Nuclear Development

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NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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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); Korea (12th December 1996) and the Slovak Republic (14th December 2000). 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 28 OECD member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, the Republic of Korea, the Slovak Republic, 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.

FOREWORD

This publication is intended to assist governments in assessing their role in energy policy making, in particular as regards nuclear energy policy. It provides data and analyses of how the role of governments has evolved and identifies future challenges for countries with different policy positions, particularly in respect of the development of increased competition in electricity markets. It does not prejudge the policies of individual member countries towards nuclear energy.

The publication was prepared by the NEA Secretariat, with the assistance of experts in nuclear energy policy. The text benefited from comments and suggestions from the Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC). It is published under the responsibility of the OECD Secretary-General.

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EXECUTIVE SUMMARY

This report looks at the role of governments in nuclear energy in the evolving context of the three main goals of energy policy in NEA countries: adequate and secure supply; competitive markets and prices; and sustainable development, including goals for climate change and air quality. The role of nuclear energy in this context, and the role of governments in nuclear energy, are essential elements of the energy policy discussion.

The intent of this report is to look at some of the forces that influence the degree of government intervention, while trying to avoid issues of ideology. Many decisions on government intervention in recent decades have been based on the earlier experience of what works best. The report suggests some considerations that all governments could take into account.

Governments have been deeply involved in the development of nuclear energy. Some of them initiated and led the development of nuclear energy since its military beginnings in World War II, because of its strategic nature and the scope of its risks and benefits. Governments later supported the development of civilian nuclear energy, primarily for the generation of electricity. In the post-war period, governments played an increasing overall role in the economies of the industrial countries. Science and technology were essential instruments of government action and nuclear energy was a highly visible symbol of their successful application.

In the 1980s and 90s, problems with exclusive government ownership and control of production equipment appeared. Governments came under pressure to cut expenditures and diminish their direct involvement in the economy. Expanding international trade forced all industries to be more competitive. Markets were championed as an alternative to government direction and regulation. Simultaneously, environmental protection and the concept of sustainable development increased in importance in policy making, whilst the need to ensure security of energy supplies persisted or even increased.

In the current era of privatisation and competitive markets, government still has an essential role in energy, electricity and nuclear energy. While, in

some countries, it may not exercise as much direct control through ownership and economic regulation as in the past, it still has the basic responsibility for creating policy frameworks within which market forces can function and public policy goals can be achieved. So, with fewer direct instruments, governments will need alternative policy measures.

The reasons for government intervention in nuclear energy have evolved as governments confront their limits. Privatisation and competition mean that many decisions are no longer directly made by governments. However, there will always be strategic reasons for government intervention – national security; emergencies, disasters and epidemics; national projects of such importance or urgency that only government can do the job. By and large, the current sentiment in most OECD countries is that the government should intervene only when it is in the best position to carry out the task and when the benefits of intervention outweigh the costs. In fact, the role of governments in nuclear energy varies considerably between countries, according to their specific history and situation.

The economic, social and environmental reasons for government intervention generally fall into two categories: market failure to allocate resources efficiently, and equity or distribution issues. Market failure may relate to several issues, some of which overlap: public goods, infrastructure, externalities, information and competitive behaviour. However, even if there is a case for government intervention, that intervention itself should be well designed and managed. Both markets and government action can fail, thereby affecting the customers and societies that they serve. The government should have the competence and resources to carry out its interventions effectively.

The most important government role is setting overall policy for the economy, energy and the environment, with an adequate base in legislation and institutional competence. In particular, governments should have clear strategies for achieving all three main goals of energy policy over the coming decades. They should show how they will meet climate change and air quality goals, given the current and prospective market dominance of fossil fuels, as well as how to ensure long-term security of supply in open market conditions. In this situation, governments have hard choices to make about whether, when and how to intervene in order to achieve the full range of policy goals.

In privatising and opening markets to competition, governments should make sure that they respect some basic principles. For markets, they have an ongoing responsibility to ensure fairness, access, transparency and effective regulation and to provide the public goods that markets may not otherwise

deliver. Governments should ensure security of supply, through incentives or other means guaranteeing that generating and transmission capacity and reserve margins are adequate, and that the grid is effectively regulated to avoid blackouts.

Governments have a role in looking at the long term to compensate for the high discount rate and short-term perspective of competitive markets, through appropriate tax incentives or other mechanisms. In particular, they should carry out longer-term and fundamental R&D with a sustainable development perspective in mind. They should also assess R&D on the basis of its contribution to achieving the three energy policy goals.

Governments should try as much as possible to treat nuclear energy on a similar basis to other energy sources, while keeping in mind its unique properties. They should sponsor studies that compare the full life-cycle costs and impacts, including risks, across the spectrum of energy sources and uses. They should also internalise the external costs of all energy activities on an even basis. Regulation and liability for radioactive wastes should be in line with those for other activities.

Regulation of nuclear safety and security remains a core function of government. It should guarantee the existence of an independent, competent regulator with adequate resources and authority. The emphasis now is on the safety culture of organisations, beginning at the most senior levels. This brings in the need to ensure good governance. Nuclear regulation should be in line with modern regulatory practice across the government, allowing nuclear energy to compete fairly. Governments looking for a future contribution from nuclear energy should ensure that regulation is prepared to deal with issues of decommissioning, refurbishment, uprating, life extension and new reactor designs.

Governments should look beyond regulation to other means of influencing the behaviour of operators and investors. Economic instruments will be important in this regard. Governments will have a role in setting up public processes for the siting and approval of nuclear installations, including waste management facilities.

Governments have a role in ensuring that flexible, stepwise policies are in place for the long-term management of wastes and that funds and institutions are available to carry out the plans. They should oversee the implementation of policy to ensure progress toward waste management goals.

Governments should ensure that the public is adequately informed about energy policy and that there is adequate opportunity for public participation in key energy decisions. Processes for decisions should incorporate the best scientific information as well as a broad spectrum of public views. Governments should take leadership on longer-term energy policy issues and provide clear justification for preferred options. They should also ensure that they and the public can continue to access basic information about energy that may not flow freely in a deregulated regime.

Governments clearly have a lead role on resistance to diversion, non-proliferation[1] and national security. This includes responsibility for the physical security of critical infrastructure, including nuclear facilities. Governments should guard against the use of nuclear power materials as radiological weapons. They should also ensure that new fuel cycle and reactor designs have built-in resistance to proliferation from the start.

Intergovernmental co-operation will continue to be essential in the field of nuclear energy. Concerns about nuclear safety and environmental impacts can be effectively addressed through international co-operation and technical assistance. The harmonisation of safety and radiation protection standards is helpful in increasing public understanding, especially in emergency situations. Joint projects on future reactor designs can make effective use of limited national resources. International consensus and state-of-the-art reports can contribute to the public discussion on nuclear energy.

1. The elements of non-proliferation are material control and accounting, technology export controls, physical security and IAEA inspections.

1. INTRODUCTION

This report looks at the role of governments in nuclear energy in the evolving context of the three main goals of energy policy in NEA countries: adequate and secure supply, competitive markets and prices and sustainable development, including goals for climate change and air quality. It will be increasingly difficult to achieve all three goals over the next half-century. The role of nuclear energy in this context and the role of governments in nuclear energy, are essential elements of the policy debate.

Governments have been deeply involved in the development of nuclear energy. What roles have they played in different countries and why? What forces are acting to change their role? In countries with active nuclear energy programmes, should nuclear energy continue to enjoy a special status in government policy?

Some governments initiated and led the development of nuclear energy since its military beginnings in World War II, because of its strategic nature and the scope of its risks and benefits. They later sponsored and managed the development of civilian nuclear energy, primarily for the generation of electricity. As a unique new source of energy with seemingly unlimited promise, nuclear energy enjoyed a very high priority in the economic and energy policies of the leading industrial countries for many decades.

In the post-war period, governments played an increasing overall role in the economies of the industrial countries (Stanislaw and Yergin, 1998). Their involvement was based on the perceived failure of markets in the 1930s and the success of government institutions in re-launching economic growth. Science and technology were essential instruments of government action and in some countries nuclear energy was a symbol of their successful application.

In the 1980s and 90s, problems with exclusive government ownership and control of production equipment appeared. Governments came under pressure to cut expenditures and diminish their direct involvement in the economy. Expanding international trade forced all industries to be more competitive. Markets were viewed as an alternative to government direction and regulation.

As prime examples of government intervention, nuclear energy programmes came under closer scrutiny. Some countries decided to move ahead with nuclear energy, others to let the market decide and others to phase out their nuclear programmes.

This Chapter includes a brief review of government intervention in nuclear energy in NEA countries, noting why governments did what they did. Reasons for government intervention in the economy and their application to nuclear energy are examined. Finally, it is suggested that a review of governments' role in nuclear energy would be timely.

Chapter 2 looks at the situations and positions of NEA countries with respect to nuclear energy and to electricity markets. The evolution of electricity utilities under deregulation and competition are examined. The features of competitive markets and their impact on the nuclear energy sector are reviewed. In Chapter 3, government intervention in nuclear energy activities is reviewed. Chapter 4 examines the institutions and instruments that governments use to intervene in the nuclear energy sector. Chapter 5 reviews the new context and the involvement of governments in nuclear energy today and in the future. Finally, conclusions are drawn on the role of governments in nuclear energy of interest to NEA member countries.

World War II and the post-war period

Some governments of leading industrial countries played an essential role in the development of nuclear energy for weapons purposes during the Second World War. These programmes were assigned top priority in terms of funding, access to personnel, equipment and materials. They were guarded by high levels of secrecy and security.

In the 1950s, governments began to develop nuclear energy for peaceful purposes, led by the United States and the Atoms for Peace programme. The countries that had embarked on weapons programmes were able to build on investments and training carried out initially for military reasons.

Many industrial countries set up large nuclear research and development (R&D) institutions under government auspices (Goldschmidt, 1964). They also provided support to the rapidly expanding electricity sector, whether privately or publicly owned, for the design and development of nuclear power plants, to the mining sector for the production of uranium, and, in some cases, to the radioisotope sector for a range of applications. Technology transfer programmes were set up by the leading countries in nuclear science and technology, partly in

anticipation of export sales. National and international agencies for nuclear energy, such as the International Atomic Energy Agency (IAEA) and the European Nuclear Energy Agency, predecessor of the Nuclear Energy Agency (NEA), were established well before other agencies dealing with broader energy issues came into existence. At the same period of time, the European Nuclear Energy Community (Euratom) was founded. The main task of Euratom was to create conditions necessary for the speedy establishment and growth of nuclear industries.

Governments put in place special legislation and regulatory institutions to ensure the safety and security of nuclear facilities. The veil of secrecy was gradually lifted for civilian nuclear energy activities as the decades went by, although the sensitive technologies that could lead more directly to weapons were kept under close control.

In the 50s and 60s, the development of nuclear energy was part of, and contributed to, an enhanced role of governments in the economies of some countries. The percentage of GDP represented by the public sector increased steadily, but governments still could afford to expand their investments. Government-owned national champions were used to develop a range of industries, especially the commanding heights of the national economy – energy and electricity supply, airlines, railways, steel, telecommunications. In these key sectors, the national interest was seen to be best served by public institutions[1] which could serve as direct instruments of national policy, mobilise public support, provide economies of scale, cope with the scale of risks and benefits, and take the long-term view. Where direct government ownership was not seen as desirable, governments maintained tight control through regulatory instruments and by funding strategic initiatives.

Increased government involvement in the economy was accompanied by the perceived success of the linear model of R&D: achieve new findings in basic science at the upstream end of the innovation pipeline, then develop applications, then engineer successful prototypes, then deploy the technology in a commercial form. In some countries, the success of government-sponsored mission-oriented R&D in achieving wartime objectives – radar, jet flight, nuclear weapons, computing – led to a belief that investing in advanced scientific development was an essential role of governments. Government funding for mission-oriented basic science was seen as the key. Technological applications would follow (Bush, 1945).

1. In the sense of government-owned or controlled.

The emphasis placed on basic science meant that scientists had power. Only technical specialists could decide on priorities in basic research and on the programmes of national laboratories, based on their views of where progress was most feasible. Scientific experts had great credibility in many fields.

Nuclear energy fitted this model well. The successful development of the US nuclear weapons programme, within a few years of the discovery of nuclear fission in 1939 by scientists engaged in very basic research, showed what could happen with an appropriate level of government commitment. Nuclear science was one of the most prestigious areas of science in the post-war period.

Given the unique safety and security implications of nuclear energy, the scale of the required investments and infrastructure and the long-time frame needed to realise its large potential benefits, it was natural for government agencies to play a lead role in its development across the entire fuel cycle. Government control extended from the uranium resource base through the reactor technology to exports and imports, and to the long-term management of waste at the back-end of the fuel cycle. However, the waste problem was not seen as overly challenging in the early decades of nuclear energy programmes (Price, 1991).

Because of the importance accorded to nuclear energy, and the potential constraints on trade and technology transfer, most governments strove for self-sufficiency with respect to technology and materials, and were prepared to intervene to achieve the desired level of national independence.

For many countries that had industrial capability but not much science and technology, such as Canada, nuclear energy offered an opportunity to develop a new technology across the full spectrum of science and technology activities, from basic research to commercially successful nuclear power plants. Nuclear energy was an important component of their innovation strategy. Through the 1950s, 60s and 70s, more than half of the government R&D expenditures on energy in the OECD as a whole was devoted to nuclear energy, and it still accounts for a high proportion of energy R&D in many OECD countries (IEA, 1996).

