources to properly secure the redundant weapons stockpile

Conclusions

In the short term the IEA business-as-usual scenario’s prediction of a moderate decline in the share of electricity generated by nuclear power may well hold true. However, we are likely to see the beginnings of a resurgence of nuclear power within the relatively short 20-year period the scenario addresses.

The challenge for the nuclear industry is to adapt to the current low level of new reactor build and to move forward with the consolidation of the supply side of the industry to eliminate the present over-capacity.

At the same time it is important that companies in the nuclear retain the skills and expertise developed over the first 50 years of the industry and continue to attract new, high quality personnel.

THE CHANGING SCOPE OF NUCLEAR POWER R&D: A US PERSPECTIVE

Dr. Robin L. Jones, Vice President
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Abstract

Rate deregulation in the US electric power industry during the next few years will result in profound changes in the economics of power production. This paper examines the impact of these changes on existing and potential new nuclear power plants in the United States and discusses the implications with regard to nuclear R&D priorities.

Introduction and background

Nuclear power is an important element of today's electric power generation mix in the United States accounting for about 17% of installed capacity and about 20% of the electricity produced. Almost all of the nuclear plants currently operating in the United States were ordered in the 1970s. During this decade, rapid expansion of the new light water reactor (LWR) technology was fuelled by its potential for very low power production costs and supported by robust R&D programmes funded by the Government, the nuclear steam supply system vendors and, after 1973, by the nuclear operating companies through EPRI.

An abrupt change of direction occurred following the partial core melt event at Three Mile Island 2 in March 1979. Public acceptance plummeted and new regulations proliferated. Many plant orders were cancelled, and those plants that were completed experienced substantial overruns in both time and costs. Meanwhile, at the operating plants, production costs climbed steadily as their major efforts, and most of their R&D programmes were focused on resolving a seemingly endless list of safety and reliability issues.

By the end of the 1980s, a reasonable degree of regulatory stability had been restored and the nuclear operating companies were able to refocus their R&D programmes on the need to upgrade plant performance. During the 1990s, the results of this R&D have contributed significantly to a steady improvement in essentially all aspects of plant performance, accompanied by a progressive reduction in production costs.

Through the middle of the present decade, the electric utility industry in the United States remained a regulated monopoly. However, during the past few years the federal and state governments have begun to move towards "deregulation" (i.e., towards the introduction of competitive markets at both the wholesale and retail levels). This process is expected to be completed during the next few years which means that in the near future nuclear power will be in head-to-head competition with the other types of bulk power generation. The prospects for nuclear power winning this competition are very different for existing and new plants, as discussed below.