Nuclear power plants began to be deployed on a commercial scale in the late 60s and early 70s. A number of governments, including France, committed more strongly to nuclear energy in response to the oil crises of 1973 and 1979. Orders for new nuclear plants rose quickly in the 70s. Projections from that time suggested that there would be 1 000 GWe of nuclear generating capacity worldwide (equivalent to about 1 000 large nuclear plants) by the turn of the

century. However, these projections peaked later in the decade and fell steadily through the 1980s. Actual world nuclear capacity in early 2003 is about 360 GWe, and nuclear energy generates about 16% of the world's electricity.

The threat of a spread of nuclear weapons had always been a concern of governments, leading to the Nuclear Non-Proliferation Treaty (NPT) in 1970. Concern increased after the Indian nuclear explosion in 1974, further constraints being applied to trade in materials, equipment, and technology. The goal for governments was to proceed with civilian nuclear power technology, while minimising the risks of diversion to weapons programmes. Political incentive rather than technical availability was seen as the key factor influencing weapons proliferation but technical barriers to the acquisition of fissile nuclear material were still regarded as essential.

From 1980 to the present

The period of intensive government involvement in the economy, and in nuclear energy, persisted into the early 1980s, but constraints on that involvement increased. A decade of stagflation – inflation combined with low economic growth – raised basic issues about the role of governments. The efficiency of some state-run programmes and companies was challenged. Social or political goals, such as maintaining regional employment, often requiring subsidies, came into conflict with business goals. Pressure mounted to deal with government deficits, and subsidies became the target of cost cutting. The percentage of GDP spent by governments reached a plateau in many countries or even declined slightly (OECD, 2003).

International trade and competition intensified, putting a premium on having competitive and lower-priced infrastructures, including electricity supply. In the United Kingdom and the United States, the governments moved towardS the privatisation of government activities and greater domestic competition. Regulation was challenged as being cumbersome and ineffective, at least in the economic sphere, although setting the framework for effective market competition proved to be a regulatory challenge of some magnitude. Regulatory regimes for environment, health and safety continued to expand.

The linear model of innovation was also challenged (Stokes, 1997). Some key innovations did not require basic science. Private businesses were shown to be adept at doing or buying the R&D they needed. It was noted that since Galileo's telescope, some basic science had developed as result of technological developments rather than the reverse. Innovative technologies were seen as too important to be left to the scientists, and their successful design, manufacturing and commercial operation depended on many factors other than the science.

Experts were seen to be fallible. Some government laboratories were criticised and sometimes challenged on their ability to innovate and adapt. Some governments now look towards more targeted programmes, in partnerships with universities, industry and other governments, and see their function increasingly as enablers and co-ordinators of research rather than deliverers (Blair, 2002).

Generating capacity from nuclear power continued to expand in the 1980s as the wave of reactors ordered in the 1970s came into service, but ran into problems of cost and public acceptance. Some nuclear plants had significant cost overruns, exacerbated by the high interest rates of the period. The accidents at Three Mile Island in 1979, and especially at Chernobyl in 1986, shook public confidence in nuclear plant safety and brought increasing pressures on safety regulation, which adversely affected costs and construction schedules.

Towards the end of the 80s, nuclear generating capacity reached a plateau of about 320 GWe worldwide, 80% of it in the OECD countries. It has slowly increased to about 360 GWe in 2003. The 90s were a period of consolidation in nuclear energy programmes. Ambitious nuclear building programmes, like those of Canada and France, came to an end, while growth continued in Asia. With the collapse of the Soviet Union, open markets and concern about safety brought increased international co-operation. Industry organisations, like INPO in the United States and WANO worldwide, arose in response to the desire of the nuclear industry for increased self-regulation, and proved to be effective in bringing change to utility management practices.

During the 90s, government budgets were under particular pressure. In the general retrenchment of government expenditures, nuclear energy proved to be a timely target. Support for nuclear energy declined and R&D in nuclear energy, which accounted for a large proportion of national energy R&D budgets, began to shrink substantially.

In some countries, refurbishment and performance improvement added significantly to the output of nuclear electricity, even in the absence of new plants coming into service; e.g. between 1990 and 2000, nuclear electricity generation in Belgium, Finland, Germany, Spain, Sweden and the United States increased by the equivalent of the production of 30 large reactors as a result of power up-ratings and better performance of units in operation.

The concern of some governments about the security of nuclear fuel supply decreased, as rich new deposits of uranium were opened in Australia and Canada and uranium from dismantled weapons became available. Enrichment services also became available commercially. Self-sufficiency seemed less essential, as the international markets could provide a wide range of nuclear materials, goods and services reliably and at competitive prices.

While most countries tried to reduce the role of oil in electricity generation, natural gas technology advanced in the 1990s to the point where it became very competitive in terms of price, operational flexibility and short-lead times, making it more amenable to private sector investment than nuclear energy. Gas became the technology of choice for new generation in those OECD countries where it was available by pipeline. At the same time, while world gas resources were seen to be adequate for several decades at least, it was recognised that imports of natural gas to Western Europe depended primarily on a limited range of sources, notably the North Sea, Russia and Algeria.

Despite its environmental challenges and increasing concerns about regional air quality, coal proved to be very competitive in many areas, as bulk transport of coal became cheaper. Programmes for renewables and energy efficiency became more popular, and took a larger share of government expenditures on energy.

Nuclear energy saw its special status in the energy policies of most OECD countries declining, but not in some countries that lacked natural resources of their own: France, Japan and Korea. In 2002, Finland launched Europe's first new reactor project in a long time. In the United States, the government has also offered support to the nuclear industry so that it could play a key role in national energy policy. While not building new nuclear power plants, many countries want to keep their nuclear power plants operating as long as technically possible.

The criticism of nuclear energy has found some resonance with the general public and with some governments. For instance, nuclear energy was specifically excluded from joint implementation and the clean development mechanism designed to help implement the Kyoto Protocol on climate change.

Some countries, including Belgium and Germany, plan to phase out nuclear energy programmes, following the earlier lead of Italy and Sweden. Plant closures would take place at the end of the anticipated plant lifetimes, effectively putting off the final closure for a decade or more. In some cases, phase-out will be conditional on finding suitable replacements for nuclear generation.

The electricity system in many OECD countries was opened to competition (as discussed more fully in the next chapter). The design of the electricity market is seen as an important function in which governments should play a lead role to ensure that strategic national energy goals are met.

However, the aim of privatisation and competitive markets is to make the companies more competitive, more focused on a limited range of business (as

opposed to political) goals, and less dependent on subsidies. Governments have also found that privatisation of state-owned electricity utilities and other nuclear facilities can bring in revenues on a one-shot basis, while relieving them of some political and financial responsibilities which they carried previously. Governments generally retained overall control on long-term management of radioactive waste and responsibility on management and disposal of historic waste and waste generated by their own activities. For waste generated by commercial electricity production, the funds were to be provided from the operating companies out of their current revenue, effectively internalising those costs in electricity prices.

A number of governments have moved to privatise facilities under their jurisdictions. Canada, for instance, privatised a radioisotope production company and a uranium mining and refining company. It has retained Atomic Energy of Canada Limited (AECL) as a reactor designer, manufacturer and performer of nuclear R&D, but is seeking private investment to fund some of the development activities. The United States have privatised its uranium enrichment facilities. The United Kingdom has downsized its national laboratories and privatised its nuclear utilities after merging them, while retaining the Magnox reactors and fuel cycle facilities, including reprocessing plants under the state-owned British Nuclear Fuels plc (BNFL) and keeping under government responsibility a range of waste liabilities.

Reasons for government intervention

One's view of the role of government may be conditioned more by a general worldview than by the specifics of nuclear energy. The political "left" tends towards more government intervention and the "right" prefers decisions made by the market. However, there are exceptions to these generalisations. People also differ in the priority they assign to freedom or to equity.

It is hard to separate ideas on the role of government from the status and prospects for nuclear energy in a given country. Chapter 2 deals with nuclear energy programmes and competitive markets. Similarly, ideas about the desired outcome of government intervention will affect one's views of the role of government. Supporters of nuclear energy will likely see a need for the government to provide financial support or intervention to level the playing field.

This report is limited to looking at some of the actual forces that influence the degree of government intervention, while trying to avoid issues of ideology. Many decisions on government intervention in recent decades have been based on the earlier experience of what works best.

The general reasons for government intervention in the economy have been widely discussed in terms of economics, political science and public management (World Bank, 1997). Facing limited resources and increasing demands, governments everywhere have been striving to identify and prioritise those functions that can be performed only by them, acting alone or jointly with others.

There will always be strategic reasons for government intervention: national security; emergencies, disasters and epidemics; national projects of such importance or urgency that only governments can do the job. By and large, the current view in most OECD countries is that governments should limit their intervention to cases where they are in the best position to carry out the task and the benefits of their intervention outweigh its costs.

The economic, social and environmental reasons for government intervention generally fall into two categories: market failure to allocate resources efficiently, and equity or distribution issues. Market failure comprises several categories, some of which overlap: public goods, infrastructure, externalities, information, and competitive behaviour. Governments should have the resources and competence to ensure that their intervention to overcome market failures is well designed and managed, is carried out efficiently.

Public goods and services

Public goods benefit society but do not attract private investors who cannot capture a sufficient share of the benefits. Public goods generally involve the characteristic of absence of rivalry, in that one person's use of them does not preclude another from using them. They are also non-excludable, in that all, or many, people have access, so some can be free riders. Examples include public parks, road systems, ocean fisheries, national security, and basic R&D. Only government is in the position to invest on behalf of society at large, and to regulate the use of the good or service. Regulation is itself an important public service that incorporates elements of equity.

In common property regimes, such as fisheries, condominiums or, in older times, the village commons (Hardin, 1968), open access can lead to over-exploitation. An argument can be made that these public goods are better run by private interests, as the owners will have an interest in preserving their assets. The challenge is to develop a means of limiting access to the resources that is both fair and enforceable, which brings one back to governments. Forcing users to pay the full costs is one approach to managing them.

Road systems and other networks, such as electricity transmission lines, can be seen as public goods. There may be economic instruments that can limit and distribute access fairly, such as toll roads, parking fees, and congestion pricing but these generally have to be regulated by governments. Access to transmission facilities is of course a prerequisite for competition in the electricity sector.

A few decades ago, activities such railways, telecommunications, electricity, coal and steel were considered to be public goods because they are essential for the economy. This is the commanding heights argument (Stanislaw and Yergin, 1998). Most of these activities have since been shown to be amenable to operation by private firms in a competitive but regulated environment.

National security is a public good, under the exclusive responsibility of governments in democratic regimes. Non-proliferation of nuclear weapons and physical security are key elements, in the framework of an energy policy including a nuclear energy component, which are by nature under the responsibility of governments. This applies to domestic use of nuclear energy as well as for exportation of nuclear materials and technologies for the development of nuclear energy programmes abroad.

For basic or long-term R&D, the benefits to society may be large, but they are often too diffuse, remote in time, and difficult to capture to warrant investment by a private firm. It seems appropriate for governments to fund such R&D. Some of the benefits may leak out of the national jurisdiction, but doing good R&D gives a country's scientists access to the international pool of R&D.

A concept that may help to guide investment is that governments should invest in basic science like astronomy, and also in basic mission-oriented research (e.g. basic research on cancer) that does not have immediate market applications, but may give rise to many applications downstream (OECD, 2002a). It should then make the results widely available. The private sector can then invest in developing the specific downstream applications that are close to the market. Nuclear energy was certainly in this category in the early days, and some aspects of it still are. The human genome could fall into this category today. There is still a challenge to defining the boundary in nuclear R&D between public goods research and commercial research that private firms should pay for. Furthermore, governments also are tempted by short-term payoffs.

Infrastructure and enabling environment

For the private sector to function effectively, it needs appropriate infrastructure, which has many features of a public good. This includes soft goods such as education and training, policy, legislation and regulation, and well-managed financial markets. It also includes public processes for siting and licensing controversial facilities. Nuclear energy might be seen both as part of this infrastructure, and as a beneficiary of having the right infrastructures, such as education, training and regulation, in place.

Externalities

Externalities are costs and benefits that are not internalised in the price paid for a product or service. A negative externality would be pollution caused in the production process where the cost of avoiding or cleaning up the pollution is not paid for by the consumer, who has no incentive to consume less of it. The cost is passed on to society at large, now and in the future. A positive externality would be a benefit to society from research that is not captured by the organisation doing the research. The consumers, or other firms, get this benefit for nothing. Thus there will be a tendency to under-invest in the research.

In both cases, the wrong price signals are sent. Governments can compensate for the negative externality by forcing the company to pay for the avoidance or clean-up of the pollution. For the positive externality, it can carry out the research at taxpayers' expense and pass it along to interested companies, perhaps charging a fee in the process. These measures will send correct price signals.

The nuclear industry internalises a large proportion of its external costs, through tight regulation, liability schemes, and electricity prices that include the eventual cost of waste management. It would be helpful, although difficult, to assign a value to security of supply and to longer-term goals, which tend to be discounted to near-zero present values under most positive discount rates.

Monopolies

The design and regulation of markets is a government responsibility. Monopolies have to be regulated or operated by governments so that they do not abuse their market power.

Some functions appear to be natural monopolies. Only one, or a few, facilities of a certain kind may be needed. Transmission lines are increasingly

difficult to site, and a limited number should serve society's needs in a given area. Economies of scale and risks may lead to natural monopolies. Some activities can be carried out, and some risks taken, only by large entities, and there may not be room in the economy for more than one. Electricity utilities were once seen as falling into this category.

Where monopolies are no longer seen as natural or inevitable, governments may deregulate the sector in order to introduce competition. In the nuclear sector, many public entities set up by governments have been successfully privatised: uranium mines and refineries, enrichment facilities, nuclear power plants, radioisotope companies, and even R&D establishments. These firms now operate successfully in competitive markets.

When privatisation of state-owned monopolies and opening of markets have been decided, governments should proceed carefully and with determination. The incumbent monopoly must be broken up or otherwise constrained, and new investors encouraged simultaneously, keeping the transition period short enough to avoid abuse of power and market distortion that may occur if that period is too long.

Regulation is seen by some observers as one of the last natural monopolies. The regulator tends to have the last word and there is no competition. The question of who regulates the regulators is an interesting one, given the desire of governments to regulate in an efficient and consistent way and to reduce costs and risks.

Asymmetric information

Markets can be distorted if some parties have better access to information than others. Governments have a role in ensuring that they and the public have continuing access to relevant information, which may be less readily available in competitive markets.

Equity and fair distribution issues

Markets may not lead to the kind of equitable distribution of benefits that society desires. People have basic rights that the market cannot guarantee. For instance, universal access to health care may be seen as a basic right, but may be denied to people who fall below a certain income level. Governments may have to intervene, transferring resources to the disadvantaged. Access to heat and electricity is taking on this quality of a basic right (UK Department of Trade and Industry, 2003).

Equity can be viewed in the international perspective, and indeed global equity is one of the basic concepts of sustainable development. Two billion people do not have access to electricity. Their needs will be powerful drivers for growth in demand for, and equitable distribution of, energy services. Access to clean forms of energy will be critical. Government policies and international co-operation will be instrumental in meeting the needs.

Reasons for reviewing the government role in nuclear energy

The reasons for government intervention have evolved as governments confront their limits. Privatisation and competition mean that many decisions are no longer made by governments. But new demands arise. The need for government leadership is not diminishing. This report examines reasons, both long-established and new, for government intervention in the nuclear energy sector.

Energy policy

Energy policy and its implementation are still a core function of governments and their intervention in this regard is globally beneficial to society. Even where decisions are left to the market, governments may have to intervene, as markets cannot deliver some public goods or pursue long-term goals.

The goals of energy policy – secure and adequate supplies, competitive costs, and acceptable environmental impacts – will be difficult to achieve together in the long term. Private sector investments focus on a shorter-time frame. Costs favour fossil fuels, potentially at the expense of security and environment in the future. Options to ensure supplies in a carbon-constrained world include energy efficiency, renewable energy sources, nuclear energy and carbon capture.

Governments have to make hard choices on if, when and how to intervene in order to achieve the full range of policy goals. They need to decide whether nuclear energy is unique, or just another energy source. They need to review the different instruments they can use in competitive markets: less funding, less control of operations, but a need for better co-ordination, market design and provision of infrastructures. Governments have to do more with less. And they act in a context that has important global elements.

It is timely to review the role of governments in subsidies and externalities. What criteria should determine the allocation of government resources to different energy sectors? Are resources aligned with policy? Are externalities fairly treated across all sectors?

Markets and economic regulation

Many NEA governments, driven by international pressures, are part way through processes of privatisation and the opening of competitive electricity markets. Some have gone all the way, but still find it necessary to revise the design of markets. Others have found traditional ownership and regulation practices are serving them well, but may nonetheless be under regional pressures to open their markets further. With respect to nuclear energy, about half the world capacity for uranium mining and conversion, enrichment, and electricity generation is in private hands and half in the public sector. Is the glass half full or half empty? In any case, broad experience has been gained on the roles of governments and of the private sector. It would be useful to review the last decade of experience before moving on.

Health, safety and environmental regulation

Safety regulation of the operation of nuclear plants and associated fuel cycle facilities is a core responsibility of the government. Nuclear regulation is particularly sensitive because of the concerns about nuclear safety and radiation protection. It raises issues that invoke the government's overall approach to the value, quality and coherence of regulation (OECD, 2002b). Is nuclear regulation in line with the standards set for safety and cost-effectiveness in other kinds of regulation? Are regulatory resources allocated appropriately, given the risks?

Research and development

Governments should review their energy R&D activity to assess its alignment with overall energy policy goals. Is the share allocated to nuclear fission energy appropriate? How much R&D should go to remedy past legacies, and how much to the future? Where is the line between R&D for the public good, to be funded by governments, and R&D that is basically commercial, to be funded by the operating companies from current revenues?

Long-term liabilities

Governments should accept policy and oversight responsibility for the decommissioning and the long-term management and disposal of radioactive wastes. This includes the responsibility to ensure that suitable financial resources will exist when they are needed. While most funds will come from the waste producers, governments have direct responsibility for their own wastes, including wastes generated previously by government companies that have been privatised, by state-owned hospitals and by public research organisations. Governments should design processes for siting and approval of waste repositories that respond to public concerns, and balance technical advice with social and ethical inputs.

International co-operation

Many of the responsibilities of governments in the nuclear sector are complex and expensive – control of waste management, safety tests, research (that may include research reactor construction and operation), etc. To the extent that governments should spend money on activities that are not inherently commercial, they should review the possibility of doing it more efficiently through international co-operation.

Governments will continue to be active in nuclear energy policy, but in ways that are different from the past. Given the recent experience with the transition to deregulated markets, and the decisions needed in the near future, this is a good time to review the role that governments could play in different areas of nuclear energy policy.

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2. GOVERNMENT INVOLVEMENT IN ELECTRICITY PRODUCTION AND SUPPLY

Governments are moving towards competitive markets for electricity supply in the conviction that they will foster lower prices and better service. The move could cause price increases in the near term in areas where electricity has been subsidised, but should result in more efficient investment and operation, lowering costs in the long term. Governments think that competitive markets can also provide high levels of reliability and security of supply, and lower environmental impact, but recognise that their continuing involvement will be required to achieve these goals.

Traditional electricity utilities

In many OECD countries such as Canada, France and the United Kingdom, governments owned the electricity utilities in the post-war period. In others, such as Japan, Germany and the United States, the utilities were privately owned and closely regulated. In both cases, utilities were constrained to provide "power at cost" or allowed a limited return on capital that was "in the rate base" i.e. actually involved in the supply of electricity. Electricity tariffs were often directly controlled by the governments. Government-owned utilities had to go to the government for financing, rather than to the financial markets.

The electricity utilities were vertically integrated with respect to generation and transmission, and had a monopoly for electricity supply in a given region. Indeed, generation, transmission and distribution were all seen as natural monopolies. Distribution was often left to local or regional authorities. In return, for effectively guaranteed but limited profits, the utilities were obliged to provide reliable service.

Utilities tended to focus on self-reliance within their own regions, rather than to invest in transmission capacity to neighbouring regions. This meant that significant cost differences could exist between regions, depending on their sources of supply.

For several decades after the war, large central plants, linked by transmissions systems to their service area, enjoyed increasing economies of scale, reinforcing the appeal of centralised monopolies. These plants had long lead times for approval and construction, but load growth was rapid and steady in the decades following the war, so matching capacity to the load was not too difficult.

Pressures and responses

The utilities served the public reasonably well, in providing reliable supply through decades of expansion in electricity use. But they became subject to increasing pressures for change in the 1980s and 90s.

International competition meant that industries needed competitive electricity rates. Industries wanted access to supplies in neighbouring regions, if they were cheaper. Governments were under pressure to reduce their expenditures, including subsidies, and to keep regulated electricity tariffs down as well. Thus utilities were caught between decreased government support and increased pressure on their revenue from customers.

The utilities came to be seen as inefficient, overstaffed, and subject to political interference. Governments wanted them to keep rates down but also to serve as instruments of public policy, as they were of sufficient size to play a significant role in the national economy. Utilities could ensure employment, favour certain fuel sources and technologies, build plants in uneconomic situations for regional development purposes, or subsidise particular industries through low tariffs or by making rebates.

As load growth became more difficult to predict, some utilities ran up debt to build capital-intensive plants with long lead times, which represented surplus capacity when they finally came on stream. They were seen as cumbersome in adjusting to shorter-term trends in supply and demand.

New technology created forces for change. Smaller, efficient gas turbine plants that became available in the 1980s could be built in two years or less, at low capital cost, allowing a more flexible approach to load growth, and appealing to financiers and private investors. Information and switching technology facilitated more complex combinations of generation and transmission, increasing the possibilities for more suppliers and better interconnections between systems.

Under these circumstances, generation was no longer seen as a natural monopoly, although transmission and distribution still maintain that status in most jurisdictions. It could be unbundled from transmission by separate ownership, by legal established boundaries within the same organisation, or by accounting mechanisms.

Competition among generators was expected to lower prices, provide more diversity, and send the right price signals. It was assumed that investors would be eager to invest in both generation and transmission, and that customers would be keen to choose suppliers.

Competition among generators implied effective transmission systems. While these systems were physical monopolies, there was no good reason to deny access to the lines to any responsible party on a non-discriminatory basis. That way, customers would be able to choose their supplier from a range of providers. Choice would first extend to wholesale customers who redistribute the electricity to final customers. Ultimately it would extend to the final customers themselves. Transmission congestion would be dealt with by higher tariffs, providing an incentive for the transmission system to add capacity.

The new gas plants offered an alternative to new transmission in some cases. Rather than building new transmission to access generating capacity in neighbouring jurisdictions, one could bring in a new natural gas plant close to the load. The gas plant could be built quickly, and it is generally easier to route a gas pipeline than the equivalent electricity transmission line, because the gas line is out of sight, once built, and perceived to be less of a threat, in terms of health and aesthetics, to the communities it goes through.

The government role would be to design the market initially and monitor it subsequently, to ensure effective competition and the fulfilment of public policy goals such as reliability, safety and low environmental impact.

As governments moved toward competitive electricity markets, the state-owned utilities were either privatised or restructured to become more business-like and more independent of government. In some cases, they were unbundled and the generating companies were broken up in order to introduce more competition.

Many companies that continued to be state-owned or state-controlled found themselves more sensitive to government policy even as they tried to become more business-like. They had to spend more time and effort trying to anticipate, influence and react to changes in government policy.

In some areas, traditional vertically integrated monopolies have been retained and continue to provide good service, with competitive costs, adequate reserves and transmission capacity, and the possibility of exporting surpluses to neighbouring regions. Hydro Quebec, Électricité de France and utilities in the south-eastern United States can be cited. In such cases, there is less pressure to open the market more fully.

In creating competitive electricity markets, many of the initial efforts have gone fairly well: the UK, Australia, New Zealand and the Scandinavian countries are cited as examples. In other cases, such as California in USA, and Alberta and Ontario in Canada, there have been problems. Designing markets turns out to be a more difficult task than originally foreseen.

Requirements for deregulated markets

It seems that a number of requirements should be taken into account in designing open markets:

- The incumbent former monopolies should not retain too much market power for too long, and new suppliers should be encouraged in order to allow real competition to evolve quickly.
- Incentives to invest in generation, transmission and distribution capacity and to maintain reserve capacity.
- Adequate transmission capacity and fair access to it at reasonable tariffs.
- Clear and stable rules and regulations for investors, including rules for the import and export of power and the pricing of peak power. Investors accept market risk but should not face undue risk of regulatory change or government interference.
- Real choice of supplier for customers, and clarity of the billing process. Customers should understand what they are paying for.
- If price caps are set, they should be high enough to encourage investment and to discourage excessive consumption.

Implications of competitive electricity markets for nuclear energy

Nuclear plants have unique characteristics in terms of their financing. Not only are they capital intensive, but they have long lead times for approvals and construction: up to 10 years or more. However, they have been built in much

less time in some countries, especially if they form part of a standardised series. In some regulatory systems, there is opportunity for intervention, changes and delays in the course of the regulatory process. The large up-front investment is at risk until the plant begins operating as well as subsequently. Also, because nuclear plants are built to meet loads anticipated many years in advance, they face the risk of being in surplus when they come into service. High interest rates, like those in the late 1970s and early 1980s, can drive up costs over the construction and approvals period. However, the costs of surplus capacity must be balanced against the cost of shortfalls, which can be very expensive.

Nuclear power plants are usually operated as base load plant for economic reasons, running full-time, since the capital charges apply whether the plant runs or not. Also, they are technically easier to run at a constant output, although some reactors have a capacity to follow the load to a degree. In a competitive market, existing nuclear plants usually have a good position because of their low avoidable costs. If their capital costs have been paid off or written off, because their operating and maintenance costs are generally low, such reactors have considerable value. Once built and financed, the cost of nuclear generated electricity is relatively insensitive to inflation.

Fuelling costs tend to be a fairly small proportion of the total costs. Increases in uranium price do not have much of an impact on electricity costs. Also, uranium fuel is very compact and several years' supply can be stockpiled relatively cheaply, contributing to security of supply.

The production cost structure of nuclear power plants is similar to those of large hydro plants, and to some renewable energy plants such as wind and solar photovoltaic, all of which have low operating costs and offer stable prices once the plants have been built and financed.