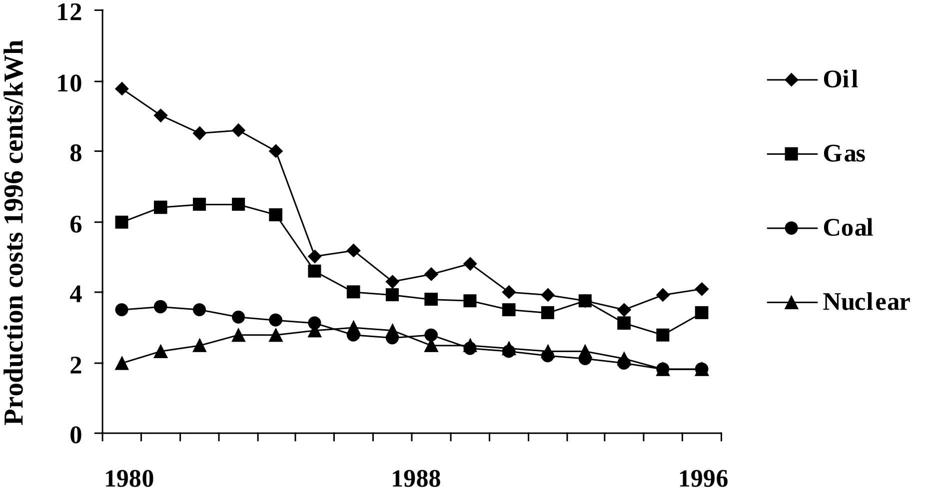
Existing nuclear plants

The future economic viability of existing nuclear plants will be determined by their ability to produce power at a cost below the wholesale market price. Early experience with power markets in the United States suggests that the market price relevant to baseload generators like nuclear plants will be in the 2-3 cents/kWh range. (Because nuclear plants are relatively inflexible with respect to shutdowns, startups, and load-following, the low end of this range probably is most relevant.) It also appears that sunk costs will not be a major consideration – provision for sunk cost recovery has been included in all state deregulation programmes to date. Thus, the winners in the competitive marketplace for baseload power in the United States will be those existing plants that can achieve total production costs (i.e., operations and maintenance plus fuel plus fixed costs associated with future capital investments) well below 2 cents/kWh.

Figure 1 shows the median variable production costs (operations and maintenance plus fuel) for US nuclear and fossil plants. Nuclear and coal plants have the lowest median costs at about 1.9 cents/kWh. The ranges for nuclear and coal plants are also similar – about 1.3-3.0 cents/kWh. However, nuclear plant costs are dominated by operations and maintenance whereas fuel costs dominate in the case of coal plants. In this situation, it should be no surprise that the R&D agenda of the nuclear operating companies emphasises the creation of opportunities to reduce operations and maintenance costs. A particularly important opportunity is associated with the shift in the US Nuclear Regulatory

Commission's regulatory framework towards a more risk-informed approach. This potentially allows the use of plant-specific risk insights to develop plant-specific maintenance programmes that simultaneously reduce costs and increase safety margins. Other important programmes aim to increase plant capacity factors by reducing forced outages, lengthening operating cycles, and shortening planned outages. Because overseas R&D needs are similar, many overseas operating companies are participating in some or all of the EPRI-managed programmes funded by the US operating companies. In addition, confirmatory R&D programmes are being conducted by the US Nuclear Regulatory Commission and their data are shared with industry when this is appropriate.

Figure 1. **Median power production costs for nuclear and fossil central station plants in the United States** (Source: NEI)



Operations and maintenance costs can also be reduced through economies of scale and this approach is being vigorously pursued in the United States via acquisitions, mergers and various forms of alliances. The outcome of these efforts is expected to be a much smaller number of US operating companies as a result of the disappearance of those operating companies that are licensed only for one unit at one site.

Turning to future capital costs, it is well known that many US nuclear plants will probably have to replace degraded major components (such as steam generators) during the next decade. This provides a strong incentive to extend the life of these plants so as to be able to amortise the capital costs over a longer period. The generic R&D required to support the US Nuclear Regulatory

Commission's process of extending the term of plant operating licenses from 40 to 60 years was completed last year, and the first two license renewal applications are currently being reviewed. It appears likely that some additional work will be required to streamline the application/review process and to develop more cost-effective aging-management programmes for the future. This is an area where public-private partnership programmes are under development between EPRI, the operating companies and the Department of Energy (see later).

The outlook for the existing nuclear plants in the United States appears quite positive overall. Although some plant closures may be inevitable, many plants are cost competitive now and most others are likely to be capable of becoming economically viable in the near term through performance improvements and operations and maintenance cost reduction measures (including mergers and acquisitions). In addition, many US plants are expected to pursue license renewal, in part as a means of minimising fixed costs associated with capitalisation of major component replacements. The US licensees are expected to continue to collaborate in pre-competitive R&D programmes aimed at the needs of their plants and extensive co-operation with overseas operating companies is expected, along with more limited co-operation with the US Nuclear Regulatory Commission and the Department of Energy.

New nuclear plants

In common with most other developed nations, the United States expects to add some new power generation capacity during the next decade in response to a slowly increasing demand coupled with retirements of existing plants as they become uneconomic. Both central station and distributed generation are expected to be needed.

In the new competitive market, it is very unlikely that any of these new central stations will be nuclear plants, at least in the near term. The reason why is illustrated in Table 1, which compares projected capital costs and busbar electricity production costs for several types of plants. In a competitive market, new orders will go to those plants for which the projected cost of electricity (which includes the fixed costs associated with capitalisation) is lowest. It is apparent in Table 1 that gas-fired combustion turbine combined-cycle (CTCC) plants should dominate new central station capacity because their low capital cost more than offsets the higher variable production cost evident in Figure 1. (It should be noted that the median numbers shown in Figure 1 are somewhat misleading in the case of gas plants because they do not reflect the substantially higher efficiencies now available in new plants.) As one would expect, all recent central station orders in the United States has been for gas-fired combustion turbine plants.