Natural gas plants have the opposite mix of capital and marginal costs. They are quick and relatively cheap to build. They are well matched to peak and intermediate loads, and to fluctuating revenue streams. The bulk of the costs are in the fuel, so that the cost of electricity which they generate is very sensitive to the price of natural gas. The dominant risks with gas plants are the future availability and price of the gas. This is generally seen as a less immediate financial risk than those facing nuclear plants.

Coal-fired plants fall between nuclear and natural gas plants in having a more equal balance between capital and marginal, mainly fuel, costs. Both coal and gas plants may be subject to increasing restrictions on polluting atmospheric emissions.

The capital costs and the construction lead times associated of existing designs and the length of licensing processes render most current designs non-competitive with new natural gas plants. Depending on the requirements placed on coal and nuclear plants, and their performance, nuclear can be competitive with coal. Few private sector entities have chosen to invest in new nuclear plants in a competitive market situation. It is interesting, though, that Finland's new order for a nuclear reactor has been pursued by a private firm, having a large internal industrial load, with no need for government financial support. Natural gas plants have dominated the market for new capacity in OECD countries, while renewable energy sources, notably wind, are growing very fast, albeit from a very small base.

A number of OECD countries, often with government support, are trying to develop new reactor designs that would lower capital costs by about 50%, in the range of USD 1 000 per kilowatt of capacity, and to shorten construction times. This would make nuclear power plants competitive with natural gas and coal plants on a life cycle cost basis. Ways to improve regulatory effectiveness and streamline the approval process for plant life extensions and new designs, while maintaining high standards of safety, are also being sought. Some countries are co-operating with a US-led effort to develop new Generation IV plants that would be ready for operation in about 2030 within the framework of the Generation IV International Forum (GIF).

Enhanced transmission capacity to neighbouring regions would ensure that the best-operated nuclear plants run at high capacity factors and thus achieve more favourable economics. This would encourage competition and complementarity between areas with a concentration of nuclear plants and those with other sources such as hydro or fossil. It would reward the most economic plants of all kinds.

Thus even with competitive markets in which decisions are made by private firms, governments have a role in setting up and monitoring the framework, imposing safety and environmental regulations in an even-handed way, and investing in long-term policies for security of supply and environmental protection that would not attract private capital.

Where you stand depends on where you sit

The role of governments in nuclear energy will vary considerably between countries, according to their specific history and situation. Therefore, the status of nuclear energy programmes, market competition and ownership patterns should be considered to better understand differences in the role of governments in various NEA countries.

NEA countries are characterised in Section A below by the existence of a nuclear energy programme, or intentions to have one. A summary of some specific countries' positions is also presented, although it should be noted that the situation is generally more complicated than a brief summary can convey. In some countries, the government's position could change with the election of different political parties. In Section B, the degree of opening or competition in the electricity market and utilities is considered. Finally, a discussion in Section C of the impact of privatisation and competition on performance and price concludes the review of different situations in NEA countries.

A. Classification by nuclear energy programmes

Countries with nuclear energy programmes

- Governments currently favourable to nuclear energy: Canada, Czech Republic, France, Hungary, Japan, Republic of Korea, Slovak Republic, United States.

In Canada, the Federal Government supports nuclear power, but decisions on new plants mainly rest with utilities owned by provincial governments. In Ontario, eight CANDU reactors are leased to a private firm, Bruce Energy. The Premier of Ontario and the head of Bruce Energy have speculated about the possibility of new nuclear reactors.

The French Government considers that the country must continue its use of nuclear to achieve its energy policy goals. New production capacity could be constructed and operated either by new entrants, who need to obtain an operating license from the Minister responsible for energy, or by the incumbent EDF.

The Government of Japan strongly supports nuclear energy. An electricity power development plan identifies power plants to be constructed during the following 10 years. A power company willing to build a new large power plant has to inform government, because the construction licence could be granted only if the plant is included in the development plan. The commercial water-cooled reactors are owned by private firms and one firm which is a producer and wholesaler of nuclear generated electricity.

Every five years, the Korean Government prepares the "Comprehensive Nuclear Energy Promotion Plan" (CNEPP) defining long-term nuclear policy objectives and basic directions, sector-by-sector objectives, budget and investment plan etc. All the nuclear power plants are state-owned.

The present Government of the United States supports nuclear power but decisions on new plants rest with the private sector, and the individual States have major roles in the approval process.

The Czech Republic, Hungary and the Slovak Republic are in the process of liberalising their electricity markets. Meanwhile, initiatives on nuclear energy rest with the national governments.

- Governments neutral on nuclear energy decided to keep the option open or leave decision to the industry: Finland, Mexico, the Netherlands, Spain, Switzerland, United Kingdom.

The Finnish Government treats nuclear energy like any other energy source and leaves decisions to the utilities. Nuclear plants are owned by both government and private firms. The Government recently approved a new nuclear plant to be built by a private firm.

The Netherlands Government reversed, in 2002, the previous government's plan to close down the country's only operating nuclear power reactor by 2004.

In Spain, there is a moratorium dated 1983 on the completion of five nuclear plants that were under construction. However, the Government maintains the nuclear option open.

In Switzerland, Government and Parliament have supported and continue to support keeping the nuclear option open. The country had a moratorium on new nuclear construction from 1990 to 2000. In May 2003, in a national vote, citizens rejected proposals to shutdown nuclear power plants and to impede the renewal of operating licences beyond 40 years.

The Government of the United Kingdom wants to keep the nuclear option as a backup in case its plans for improving energy efficiency and introducing renewable energy sources do not materialise. It believes that nuclear energy is not economic in the UK competitive market.

- Governments committed to nuclear energy phase-out: Belgium, Germany, Sweden.

The Belgian Government has decided to phase out its nuclear plants, which supply 60% of the country's electricity, at the end of their 40-year lives, over the next 25 years.

The German Government has adopted a policy of phasing out its nuclear plants after they have produced an amount of power specific to each plant, equivalent to an overall average plant lifetime of 32 years. The plants will be phased out over the next 20 years.

In Sweden, the legislation established after the 1980 referendum envisage a complete shut down of all nuclear units before 2010 provided that alternative energy supply sources will be available and national economy will be affected. The first shut down of a nuclear unit occurred in 1999 and discussions between the Government and the industry are ongoing for the closure of a second one. However, recent public opinion polls show that a majority of Swedes favours maintaining nuclear energy.

Countries with no nuclear energy programme

- Plans for nuclear energy programme: Turkey.

At present, the Turk Government has no access to the credits required for nuclear investment. However, it considers relying for the future on private investment to finance reactors with lower capital costs (Birol, 2002).

- No plans for nuclear energy: Australia, Austria, Denmark, Greece, Iceland, Ireland, Italy, Luxembourg, Norway and Portugal

Austria and Italy have phased out their nuclear programmes years ago. The other countries have never considered the nuclear option.

B. Classification by electricity market and utility ownership

The levels of ownership and competition in the electricity markets in NEA member countries with nuclear energy programmes or intentions are not easy to capture in a single indicator. Ownership and concentration can vary across the country. The market can be open for some consumers but not others, and for some states or provinces but not others. Many countries are in transition, so conditions will vary with time.

Utility ownership can be government or private, or mixed. It is interesting that about half of the world's nuclear electricity is produced by government-owned entities (May, 2002). This proportion may not change much worldwide in coming decades, because of the growth in energy consumption in countries where nuclear energy is pursued and government ownership prevails – i.e.

China, India, Republic of Korea. Even in the OECD, the proportion is probably not much below 50%, but the trend is toward greater private ownership.

The electricity market of the 15 initial member states of the European Union will be open for non-household customers in 2004 and for households in 2007 (Finnish Energy Industries Federation, 2003). All the European Union member states are also NEA members. Three of the 10 new EU Member States (Hungary, Czech and Slovak Republics) and 1 of the 3 EU applicant countries (Turkey) are NEA members. They are at different stages in preparing to accede to the European Union electricity directive. Even when the market will be fully open, there will be differences in individual countries, and in the concentration and nature of ownership.

The first column in Table 1 below shows an assessment of ownership in the electricity sector carried out by the IEA in 1996, completed by NEA estimates for countries not included in the IEA study. The types of ownership considered are: mainly government (public or PU); mixed (M); or private (PR) (IEA, 1996). The situation has not evolved significantly since 1996.

Table 1. **Electricity sector ownership and concentration**

	Private, mixed, or public[1]	**Market share of top 3 firms**[2]
Belgium	M	96
Canada	M	high*
Czech Republic	PU*	(high)
Finland	M	45
France	PU	92
Germany	PR	64
Hungary	(PU)	(high)
Japan	PR	(high)
Korea	(PU)	(high)
Mexico	(PU)	(high)
Netherlands	M	59
Slovak Republic	(PU)	(high)
Spain	PR	83
Sweden	M	90
Switzerland	PR	(high)
United Kingdom	PR	36
United States	PR	(variable)

1. Source IEA (IEA, 1996).
2. Source EC (CEC, 2002).

* NEA Secretariat estimate.

The second column of Table 1 shows the percentage of the national markets held by the three leading companies, as a measure of market concentration for EU countries, according to a study from the European Commission (CEC, 2002) and NEA Secretariat estimates.

The concentration in the United States varies from state to state (IEA, 2002a). The interstate wholesale market is largely liberalised. Most Canadian provinces have a government-owned utility with a *de facto* monopoly.

Table 2 shows recent estimates of market opening for IEA member countries (IEA, 2003). The year of full opening is shown in parenthesis.

Table 2. **Degree of market opening in % (year of full opening)**

Belgium	52 (2007)
Canada	0-100
Czech Republic	40
Finland	100
France	37 (2007)
Germany	100
Hungary	35
Japan	30 (2007)
Korea	24
Mexico	0
Netherlands	63(2003)
Slovak Republic	0
Spain	100
Sweden	100
Switzerland	–
United Kingdom	100
United States	0-100
Turkey	–

In Canada and the United States, much of the jurisdiction over electricity resides with states and provinces. In Canada, markets are opening in Alberta and in Ontario, the main nuclear province. In the United States, states representing about half the generating capacity are opening their markets.

In Switzerland, a new electricity law on market opening was rejected in 2002. The Government is working on a new law. In Turkey, a law was passed in 2001 with the goal of creating a competitive electricity market with a majority of private ownership (Birol, 2002).

Considering the above data and others, NEA countries with nuclear programmes and intentions can be categorised by the openness and degree of competition, as recognising that the grouping is somewhat arbitrary and in some cases changing rapidly.

Fully competitive markets (Finland, Spain, Sweden, United Kingdom)

This means markets where there is real competition among a range of players, none of whom has undue market power, and, open access to transmission.

Partly competitive markets (Canada, Germany, Netherlands, Switzerland, United States)

A country may be in the process of opening all of its market over time. Some of the national market may be open by category and some not (e.g. bigger customers versus smaller). Some states or provinces may have open markets and some not.

Less competitive markets (Belgium, Czech Republic, France, Japan, Korea, Mexico, Slovak Republic, Switzerland, Turkey)

Markets are only partly open for some categories of consumers only, or the national or provincial market is dominated by three or fewer large companies, as indicated in Table 1.

C. Competition, ownership and performance

Countries may be classified by ownership (public or private) and markets (competitive or regulated) (May, 2002). The NEA nuclear countries in his classification are shown below. Competitive markets are also regulated but they differ in that competitive markets decisions are based on a price set by a competitive process whereas in regulated markets, they are decided by the regulator. This classification is largely consistent with Tables 1 and 2 above.

Mainly private ownership, competitive markets: USA, Germany, Spain

Mainly private ownership, regulated markets: Japan, Switzerland

Mixed ownership, competitive markets:	Belgium, Finland, the Netherlands, Sweden, United Kingdom
Government ownership, regulated markets:	France, Republic of Korea, Eastern Europe

It is noted by some authors (May, 2002) that nuclear plant performance tends to be better in private firms and competitive markets and that prices tend to decrease after opening of markets to competition. It would be interesting to see the impact of privatisation on performance and costs over time for different energy sources. The UK example suggests that performance has improved and costs have gone down when government companies are privatised.

It has been argued (Romerio, 2002) that, on balance, competitive markets in Europe have generally led to lower prices between 1995 and 2000, although the decrease has been small, and price differences between countries remain high. However, he notes that European countries are still in the early days of market opening, and that market design and regulation will play critical roles, especially in maintaining reserve margins. Inadequate margins could result in price spikes. The only private firm intending to invest in a new nuclear plant in a competitive market to date is TVO in Finland.

Market challenges: the United Kingdom

The United Kingdom was the first country to open its electricity market to competition, and the first to privatise a state-owned nuclear generating company. Its experience is illustrative of the challenges and possibilities of these initiatives. It therefore provides an interesting example of the role of governments in nuclear energy, and the role of nuclear energy in a competitive electricity market.

The electricity market of the United Kingdom was gradually opened to competition during the 90s. Companies were unbundled and privatised. They made good profits, supply was adequate, and prices fell slightly. However, the incumbent generators retained significant market power and although they reduced their costs, they did not pass on the gains to consumers (IEA, 2002b).

These arrangements encouraged a major thrust of investment in gas-fired generating plant – known as the “dash to gas” – which expanded its share of the electricity market to 40%, from about 1% in 1990, mainly at the expense of coal, which fell from near 70% to about 30%. New capacity resulted in a 30%

reserve margin, which heightened the competition. Nuclear energy maintained its share of an expanding market in the low 20% range, due in part to improved performance of the existing plants and in part to the entering into service of the Sizewell B station, the only LWR in service in the country.

The newer nuclear generating stations of the United Kingdom were privatised in 1996 as part of British Energy plc. (BE). The older magnox stations were transferred to a government-owned company, BNFL, which provides fuel cycle services throughout the world.

British Energy improved the productivity of the nuclear units significantly. Changes to the electricity market rules in 2001, and the presence of a much larger number of generators, resulted in a much more competitive market, with prices going down by 40% in the four years to 2002.

British Energy, in the fall of 2001, proposed to the Government Energy Review that nuclear energy should be replaced with nuclear energy as existing reactors were phased out over the next 20 years (British Energy's Submission to the Government's Review of Energy Policy, 2001). British Energy agreed that new nuclear plants could not compete with gas, but argued that it was essential to preserve the nuclear share of the market as a means to address climate change issues and to ensure energy security and diversity. Without nuclear energy, gas would take 70% of the market, and within a few years, the United Kingdom would be importing most of its gas, mainly from Russia or North Africa. The market, with its fierce competition, low prices and short-term perspective, could not set policy for the long term. To maintain the market share of nuclear energy, British Energy suggested that the government would have to assume the charges for reprocessing nuclear fuel and historic liabilities.

The Energy Review (UK Cabinet Office, 2002), released by the Prime Minister's office in February 2002, suggested that the Government should keep the nuclear option open, in case renewable energy sources and efficiency, the leading priorities, did not deliver. It also noted the need to maintain skills to ensure safe operation of existing reactors for their lifetime, and to deal with radioactive waste management and disposal. However, it also noted that new nuclear plants would not be competitive and that private firms were unlikely to invest in new nuclear units. It did not suggest means for keeping the nuclear option open.

Matters came to a head in the fall of 2002, when British Energy approached the Government seeking immediate financial support and discussions about longer-term restructuring. The Government's overriding

priorities were to ensure the safety of nuclear power and security of electricity supplies. In accordance with these priorities, the Government provided short-term financial assistance. In due course, the Government decided to support the company's restructuring proposal which involves, amongst other things, the sale of its North American assets. Coal-based utilities complained that the market was being distorted (The Scotsman, 2003). Thus privatisation and competition had succeeded very well in exposing the inefficiency of the previous system (The Economist, 2002), prices had fallen and capacity increased as new gas-fired units exceeded in capacity old units retired because they were obsolete and not competitive. The privatised nuclear company could not compete, like many fossil generators, and British Energy collapsed. But this raised strategic questions about the future of the nuclear generating capacity.

In the Spring of 2003, British Energy had made progress in implementing its restructuring plan, but had some way to go to implement it in full. It is likely that the nuclear plants will continue to run, as they form an essential part of the electricity supply in the United Kingdom. However, the capacity situation is such that they no longer appear indispensable, at least in the near term. Despite the efforts of the Government to let market forces decide the future of the electricity supply, government policy will remain the key factor for some years to come.

Market challenges: Ontario

The recent evolution of the electricity market in Ontario serves as another example of the challenges. Ontario is a province of Canada, similar to Sweden in population and twice as big in area. In Canada, the provinces have jurisdiction over electricity, although the Federal Government has jurisdiction over nuclear energy. Electricity has traditionally been provided in Ontario by a vertically integrated provincially owned utility, Ontario Hydro. It used a mix of hydro, coal and nuclear capacity, the latter based on 20 CANDU reactors. The utility was a monopoly in Ontario, and effectively set its own electricity rates.

The Government of Ontario decided, in 1996, to move toward a competitive market. It broke Ontario Hydro up into a generation company, a transmission company, and an independent market operator, and strengthened the regulatory powers of the Ontario Energy Board. It decreed that Ontario Power Generation (OPG), the successor to Hydro on the generation side would retain control of only 35% of the generating market after 10 years. It planned to privatise the transmission company, Hydro One. Independent Power Producers were encouraged to enter the market.

Things did not go according to plan. The oldest seven of Ontario Hydro's 20 nuclear plants were shut down and mothballed in 1997 in a move to focus the company's resources on improving performance of the newest 12 reactors (one older plant had already been shut down). New investors were wary of investing in a system where the Government seemed unsure of how to proceed, and the transition to a truly competitive market was delayed. Some industries were granted special rates to remain in the province.

The shutdown nuclear plants were supposed to come back on line, but the OPG refurbishment suffered large delays and cost overruns. Private investors noted that they would not have been able to afford such cost overruns, implying that the competition from the OPG plants was unfair. OPG leased the Bruce plant with four shut and four operating units to British Energy. This represented about 20% of Ontario's electricity supply, but further diversification of ownership or control was very limited. British Energy, beset by problems in its home market had to pull out early in 2003, but new buyers were found. The Government had to shelve its plans to privatise Hydro One and when it decided to sell a 49% minority interest, no buyers were found at the appropriate price. Consequently, the Government decided to retain it in public hands.

At the same time, rate increases and the threat of shortages were causing concern among the public. In the summer of 2002, Ontario had to import a lot of electricity from coal fired generators in neighbouring US states, driving up both the cost of power and the environmental impact of electricity use in Ontario. Under pressure from constituents, the Government decided to put a price cap of CAD 4.7 cents per kWh on rates, which had been averaging CAD 6.1 cents, still fairly low in the North American context, but apparently unacceptable to Ontario voters. The Government pledged to rebate retroactively prices above that level, to repay customers who had signed contracts with independent suppliers at higher rates, and to avoid disconnecting low-income customers from supply during the winter, even if they did not pay their bills. While these moves will simply transfer the costs of electricity from ratepayers to taxpayers, who are largely the same people, the price signals will be much less clear. Overall, these initiatives will increase consumption and discourage investment in new capacity and transmission (although the Government planned a separate series of initiatives to attract investment), the opposite of what a reasonable policy should be trying to achieve.

Ontario probably has enough capacity and interconnections to weather the next crisis, and the shutdown nuclear plants should begin coming back on line this year. However, the Ontario Government's policy twists and turns will make investors wary of investing in new capacity until there is tangible evidence of a willingness to go to a truly fair and competitive market.

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3. AREAS OF GOVERNMENT INTERVENTION IN NUCLEAR ENERGY

Nuclear fuel production and supply

At the front-end of the nuclear fuel cycle, the intervention of governments has decreased considerably from the high levels of the 1970s. Most countries now place greater confidence in the international market to ensure a reliable supply of nuclear fuel at attractive prices. Fuel cycle services such as enrichment and fuel fabrication are readily available, with excess capacity and intense competition (Bertel and Wilmer, 2002).

Many uranium producing countries and regions, notably Australia, Africa, and North America, have moved away from tight control over amounts exported, foreign ownership, prices and contracts, and they have privatised mining and milling facilities. On the demand side for uranium and enrichment, the US restricts Russian imports and the European Union monitors imports, in particular those from Russia and Central Asia, to ensure diversification of supply. The European Union is subject to anti-dumping and/or countervailing duties upon import of enriched uranium into the United States. Some uranium companies that acted effectively as agents for their government's uranium procurement policies do not fulfil that function any longer. Indeed, an important share of fuel cycle facilities worldwide remains under public ownership (May, 2002). Where exporting and importing countries can both rely on the market or agree on harmonised controls such as non-proliferation requirements, they can reduce the level of intervention with uranium trade. The nuclear fuel production and supply has evolved in the following ways:

1. Non-proliferation concerns have not been a significant impediment to uranium trade in recent years. Indeed, it was non-proliferation concerns that resulted in the availability of uranium from dismantled weapons on the civilian market. In the 1970s, when non-proliferation controls were being instigated, and uranium prices were rising, there was concern that countries would have to agree to restrictive conditions on their uranium imports in order to obtain uranium, and that they would be pressured to accept high prices. Canada, for instance, terminated exports to Europe and Japan for

several years, pending re-negotiation of the conditions pertaining to nuclear exports. At the same time, it was renegotiating the conditions of its export contracts (Morrison and Wonder, 1978). Australia had a restrictive policy of new mine development from 1983 to the mid-1990s, and banned uranium exports to France on two occasions (Uranium Information Centre, 2003).

Since the late 1970s, OECD countries have largely adopted similar non-proliferation policies, involving the acceptance of full scope safeguards on the entire nuclear fuel cycle. Non-proliferation requirements are no longer a major concern for normal transactions under safeguards, nor are they a source of unfair commercial competition.

2. Enrichment and fuel fabrication services have become much more widely available as additional capacity was added in the 1970s and 1980s in anticipation of increased demand that never materialised. Although enrichment is still a sensitive technology, and facilities are limited to a small number of countries, the current facilities have proved to be more than adequate for supply. The US facilities were privatised and now operate commercially. In addition, the down-blending of highly enriched uranium from dismantled nuclear weapons has provided supplies of low enriched fuel without the need for enrichment facilities. Replacement of older less competitive gaseous diffusion enrichment plants with more advanced centrifuge technology is considered in France and in the USA.

3. Plutonium reprocessing and recycling as fuel are no longer seen as essential for the security of nuclear fuel supply, at least in the medium term, as they once were by several countries. Reprocessing is generally less cost-effective today, given the abundance and low cost of uranium supplies. A number of countries now use mixed oxide plutonium-uranium fuel (MOX) to fuel a percentage of their needs, but this practice is more limited than had been anticipated. MOX fuel supplies the equivalent of less than 2 000 tonnes of uranium per year (WNA, 2002). Reprocessing is a sensitive technology, because separated plutonium is potential weapons material. Therefore, reprocessing facilities remain in government hands.

4. In the 1980s and early 1990s, there was a concern among uranium customers that environmental assessments, concerns about aboriginal people, or outright political opposition would result in the delay or cancellation of uranium development projects in Canada and Australia. While most of these projects have gone ahead, other projects are on hold or have been discontinued. Jabiluka in Australia is an example of a high-quality deposit whose development has been halted for the foreseeable future due to political opposition.

Policies of Canada and the United States are illustrative of how far the uranium market has come since the 1970s. As a major uranium producer in the 1970s, Canada had a strong policy on foreign ownership of its uranium mines. The Canadian Government owned a major uranium producer and refiner, Eldorado, and the Saskatchewan Government had its own mining company. The Canadian Government bought and stockpiled uranium to keep some companies going. Uranium export contracts were reviewed at Cabinet level, with floor price a major consideration. Uranium producers had to set aside reserves to ensure that Canadian needs, projected over several decades, were met. A policy on further processing tried to ensure that the uranium would be refined in Eldorado's facilities (Morrison and Wonder, 1978). On the consumer side, the Government of the province of Ontario intervened in the price, duration and diversity of the uranium contracts of its government-owned utility, Ontario Hydro (Doern, 1980). All these policies have essentially gone now, or greatly diminished in their impact. The stockpile was sold. The two government mining companies were merged and privatised as Cameco, now the world's largest uranium producer.

The United States imposed controls on uranium imports in the 1970s, through conditions on enrichment, in order to protect its domestic producers. Since it was the world's biggest consumer of uranium, this had a considerable influence on the uranium market. Orderly marketing arrangements were organised by a group of non-US producers, including some government-owned companies, to try to influence prices and keep the industry going. Prices rose quickly in the mid-1970s from supply and demand considerations, and the marketing group soon disbanded. By 1980, prices were falling again, and have remained low since then. US controls on imports excepting those from Russia and Central Asia, were phased out in the 1980s, although some new ones have been imposed on Russian or Central Asian uranium. US uranium production fell from over 16 810 tonnes in 1980 to 1 077 tonnes in 2001 (NEA, 2001).

In Europe, the Euratom Supply Agency, operative since 1960 and based on the Euratom Treaty was established to ensure supply of nuclear fuels for European Community users by means of a common policy based on the principle of equal access to sources of supply. The Euratom Treaty gives the Supply Agency the right, in general, of option to acquire ores, source materials and special fissile materials produced in the Community and an exclusive right to conclude contracts for the supply of such materials from inside the Community or from outside. Currently, in order to be valid under Community law, supply contracts must be submitted to the Supply Agency for conclusion.

Plant construction and operation for electricity generation

Governments can be involved in plant construction and operation in several ways, and countries take very different approaches to the possibilities for government intervention. In general, governments are probably less involved in these mid-fuel-cycle activities than they were in the 1980s, with the exception of the core function of regulation for health, safety and environmental protection. Many government-owned utilities have been privatised or at least subjected to greater market competition and/or business discipline.

All OECD countries with nuclear energy programmes have licensing process for plant construction and operation mandated by legislation. The licenses are granted either by governments or by a regulatory authority that has a high degree of independence in its judgement but is ultimately responsible to the government. All OECD countries also have an environmental assessment process to ensure that the impact of a new plant is acceptable, especially if it is on a new site. The process in most cases will involve opportunities for public consultation or participation.

As signatories to the Convention on Nuclear Safety, OECD Governments agree to commitments in the area of nuclear safety, including an obligation to have a regulatory agency, which is independent, competent, functionally separate from the operating organisations, and endowed with the necessary authority and resources to do its job. They also agree to submit a National Report on nuclear safety to the IAEA and to undergo a peer review process every three years.

Governments may be involved in the choice of nuclear technology for a new plant, and in financial support of various kinds. They can encourage the refurbishment and life extension of plants. They may provide R&D support for new designs or, more commonly now, for research on safety and waste management. The US Government is considering partnership with the industry to encourage new orders for existing reactor designs. It is also supporting R&D for more advanced designs, jointly with international partners.