Table 1. **Projected costs of new capacity in the United States** (Source: EPRI)

Type of Plant	Est. Capital Cost (US$/kW)	Est. Busbar Cost of Electricity (¢/kWh)
Gas-Fired Combustion Turbine Combined-Cycle	450	3.0-3.5
Pulverised Coal	1050	3.5-4.0
Combined-Cycle Gasified Coal	1200	4.0-4.5
Advanced Light Water Reactor	1550	4.5-5.0

Obviously, the nuclear R&D agenda related to new plants needs to focus on capital cost reduction, and there are a number of opportunities for achieving significant improvements in the future. However, the nuclear operating companies are unlikely to fund such R&D at a significant level because their R&D priorities properly emphasise the needs of the existing plants. Thus, these programmes, and others related to nuclear concepts beyond advanced light water reactors, will have to be funded by the government, which also has the responsibility for managing the R&D related to several important institutional issues (such as nuclear waste disposal).

The public-private nuclear R&D partnership in the United States

To assure cost-effectiveness, it is important that the predominantly industry-funded R&D programmes related to existing plants be effectively co-ordinated with the predominantly government-funded R&D programmes related to future plants. Fortunately, this is not an entirely new situation, and there are previous programmes that provide models of how the needed public-private partnership can be created. For example, the Advanced Light Water Reactor (ALWR) Programme, which is ending this year, was an industry-wide effort to pave the way toward new nuclear plants by defining, and pre-certifying, standardised plant designs reflecting world-wide experience to date. This programme attracted participation by nuclear operating companies, vendors, regulators and government agencies from all over the world and established principles and processes for co-operation and co-ordination around which future programmes can be built.

Within the United States, the nuclear operating companies and the Department of Energy (DOE) have agreed to continue to co-ordinate their R&D programmes in a more-or-less formal fashion. Three programmes are involved:

- The licensees' collaborative programme managed by EPRI (EPRI Programme). Co-ordination is achieved by DOE participation in the industry advisory committees that guide the EPRI programme and through regular meetings between the DOE and EPRI staff.

- The DOE's Nuclear Energy Research Initiative Programme. EPRI is represented on the advisory committee for this programme, which focuses on longer-term, more exploratory R&D related to options for next-generation nuclear plants.

- The DOE's Nuclear Energy Plant Optimisation Programme. This programme is jointly planned and funded by DOE and industry (via EPRI) and focuses on the mid-term and long-term needs of existing plants.

Having the same DOE and EPRI staff involved in the management of all three programmes plus having some commonality in the makeup of the various advisory committees has resulted in a high degree of co-ordination. Going forward, it is planned to invite expanded international participation to ensure avoidance of unnecessary nuclear R&D duplication on a more global basis.

Summary and conclusions

Rate deregulation of the US electric power industry over the next few years will transform bulk power production from a regulated monopoly to a commodity-type business in which production costs will determine the economic viability of existing and new power plants. Performance improvements during the past decade have positioned existing nuclear plants to succeed in a competitive wholesale power market, and further improvements appear to be achievable through economies of scale and technological advances. Most of the pre-competitive R&D programmes needed to achieve these advances are likely to be funded collaboratively by the US nuclear operating companies. The expected outcomes are that most of the existing plants will prove to be economically viable and that many of them will extend their operating licenses as it becomes apparent that their economic life is longer than 40 years.

However, no new nuclear plants are likely to be built in the United States in the near future because their high capital costs make them non-competitive with gas-fired combustion turbine combined-cycle plants, which currently offer the lowest projected busbar cost of electricity among the new central station alternatives. There are opportunities to lower the construction costs of new light water reactors significantly. The R&D programmes needed to explore these opportunities (and others related to nuclear plant concepts beyond advanced light water reactors) are unlikely to be funded at more than a token level by the operators of the current nuclear plants. These programmes will have to funded mainly by the government, along with the programmes needed to resolve the important institutional issues for which they are responsible.