Nuclear technology may be a component of a country's energy policy for reasons of diversity and security of supply, or because of its contribution to air quality and emissions reduction. Governments may want to encourage new plants in order to maintain an active nuclear capability that keeps a nuclear option open for the future. They may also support new facilities for non-energy reasons, such as employment or regional development, although such motivations have not been much in evidence recently.

Some governments consider that nuclear energy must compete in the market on the same basis as other technologies. Finland and the United Kingdom are in this category. This is feasible more easily where the electricity utilities are privately owned. However, state-owned utilities are also under increasing pressures to operate on a business basis, and to make decisions on purely economic criteria. Some countries, such as the United Kingdom, find that nuclear power is not economic under current conditions of competition (UK DTI, 2003). Others, such as Finland (Ministry of Trade and Industry, 2001), France (Ministère de l'économie, des finances et de l'industrie, 2002) and Japan (METI, 2003) have found that it could be.

Governments may also take political decisions to forbid new nuclear plants and/or to phase out existing plants (e.g. Belgium Germany and Sweden). The phase-out is often conditional upon suitable replacement sources being found, or is mandated to occur at the end of the lifetimes of the existing plants. This can have the effect of postponing the actual closure of the plants for a decade or more after the decision has been taken.

Governments without nuclear programmes are often concerned about the safety of nuclear plants and other installations in neighbouring countries. They can pressure those countries to improve the safety of their existing plants, to limit releases of effluents, or to shut them down, to be replaced by safer nuclear plant designs or non-nuclear plants. All governments can assist with plant safety, through co-operation with the operators and international organisations and projects, in particular for strengthening safety in other countries. This has been the case with OECD countries helping the countries of Eastern Europe, some of whom are now NEA member countries. The European Union has also sponsored safety assistance for Eastern European countries that are in the process of becoming Member States of the European Union.

Transport

Transport of radioactive waste and nuclear materials has been an area of increasing policy interest, not least because it is seen by the anti-nuclear movement as an effective means of arousing public concern and getting more direct access to nuclear materials than is possible in industrial or research facilities. Pictures of opponents blocking rail or road traffic are more dramatic than demonstrations outside facilities seen distantly through chain-link fences. The idea of nuclear materials going through a community is one that readily raises fears, even though thousands of radioactive shipments, including medical radioisotopes, are carried out safely every year. Governments are responsible for the regulation concerning the safe transport of hazardous materials including the licensing of the packaging.

International transport of nuclear materials by ship or plane has also attracted public attention. It is an area that naturally lends itself to international co-operation. The IAEA, assisted by the industry, has been instrumental in developing a safety and regulatory regime that is accepted by almost all countries active in the transport of nuclear materials. The IAEA Regulations for the Safe Transport of Radioactive Material were published first in 1961 and have been revised several times since. Most countries have adopted them in their own regulations, and they have also been incorporated into the UN Recommendations on the Transport of Dangerous Goods, and into the various regulations for air, sea and land transport. The IAEA Regulations are based primarily on the integrity of the packaging as a means of ensuring safety (World Nuclear Transport Institute, 2002).

Decommissioning facilities and radioactive waste disposal

Contrary to trends at the front-end of the fuel cycle, the role of the government at the back-end has probably intensified in the past decade, as increasing attention is paid to decommissioning and long-term management of radioactive waste. Since there are very long-term liabilities associated with radioactive waste, and since it is an area of intense public controversy, governments are moving cautiously. They are simultaneously trying to deal with the technical, economic, safety and health and environmental protection issues involved, while also addressing the public concerns about social and ethical issues.

Government involvement in the back-end of the fuel cycle can take many forms. The government has the responsibility to define national policy on nuclear waste. It may carry out policy oversight and regulation, define the processes for funding, siting and environmental assessment of the facilities and possibly implement them. In some cases, governments build and operate the facilities, and perform R&D, either generic (Belgium, France) or site-specific (United States). In their policy making, governments have take into account international obligations into account. For example, European Commission proposed in January 2003 a Directive on radioactive wastes which seeks to establish a clear, transparent answer to the management of radioactive waste within a reasonable deadline.

Most governments already have responsibility for most historic wastes, produced before regulation and legislation were firmly in place, wastes from government-sponsored or government-owned activities, such as R&D, and, in some countries, wastes from weapons activities. When the government privatises nuclear organisations, it may take on the long-term responsibility for

wastes generated previously by that organisation, as the private sector buyers are not likely to want to take on such open-ended liabilities for wastes they did not produce.

In general, governments are now very conscious of radioactive waste liabilities, and try as much as possible to ensure that the cost of managing any wastes generated now or in the future will be paid by or recovered from the producing organisation, and that funding mechanisms are in place that will cover those costs. The operating licence for a nuclear facility may require that funds be set aside for the eventual management and disposal of wastes generated by that facility. In most cases, the operators will in turn pass the costs on to the customers as part of the price of electricity. This is the Polluter Pays principle: in this case paying not to clean up the pollution after it occurs, but to avoid pollution in the first place by containing the waste in isolation from the environment. In this respect, governments have largely succeeded in internalising the costs of nuclear waste management.

Looking at the longer term, one duty of governments is to ensure that funds will be available to carry out decommissioning and waste management for facilities that may not close for a century or more. This may require fairly sophisticated financial management of billion-dollar sums of money. The tendency in many countries is to move toward segregated funds to ensure that they remain dedicated to their intended purpose. It might be wise to adopt similar treatments for long-term legacy of other energy sources.

The government may require that the utilities set up, fund and manage a separate waste management organisation that has specific responsibilities for long-term management and disposal of the waste. This is the case e.g. in Canada, Finland and Sweden. The government provides regulation and oversight, and ensure that the funds are spent for the appropriate purposes.

In most OECD countries, decommissioning and dismantling of nuclear facilities are the responsibility of the operator and must be conducted under license. As with wastes, legislation generally exists to ensure that the operators are in a financial position to carry out decommissioning. A separate license is often required for decommissioning. One goal of decommissioning is to remove some of the regulatory requirements. Some governments will agree to take over responsibility for a site once it has been restored to green-field conditions. Also, governments are responsible for decommissioning their own facilities, which can include a spectrum of R&D, prototype and fuel cycle activities.

Useful experience has already been obtained in the decommissioning of a range of nuclear facilities in many countries. As the majority of the large

commercial nuclear power plants built in the 1970s and 1980s approach the end of their lives in a decade or so, a new set of challenges will appear (Wald, 2003). Decommissioning of major nuclear facilities is fairly complex, with a variety of wastes going to different disposal sites according to their physical form and hazard levels. The regulatory and financial rules concerning access to sites will also influence the distribution of the different wastes. Some wastes may remain at the site until permanent solutions are available, restricting the use of the land for other purposes. The local community will have an interest in the permitted uses for the site, and the time-scale on which these can be implemented. The success and cost of decommissioning existing nuclear reactors will influence the public's willingness to support new reactors.

Of course, broader government policies and regulations pertaining to health, safety and the environment at national or local levels can also apply to the nuclear sector. In Canada, for instance, any project that involves federal regulations can trigger the application of the federal environmental assessment act. Thus, assessments can be triggered by federal jurisdiction over waterways or migratory birds or fish. Since provinces also have environmental and resource responsibilities, a joint assessment process is often required.

Short-term storage and management of radioactive waste, including spent fuel, is the responsibility of the operator, usually as part of their operating license. For the longer term, central storage or disposal facilities may be required, subject to government regulation.

Although there are space limitations at some sites, storage of spent fuel at the reactor sites can be carried on safely and economically in most cases for many years. This means that there is no great technical urgency to move towards permanent disposal of the spent fuel. However, as long as there is no permanent, licensed disposal site, the belief persists to some extent among the public in some countries that there is no solution to the issues posed by spent nuclear fuel. Therefore, governments have to move toward concrete solutions: to develop processes that will ensure the funding, siting, licensing and effective operation of radioactive waste repositories.

Siting processes for nuclear waste facilities often require extensive public information, as well as consultation and participation. If the nuclear energy programme is considered an essential part of the national energy policy, or if the government is the proponent of the waste facility, the government may get involved in providing information itself. In other cases, the industry or an independent organisation will make the case for the facility. In any event, the regulator will have a responsibility to inform the public about the criteria and processes it uses to ensure long-term safety.

The environmental assessment may be the responsibility of an independent panel established for that purpose. The panel's findings may be binding on the government, or only advisory. Generally, governments reserve to themselves the ultimate decision. The role of local and regional authorities will be central. The choice of site may be the subject of local or national referenda. Even if the proponent is a private sector organisation, the government will have a keen interest in ensuring the legitimacy of the process and the acceptability of its outcome.

Many OECD governments have legislation that bans either the import or the export of nuclear waste, or both. The current idea is one of self-sufficiency. That way, a national government is not subject to accusations that it is acting as nuclear garbage man for other countries, nor that it is dumping one's garbage in other countries. In the long term, when several repositories may be in operation, economies of scale may bring about a greater degree of cross-boundary movement and international co-operation in the field.

The Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management obliges signatory governments to take a number of measures to ensure the safety of spent fuel and radioactive waste management facilities, and to submit national reports on their activities and policies for peer review every three years.

The United States has one permanent repository operating for military nuclear wastes, and is moving ahead with a spent fuel repository at Yucca Mountains in Nevada. Finland and Sweden have spent fuel disposal facilities under preparation. The French government authorised in 1999 the creation of an underground laboratory in clay in order to investigate the feasibility of deep geological disposal for high-level radioactive waste. Canada has developed a generic concept for radioactive waste disposal in the stable rocks of the Canadian Shield. An independent Panel advised the Canadian government that the concept was technically safe but that the level of social acceptance was not adequate. The utilities that produce spent fuel have set up a waste management organisation and will now move ahead to obtain public acceptance and regulatory approval for a site and a facility.

Uranium mine tailings raise specific environmental problems. Because of their large volume, they must generally be treated *in situ*. The long half-lives of the radioisotopes they contain necessitate a long-term approach to tailings management. The risks will vary from site to site, depending in part on whether the climate is wet or dry. There are risks from dust blowing around, and from liquid tailings leaking into natural drainage systems and watercourses. Historic wastes are generally under containment regimes, but there are continuing discussions in some countries about who bears the responsibility for their

management and final disposal according to modern standards. Licenses for current operations are generally dependent on assurances that financial and technical measures are in place to deal safely with the tailings in the long term. Such measures may also be the subject of environmental assessment processes for new mines. As noted, new mines in Canada and Australia have recently been authorised after extensive environmental assessments that looked in particular at the long-term plans for tailings management.

Fuel cycle operations in the former Soviet Union have led to environmental problems from fuel wastes, mine tailings and other radioactive wastes. OECD countries have assisted in remediation of these problems, but there is much work remaining to be done.

Low- and intermediate-level radioactive wastes constitute a broad range of substances, forms, and origins in OECD countries. In general, they do not pose a major threat to public health and safety due to their low radioactivity levels and, often, short half-lives. However, they are often large in volume, variable in concentration and distributed widely. The original producer is in some cases no longer in existence or does not have the financial resources required for clean-up and disposal of the wastes. Disposal can usually be carried out within surface or near-surface facilities, but their proximity to populations requires careful facility design and stringent regulation. The local community will be closely involved, as the presence of the wastes will influence their ability to attract people and investment.

Governments will clearly have an essential continuing role in finding acceptable solutions for the management and disposal of all radioactive, taking into account social and ethical as well as technical and economic issues.

Regulation of safety, security and health and environmental protection

The regulation of health, safety, security and environmental protection constitutes a core role of government. Setting out the specific regulations involves a range of technical matters but the government should decide on behalf of the public the level of risk that is acceptable for a given activity. This decision is essentially political. Only governments can ultimately be responsible for the legislation, the regulations, and the processes required to limit the risk to the level adopted. As long as public concerns remain, regulation of health, safety and environmental protection should remain a priority for governments.

The onus should remain on the operators to ensure safety, but governments should set out the framework. They should set firm but broad standards, and

leave as much flexibility as possible as to how the operators should meet those standards. Economic globalisation demands that these standards should be more and more harmonised on the international level. One example is the European Commission's proposed directive on nuclear safety.

Governments are obliged to ensure that a competent, independent regulatory authority exists, with the resources to ensure compliance. In cases where the government is taking a hands-off position on the future of nuclear energy, or is committed to phasing it out, it should pay particular attention to maintaining the capability and effectiveness of the regulator.

Emergency planning for nuclear incidents is an important responsibility for operators, regulators and governments at all levels. Plans for nuclear facilities should be closely integrated with the public health and security bodies, and should be tested from time to time, including their internal and public communication aspects. International collaboration can help to benchmark these tests, and may also address transboundary impacts.

The security of nuclear installations takes on a new light in the face of terrorist attacks like September 11, 2001. Concern has also been heightened about radiological weapons that do not involve nuclear explosions but simply disperse radioactive material around a region. Clearly governments have a responsibility to review the security procedures at nuclear plants, as for other critical infrastructure, and to implement both physical and procedural measures intended to counter any threats to security. They must also ensure that radioactive sources used in hospitals, industry and research facilities are not diverted for terrorism purposes.

The reporting relationship of the regulators within the government varies considerably within the NEA countries, as defined by their enabling legislation. Some regulators report within the same department as the nuclear policy people, though often they report directly to the Minister (or through the Minister to Parliament, as in the case of Canada). Others report to a separate Minister, usually of health or environment. In some countries the safety authority, like in Spain, reports directly to the Parliament. In others, like the United States, independent agencies such as the NRC are created by statute. All these arrangements are workable. Ultimately, though, the national regulatory body and its staff are creatures of the government and its policies, and the government is responsible for their actions.

Beyond the specific goals of regulation, it has become evident that a safety culture is an essential feature of a safe operating organisation. While inspection and monitoring are needed, one cannot inject safety into an organisation by

these means. Everyone involved with the operation must take safety as a top priority in terms of their own engagement. This requires specific training programmes and management systems related to safety.

A safety culture begins with the commitment of the company's senior management, including the Board of Directors. Executives must be directly engaged with safety matters, and reports on safety matters should have a reporting route straight to the top.

Regulators are trying to learn how to assess and encourage the degree of safety culture in organisations, as well as the commitment of the senior management. This involves looking at basic issues of governance. Of course, the same strictures about safety culture and senior management commitment should also apply to the regulator.

In a number of NEA countries, the operators cover most of the costs of regulation through licensing fees. This is in line with the idea of the "Polluter pays" (or that operators pay to avoid pollution). This makes the industry a keen observer of the expenses that the regulator incurs, in addition to the charges imposed on industry by the requirements.

Regulators generally take the position that they do not take costs into account when setting basic standards. An operator that cannot meet basic safety standards should not be in the business. Nonetheless, requirements can be imposed in a way that allows the costs of meeting it to be minimised, and the regulators' own operations should meet normal standards for efficiency and effectiveness.

Industry is generally concerned about the cost of regulation. It wants regulation to be based on a systematic assessment of risks, and to be cost effective in reducing those risks. The nuclear industry also wants assurances that it is not being regulated more onerously than other activities that present similar risks, and that costs of reducing risks are internalised in a fair way for all energy sources and all industries.

Countries planning to continue with nuclear energy programmes will want to ensure that regulatory processes are in place that will allow a fair and timely review of applications for refurbishment, uprating, life extension operation and construction of reactors.

To date, regulation of different industrial activities has tended to occur in isolation. There are separate regulatory bodies for each activity. They all want to keep their activities safe, and do not have much time to look at standards in other activities. No one in the government has the authority or knowledge to

harmonise standards and implementation across the whole range of regulatory agencies. A coherent approach to risk management across the government would be a major undertaking, but could have a number of benefits.

Because of the involvement of OECD governments in regulation across so many sectors, they are interested in developing overall approaches to regulatory policy. They set up principles, guidelines and appraisal systems to ensure the effectiveness of regulatory systems. They assess the costs and benefits of various approaches. And they look for new mechanisms of consultation to enhance the input of information to the process (OECD, 2002). Nuclear regulators can benefit from the new insights being generated by these developments.

Regulators keep in touch internationally to ensure that high standards for safety are being met everywhere. International organisations, such as IAEA and NEA, have an important role to facilitate this work. Regulatory systems will inevitably differ, but it is useful to harmonise them wherever possible, or to show that they achieve similar levels of safety. The public reacts badly when there are different standards on basic health issues, for no good reason, on different sides of a border, as was shown during the Chernobyl accident. Differing standards could also have an impact on trade.

Nuclear research and development

Nuclear energy is largely a creation of government-sponsored R&D. Its future still depends on the willingness of governments to invest in long-term R&D. In the past, they set up national or quasi-national nuclear R&D laboratories and employed thousands of people. They often had a close relationship or owned the reactor vendors as well as the electricity utilities. They co-ordinated the relationship between R&D, industrial development, and electricity generation. Through the 1990s, most OECD governments with nuclear programmes reduced the funding dedicated to nuclear R&D, both absolutely and as a proportion of energy R&D budgets, which were themselves declining. France and Japan are the main exceptions to this trend (IEA, 2000; IEA, 1999). Within energy R&D budgets generally, renewable energy sources and efficiency were assigned progressively higher priorities in many countries, such as Germany and the United Kingdom.

Priorities also shifted within nuclear R&D budgets. R&D for the safety of existing reactors and for waste management legacies took on greater importance. In some countries, such as the United States, there is a renewed interest in a next generation of reactors, Generation IV that would have lower capital and operating costs and enhanced levels of safety. Ten countries co-

operate with the United States to develop this new generation of reactors and fuel cycles. Earlier on, the IEA, the IAEA and the NEA carried out a study on innovative reactors focusing on opportunities for international collaboration for development projects (IAEA/IEA/OECD/NEA, 2002).

Governments were under pressure in the 1990s to limit spending and nuclear R&D was in many cases a target. The nuclear industry was seen as a mature one that does not need further government support for development whereas renewable energy sources still were perceived as emerging technologies that merit it (UK DTI, 2003). Where governments did spend on nuclear R&D, they tended to move away from government laboratories and state-owned firms, and to invest in partnerships with industry, other levels of government, and international projects. They saw themselves as facilitators and enablers, rather than direct sponsors (Blair, 2002).

Regulators should be able to commission independent R&D on safety matters. There is a concern that in a competitive environment, and with existing designs that have operated for several decades, operators may not be eager to support further R&D on safety. Safety R&D is a good candidate for international collaboration as it benefits everyone and it is not likely to be a source of competition (Frescura, 2001).

The private sector has not generally increased its spending on nuclear R&D to compensate for decreased government support. Competitive electricity market means that operators, whether private, recently privatised, or public, are less inclined to spend money on forward-looking R&D projects. The tendency is to spend on projects that have a clear short-term return or that are obligatory, such as improving operations and dealing with liabilities.

Funding for R&D is a measure of input only. However, these spending statistics are readily available, and serve as a useful indicator of the priority assigned and the effort undertaken in different sectors over time. It is much more difficult to assess the actual outputs and the return on investments in R&D. However, there is a general belief that R&D is a necessary precursor for a successful programme in nuclear energy, as in other energy and industrial sectors. An active R&D programme, with researchers on the leading edge of key fields, can respond to specific problems and generate results of direct usefulness for continuing energy programmes. It can also inform overall energy policy decisions about priorities and directions, by identifying promising new developments in other countries and trends of interest for the future.

A key issue is how funding and performance of nuclear R&D should be divided between the public and private sectors. In general, governments prefer

to see the private sector fund R&D that is close the market support for existing reactors and development of near-term commercial opportunities. Research to meet regulatory requirements is also seen as a cost of doing business. The government role is then to fund, and possibly also perform, basic, underlying, and long-term research, including the early stages of advanced reactor and their fuel cycle developments. Some R&D for public policy purposes, such as developing non-proliferation measures or cleaning up waste legacies, is also seen as a legitimate charge on the public purse.

Given the financial pressures they are under, however, governments often look askance at longer-term projects with risky and diffuse payoffs. They seek near-term, more direct boosts to the economy, which leads them back to nearer-term commercial developments and partnerships with industry (OECD, 2002). Both short- and longer-term R&D programmes can benefit from international collaboration, especially if they involve large-scale projects that can strain the resources of individual countries. The UK Royal Society suggested that given the revenues from global electricity generation of about USD 800 billion, an expenditure of USD 8 billion, or one per cent, on international energy R&D projects would not be excessive (The Royal Society and the Royal Academy of Engineering, 1999), although an amount close to this sum is probably being spent already by national governments, some of which is dedicated to international projects.

Civil nuclear liability

Most OECD countries have adopted special liability and compensation legislation to ensure that those who would suffer damage as a result of a nuclear accident have recourse to adequate compensation. These special regimes are unique, deviating as they do from the normal legal principles that determine liability for damages resulting from a hazardous activity (NEA, 2003).

Under these regimes, the operator of a nuclear installation[1] is both strictly and exclusively liable for nuclear damage suffered by third parties as a result of a nuclear accident occurring at its installation or involving nuclear substances coming from that installation. However, a limit is usually placed upon the amount of that liability as well as upon the time within which claims for damages must be brought. Within the OECD, the operator of a nuclear

1. While the definition of nuclear installation may vary somewhat from country to country, it generally includes nuclear reactors, nuclear fuel fabrication and processing plants, isotope separation plants, irradiated nuclear fuel reprocessing plants, and facilities for the storage or disposal of nuclear fuel or radioactive products or waste.

installation is required to maintain financial security covering the amount of its liability to ensure that funds will be available to compensate the damage suffered. Although this financial security may be obtained through a variety of means, e.g. a bank guarantee, a pledge of assets, a State guarantee or through a form of State insurance, in practice, private insurance is the most common form of financial security.

Given the risks involved and the large amounts of coverage required, it is impossible for individual insurance companies to insure this risk on their own. As a result, within each country private nuclear insurance is provided by a "pool", a group of insurance companies who have joined together on a co-insurance basis.[2] Since their creation in the mid-1950s, the capacity of these pools has increased many times over – not only because more companies join but because with increasing experience, they are able to assume more risk. Nevertheless, even with this pooling of resources, their total financial capacity is still usually less than the amount of financial security required of the operator of a nuclear power plant. Consequently, the national pools work with other national pools to obtain coverage for the balance. Generally, the sponsoring national pool commits itself to provide the full amount of insurance to the policyholder and then reinsures[3] most of that amount through re-insurance contracts with another pool.

It is acknowledged that operator liability amounts may not be sufficient to cover the consequences of a catastrophic nuclear accident. Therefore, most OECD member countries have mechanisms or policies in place to provide victims with additional financial assistance or compensation, out of public funds, in the event that the operator's financial security is not adequate to compensate the damages incurred. Specific measures and amounts vary from country to country. In addition to these national compensation regimes, many countries are signatory or party to one or another of the several international conventions that establish liability and compensation regimes to manage the complicated process of claiming compensation for a nuclear accident with transnational effects. These conventions include:

- The 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention).

2. Co-insurance means that a number of insurers collectively insure a certain risk, the sum of their individual shares totalling 100%.

3. Re-insurance is where an insurer or co-insurer cedes part of the risk it has assumed to another insurer for which it pays a premium, essentially insuring the risk it has itself insured.

- The 1963 Brussels Convention Supplementary to the Paris Convention (Brussels Supplementary Convention, BSC).
- The 1963 Vienna Convention on Civil Liability for Nuclear Damage (Vienna Convention).
- The 1988 Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (1988 Joint Protocol).
- The 1997 Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (Vienna Amending Protocol).
- The 1997 Convention on Supplementary Compensation for Nuclear Damage (CSC).

The Paris and Vienna Conventions as well as the Vienna Amending Protocol contain the same basic principles:

- Strict and exclusive liability of the operator for third party nuclear damage.
- The operator's obligation to secure this liability financially.
- Limitation on the amount of operator liability and a time limit within which victims must bring their claims.
- Non-discrimination among victims on grounds of nationality, domicile or residence.
- Unity of jurisdiction, meaning that one single court determines all claims for compensation resulting from a particular accident.

The 1988 Joint Protocol acts as a geographical link between the Paris and Vienna Conventions. The Brussels Supplementary Convention provides for compensation supplementary to that called for under the Paris Convention. The CSC is designed to provide for compensation supplementary to that called for under either the Paris Convention, the Vienna Convention or the legislation of an Annex State as defined in that Convention. Both the Paris and Brussels Supplementary Conventions are currently in the process of revision.

Many countries that generate significant amounts of nuclear electricity are not party to these conventions, e.g. Canada, China, Japan, the Republic of Korea, the Russian Federation, Switzerland and the United States, but most of them have adopted identical principles in their national legislation.

Non-proliferation and physical protection

Intergovernmental agreements on non-proliferation of nuclear weapons are among the most important international instruments for peace and security. The basic solutions to proliferation issues are political, including the possibility of reducing the incentives to proliferate. Governments have a key political role in this regard. The NEA is concerned only with peaceful uses of nuclear energy. Non-diversion and non-proliferation issues are addressed in other international fora, notably the IAEA. However, non-proliferation policies affect NEA member countries and may affect the activities of the Agency.

The key technical factor for the manufacturing or illegal acquisition of nuclear weapons is access to fissile nuclear material and production technology. One possible route to obtaining such materials and technology is the civilian nuclear cycle, even though most countries with weapons have obtained them from dedicated facilities separate from civilian nuclear power programmes. IAEA application of safeguards on nuclear materials, including accounting for all nuclear materials in the civilian nuclear fuel cycle, are one way for countries to build confidence by demonstrating the absence of diversion. Safeguards based on the Non-Proliferation Treaty (NPT) involves measures to detect diversion from the civilian fuel cycle and also to detect so-called undeclared nuclear material and activities (i.e. where a State has failed to report to the IAEA something that it should have reported). It is a primary responsibility of governments to create the means of fulfilling their obligations under the NPT.

Normal power reactor fuel is not directly useable in nuclear weapons. The fissile material has to be separated. Reprocessing facilities that separate plutonium from spent fuel are sensitive, as although the plutonium issued from nuclear power plant spent fuel is not suitable for the manufacturing of nuclear weapons because of its isotopic composition, could be useful for trying to fabricate a crude explosive device.

At the front-end of the civilian fuel cycle, uranium for reactor fuel is generally used in its natural state, or enriched to a few percent fissile material. Low enriched uranium is not weapons suitable material. However, uranium enrichment facilities could be reconfigured to produce highly enriched uranium, and are, therefore, considered sensitive.

In general, barriers to material diversion are included in the civilian nuclear fuel cycle facilities to make it as difficult as possible to divert nuclear material undetected. Such barriers are best incorporated at the design stage. Retrofits may be costly and inefficient. Thus new reactors, and the fuel cycles associated

with them, should be designed in such a way as to make diversion even more difficult, and to make materials accounting verification simple and transparent. In addition, research on nuclear fuel cycles should take into account non-proliferation concerns.