In the United States, the predominantly industry-funded R&D related to current plants and the predominantly government-funded R&D related to future plants is being co-ordinated through a "public-private partnership" involving, for example, the joint preparation of R&D plans in areas of potential overlap and jointly-funded R&D programmes in areas of common interest. In view of the commonality of needs and the scarcity of resources, co-ordination in nuclear R&D is expected to become increasingly global in scope in the future. The ALWR Programme exemplifies the type of co-operation that will be needed if nuclear power is to achieve its full potential in the new millennium.

Annex

AGENDA

14 October 1999

14:00-14:30	**Opening Welcome And Overview**

Meeting Chair: Mr. Nemesio Fernández Cuesta
Former Secretary of State for Energy, Spain

Welcome by Mr. Robert Priddle, Executive Director, International Energy Agency

Welcome by Mr. Luis Echávarri, Director General, Nuclear Energy Agency

Overview Presentation by Mr. Fernández Cuesta

- Definition of business-as-usual.
- Nuclear is part of the current energy mix.
- Wide range of views on the future of nuclear power.
- Several countries have prohibitions; others are actively expanding.
- If current policies remain unchanged, the role of nuclear power is going to diminish over the next 20 years.
- This meeting to talk about the policy implications of such a future. Both energy policy and nuclear/industrial policy will be affected.
- Summary of the programme.

1430 – 1700 **SESSION 1: BUSINESS AS USUAL SCENARIOS FOR OECD NUCLEAR POWER USE**

Session chair: Dr. Nigel Lucas, former Professor (Energy Policy), Imperial College, University of London

This session will address OECD-wide trends in nuclear power generation as discussed in the World Energy Outlook (WEO). The WEO's analysis will form an important basis for the discussion of "Business as Usual" (BAU). The second presentation will focus on how economics of electricity markets are expected to influence BAU outlook for nuclear. The final presentation will focus on environmental pressures affecting nuclear power in BAU and the longer-term resource use implications of alternatives to nuclear power.

Nuclear Power in the World Energy Outlook
Dr. Fatih Birol, Head, Economic Analysis Division, IEA

- A summary of WEO conclusions.
- Further elaboration on the assumptions pertaining to nuclear power (e.g., nuclear policies, comparative economics, greenhouse gas emissions control regimes).
- Implications of the nuclear power outlook on other electricity generation.

Nuclear Power in the Electricity Market
Dr. Peter Wilmer, Head, Nuclear Development Division, OECD/NEA

- Comparative economics.
- Regulatory change.
- External costs.
- Plant life management.

Nuclear Power and Environmental Policy
Dr. Jonathan Pershing, Head, Energy and Environment Division, IEA

- Environmental pressures affecting nuclear power directly.
- Role of climate change.
- Implications of reduction of nuclear power for emissions/resource use if replacement supply is fossil/renewable resources.

1930 – 2130 **After-Dinner Speech: French nuclear industry policy latest governmental decisions**

Dominique Maillard, Director General of Energy and Primary Materials, French Ministry of Economy, Finance, and Industry

15 October 1999

0830 – 1100 **SESSION 2: ENERGY POLICY IMPLICATIONS OF BUSINESS AS USUAL: COUNTRY VIEWS**

Session Chair: Mr. John Ferriter
former Deputy Executive Director, IEA

Speakers from IEA/NEA Member governments will discuss experiences and draw lessons on the energy policy implications of business as usual in a range of national policy contexts from countries who have phased out nuclear power, to those with an active phase-out policy but have yet to take action, those who appear to be adapting to a gradual decline in nuclear output or finally, those who are continuing with nuclear power construction programmes.

The German Debate on the Phasing Out of Nuclear Power

Dr. Walter Sandtner, Head of Division, Federal Ministry for Economics & Technology, Germany

- The current state of German policy on closure of plants.
- What would the financial, electricity price & environmental implications of early closure of power plants?
- What have been the effects on other German energy policy initiatives (renewables, energy conservation, market liberalisation)?

Policies and Events Affecting Nuclear Power Use and Investment in the USA

Mr. Kevin Kelly, Deputy Director, US Federal Energy Regulatory Commission, USA

- How are changes in the US electricity sector affecting nuclear power development and operations?
- How is the US government adapting its energy policies to account for a gradual decline in nuclear power production?

Phasing Out Nuclear Power – the Swedish Experience
Mrs Yvonne Fredriksson, Director General, Ministry of Industry, Employment and Communications, Sweden

- Evolution of the Swedish policy since the 1980 referendum.
- The constraints to policy implementation.
- Assessments of cost, feasibility, and environmental implications of replacement energy sources.
- How do liberalised markets and increased electricity trade affect the feasibility of the phase-out policy.

Nuclear Power Development in Japan
Dr. Masaaki Mishiro, Director, International Affairs Division, Ministry of Trade and Industry, Japan

- Energy policies supporting the continued development of nuclear power.
- Influence of different policies in other OECD countries on government policy in Japan.
- What is the role of Asia in maintaining and developing nuclear power?

The Austrian Experience
Mr. Andreas Molin, Director, Division of General Affairs of Nuclear Co-ordination, Federal Chancellery, Austria

- Austria's experience in doing without nuclear power
- Costs, financial and environmental implications, and future policy challenges
- Application of this experience to other European countries

1130 – 1300 **SESSION 3: NUCLEAR POWER POLICY IMPLICATIONS OF BUSINESS AS USUAL: COUNTRY VIEWS**

Session Chair: Mr. Mikko Kara
Managing Director, Technical Research Centre of Finland

Speakers from IEA/NEA Member governments will discuss the implications of business as usual for other nuclear power policy issues, such as industrial development policy, wastes, safety and international co-operation.

Infrastructure Needs for Nuclear Power
Mr. Renzo Tavoni, Head Sustainable Energy Systems Division, ENEA, Italy

- Manpower availability.
- Educational Implications.
- Industrial Supporting Infrastructure.
- Regulatory Implications.

World-wide Co-operation in Nuclear Power: a Canadian Perspective
Mr. Dan Whelan, Director General, Energy Resources, Natural Resources Canada

- Implications of a stagnant world market for domestic nuclear power development?
- What actions do governments need to take to ensure safe operation of nuclear plants?
- Are there opportunities to pool resources through better international collaboration on nuclear matters?
- How should OECD countries co-operate with developing countries in the use of nuclear power?

Regulatory Control, Nuclear Safety Regulation and Waste Management in Spain
Mr. Aníbal Martín Vice-President, Nuclear Safety Council, Spain

- How have the regulator's priorities shifted with no new orders on the horizon?
- Do regulatory policies on closure, life extension need to change?
- What role for international co-operation among safety regulators?

1430 – 1600 **SESSION 4: IMPLICATIONS OF BUSINESS AS USUAL: INDUSTRY VIEWS**

Session chair: Mr. Georges Cornet
Director General, Belgonucleaire, Belgium

The business strategy of the nuclear industry is also critical. Decisions taken by the industry, both the developers of nuclear power and the customers will affect the energy policy options for the coming years.

EDF's Nuclear Strategy: New Markets and Skilled Players
M. Hervé Machenaud, Deputy Executive Vice President, Industry, EdF, France

- Responding to an evolving electricity market.
- Renewal of existing assets.
- Mergers and acquisitions.
- Privatisation.
- Internationalisation.

Implications for Providers of Nuclear Power Plants, Materials and Services
Mr. Derek May, Executive Director of Corporate Strategy, British Nuclear Fuels plc, United Kingdom

- Adapting corporate strategies to market trends.
- Dealing with developing countries.
- Managing liabilities and risks.
- Industry consolidation.

The Changing Scope of Nuclear Power R & D: A US Perspective
Dr. Robin L. Jones, Vice President Science and Technology Development, Electric Power Research Institute

- How must nuclear R&D change in a BAU scenario?
- How are priorities shifting in nuclear R&D?
- What is the long-term role of governments in supporting nuclear research?

1600 – 1615 **The meeting chair will give a brief summary drawing out the main themes**.

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