Dual use equipment that can be used both for both civilian and weapons purposes are a challenge to the export control regimes. Governments have to exercise great care in the export of such equipment. For this purpose, the Nuclear Suppliers Group (NSG) was established in 1975 and the participating nuclear supplier states seek to ensure that nuclear trade for peaceful purposes does not contribute to the proliferation of nuclear weapons. The NSG has developed a series of guidelines governing the transfer of key materials and technologies including dual use items and technologies that participating states apply in making decisions about exports. These Guidelines facilitate the development of trade in this area without hindering international co-operation but in a manner consistent with international nuclear non-proliferation norms. Preceding NSG, the Zangger Committee developed a trigger list of especially designed or prepared nuclear equipment as an aid to States party in interpreting the NPT.

Governments also have an obligation to ensure that effective physical security measures are in place at nuclear installations. The stringency of these measures is graded according to the type of material and/or facility and their usefulness for nuclear weapons development. Renewed concerns about proliferation focus on the possibility of using different nuclear materials in radiological weapons or explosive devices that would disperse radioactive matters.

The diversion and proliferation problems have probably intensified since the end of the Cold War. Thus governments should continue to be highly vigilant in their civilian nuclear energy activities to make sure they do not contribute to the spread of potential nuclear or radiological weapon development.

Public information and communication

At a minimum, governments will want to ensure that there is an adequate basis for public discussion about important or controversial national issues. Nuclear energy will often fall into this category. Governments will want to have confidence that the regulator provides information that allows the public to understand the established basis for maintaining safety. Governments also have a responsibility to provide information about how they plan to achieve the three

energy goals, and about longer-term scenarios and the uncertainties that surround them. For current activities, they may leave industry to interact directly with the public about its operations.

In a democracy, the people elect the government to make decisions for it. In many current issues, particularly involving projects with local impact, the public wants to participate more directly. The argument in favour of broader public participation in the decision process is that:

- It provides essential information about the community and its values, and about the specific impacts of the project, and allows for the discussion of public concerns and aspirations.
- It responds to issues of equity and transparency by ensuring that people's views are given a fair hearing and that the relevant information for the decision is open to all.
- It legitimises the decision process, making the ultimate decision more acceptable. If people see that they have been able to voice their concerns and present all relevant information, and that their views have been heard and considered, they are more likely to accept the decision.

Broader participation is considered to be an optimal solution in part because other approaches have often failed. In some cases, governments have been forced to retreat from positions because opposition has mounted. In the absence of thorough public discussion, misleading or biased information may influence public opinion. In other cases, forceful government leadership has been able to achieve desired goals, but if there is a political base for opposition, it may surface at a later date.

Thinking about risk management communication has evolved over the past few decades (Fischhoff, 1995). Originally, people believed that one had simply to explain the science and the public would be comfortable. Then it was recognised that the public interpreted messages differently from the scientific community and that many factors were involved in people's responses; fear or dread, trust in people or institutions, degree of control or voluntariness, uncertainty, familiarity, etc. Messages had to be carefully tailored to take into account the public's prior knowledge, its psychology and values, and its likely response. Then it was realised that this too might be seen as manipulative and that the best approach to important controversial issues was to allow full public participation, and to let the information flow be determined at least in part by the participation process, i.e. people would define their own information needs.

As an approach to decision making, broad public participation is still at an early stage in terms of establishing a track record. In each situation, it will have costs and benefits, and its effectiveness will depend a great deal on specific circumstances. For the present, with controversial issues like nuclear energy, it may prove, in many situations, to be the best way to proceed, and seems to be increasingly sought by the public. The government has the ultimate oversight of the processes for public participation, and for ensuring that they are harmonised with the institutions of representative democracy.

One of the trends that may result from greater public participation in decisions about broad social issues like nuclear energy is that people want to discuss social and ethical issues rather than technical ones. This is simply the recognition that many decisions about facilities and siting are inherently political. The challenge is to incorporate into the decision process both people's views on social and ethical issues and the best possible science. Again, the broadest possible discussion consistent with the importance of the issue would seem to be the best solution. Ethical and social issues might appear as a cover for anti-nuclear views, but that would be to underestimate the social and ethical arguments in favour of nuclear energy.

Public participation can be a long and labour-intensive undertaking. But the costs are still a small fraction of overall project costs, millions against billions for large projects. If the empirical evidence in a given situation is that the public wants to focus on social and ethical issues, it would be useful to ensure that adequate resources are provided to support these kind of discussions, as they are for technical discussions.

As an essential international forum for high-level technical discussions, the NEA should maintain its capabilities in this field. However, if member countries' governments are dealing increasingly with social and ethical issues on their nuclear files, the NEA might have a complementary role in developing relevant information about these areas.

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4. INSTITUTIONS AND POLICY INSTRUMENTS

Institutions

This is a major topic that could involve a full review from the perspective of political science and public administration. How are the people governed? How are key government decisions made? Only some of the major institutions and instruments that influence government policy on nuclear energy will be considered below.

Central bodies of government

The dominant influence on nuclear energy policy is probably the policy approach of the government to the economy and the environment. Generally, OECD Governments profess to favour markets and competition to a greater degree than 20 years ago, and are less inclined to intervene, certainly in terms of normal business operations and decisions. However, as an IEA study of the role of governments in energy policy notes, it is recognised that governments should set up the framework within which companies should function (IEA, 1996). Governments should establish, monitor and enforce well-functioning markets and rules of competition. Competition may lead to innovation and promote exportation. The overall approach of government to these areas may influence their nuclear energy policy.

It is recognised that markets cannot perform some core functions of government, such as the determination of overall policy, legislation and regulation, and the implementation of some projects that involve long-term risks and benefits. Governments may also be involved in setting up broad processes for the siting of facilities and the assessment of their environmental impacts, and in deciding on the degree of public consultation and participation they entail.

Requests for funding remain a major reason for government intervention. These tend to get attention throughout the chain of command, especially in a time of government restraint. In fact, they provoke perhaps the closest scrutiny

and the greatest debate that projects receive in their lifetime. Once the funds are granted, projects tend to get rather less attention, despite the occasional efforts of critics and auditors. While decisions on funding can be made independently from policy goals, and for different reasons, the overall pattern of spending in an area like nuclear energy can be a good guide to the government's overall policy.

The respective roles of ministers, their departments, parliament, traditional policy bureaucracy, regulatory agencies and the government-owned companies will vary from country to country, from issue to issue and from time to time. Along with the Cabinet and Ministers, Parliament or Congress and related government committees will be critical, as the crucible of legislation, and as a forum for research and discussion. Key institutions in setting policy will be the central agencies of government and the economic departments e.g. the department of finance or treasury, departments of trade and industry, economic development, etc. To the extent that international trade in materials, equipment and technology, or concerns about non-proliferation, are important for a country, its department of foreign affairs may have a dominant role. It is also noted that environment departments play an increasing role in energy policy, including nuclear energy.

Energy policy officials

The contribution made by nuclear energy is strongly conditioned by overall energy and electricity policy. It is a central decision as to whether its deployment is left to market to decide or whether government intervention is necessary. As noted earlier in the paper, three goals of energy policy, common to most OECD countries, can be generally expressed as:

- Secure and adequate supplies of energy.
- Affordable and competitive costs.
- Acceptable environmental impacts.

The world is 90% dependent on fossil fuels, and this high level of dependence is expected to continue under "business-as-usual" scenarios as fossil fuels are expected to continue to be relatively cheap and abundant. Energy demands will grow significantly over the next few decades, and fossil fuels will be the most obvious source to meet that growth. Yet the world wants to improve air quality and reduce greenhouse gas emissions. Clearly purposeful government action will be required to achieve these goals of energy policy.

Governments may feel obliged to intervene on security and diversity issues, especially where dependence on energy imports is concerned. Other aspects of energy policy will involve government's role in the innovation system, in regional or national development, in trade, and in ensuring fair access to energy supply for everyone.

In most OECD Governments, energy matters are addressed by divisions within the broader departments or ministries of industry, trade and economic development. In some countries, such as Canada and the United States, there are separate departments of energy or energy and resources.

Health and environmental policy officials

Governments are concerned with the vulnerability of the critical infrastructure to accidents, to attack, to common-mode failures or to natural disasters (e.g., ice storms that bring down power lines). They certainly have a continuing role in regulation, for both health and safety and environmental reasons, and also to ensure effective and efficient markets.

Because health and environmental impacts are now a major aspect of energy policy, departments responsible for health and environment will play an increasingly important role. Health matters related to use of nuclear energy have generally been dealt with by agencies that specifically regulate nuclear energy, whereas environment impacts, which often include health impacts, have generally been characterised by the development of independent environmental legislation, processes and institutions. For example, governments may set up separate agencies responsible for environmental assessments of major projects, who may then establish terms of reference and panels of independent citizens to carry them out. The reports of these panels may be binding or advisory, but even in the latter case, will have a great influence on government decisions.

Nuclear energy policy officials

Nuclear energy policy is often developed by groups within the departments responsible for overall energy policy. In some cases, the nuclear work forms part of an electricity group. Countries with significant nuclear power programmes may set up a separate nuclear division, on par with oil, gas, coal, energy efficiency and renewable energy sources.

The size of the team in charge of nuclear energy policy within governmental bodies varies from country to country, according to the

importance of the national nuclear energy programme and to the policy options adopted by the government. In some OECD countries, nuclear policy typically requires a staff ranging from a few people up to 20 or 30, responsible for issues such as legislation and policy, fuel supply, generation, R&D, data and analysis, radioactive waste management and nuclear exports.

The group members liaise with other departments on cross-cutting issues such as health and environmental impacts, non-proliferation and security issues. They also represent their country internationally in fora like the NEA, perhaps jointly with staff from foreign affairs or environment ministries.

Nuclear regulator

Countries with active nuclear power programmes will generally have an independent safety regulator with staff that may number in the hundreds, and budgets in the ten or hundred million dollar range. In many cases, that budget is largely cost-recovered through plant licence fees.

While ideally independent, the regulator is ultimately dependent on government for overall policy direction, legislation and for the appointment of its top officials. It should have the requisite competence, resources and authority to carry out its job.

In countries without nuclear power programmes, the relevant regulation of radioactivity and its impacts will usually be done within health and environment departments.

Provincial and state governments

Provincial and state governments may have responsibility for electricity supply and perhaps even for licensing nuclear plants within their jurisdictions. If so, they will have a range of institutions similar to those of national governments.

Different levels of government may have joint jurisdiction in some areas, such as for the environment or emergency responses. One of the challenges in federal systems is to ensure effective co-operation between the different levels of government and to avoid overlap and duplication in regulatory and policy matters.

Intergovernmental organisations

The intergovernmental organisations, such as IAEA, IEA and NEA, are vehicles for the governments of their member countries to facilitate collaboration. Their role is to assist governments and they often serve as a platform for international agreements.

The European Commission, however, has a right of initiative. This right empowers and requires the Commission to make proposals on matters contained in the EU and Euratom treaties. The Commission has also some executive power on some matters defined by the treaties, such as R&D programmes and radiation protection.

Government-controlled or owned entities

Some OECD countries have large state-owned nuclear R&D establishments, reactor designers and vendors, uranium and fuel supply companies, electricity generating companies, or liability management companies. These organisations are often large and powerful, with hundreds or thousands of employees. They generally report directly to the relevant ministry, may operate under contracts or agreements with that ministry and provide advice on policy issues upon request.

Generally, senior ministerial staff and policy advisers refrain from interfering in the day-to-day operations of the government agencies or companies, but may be compelled to interfere if significant problems occur, or if controversy arises. When government-owned or controlled companies are operating in competitive markets they have to compete with private companies and government intervention should be designed and managed accordingly.

Governments have an important role in ensuring that the privatisation of their own companies is carried out effectively. They should structure the privatisation so as to attract several bidders, structure the market so a previous monopoly does not retain too much incumbent power as a private entity and ensure that public policy needs continue to be served, for instance the reliability of electricity supply. The same objectives apply to the commercialisation of government-owned companies, i.e. the process of providing greater independence and a business-like mandate while retaining ownership, possibly as a prelude to privatisation.

Private industry

Private firms carry out a range of nuclear energy activities: electricity generation; design and marketing of reactors; mining of uranium and production of nuclear fuel. They are active in fields like nuclear component supply, engineering, research, and consulting. Even in countries where the major nuclear companies are government-owned, many private firms take an active interest in the nuclear industry. They will often come together in a national nuclear industry association to promote nuclear energy to the government and to the public. Private industry often provides support for the state-owned sector by means of commercial contracts.

International nuclear industry associations also represent various aspects of the nuclear industry's interests, such as World Nuclear Association, formerly the Uranium Institute and the World Association of Nuclear Operators. National nuclear industry associations exist in many OECD countries.

Professional associations and universities

Nuclear scientists and engineers in many countries form professional associations, similar to those for physicists or doctors, such as the American Nuclear Society, the European Nuclear Society and the Société française d'énergie nucléaire. Their meetings and communications generally focus on scientific, technical and professional matters, but they also make effective contributions to policy debates on nuclear energy. University professors and researchers are often seen by the public as more independent than those working directly for governments or for the industry. They can function as sources of independent expert opinion through publications, seminars and web-sites, and may serve directly on advisory or public panels.

Non-governmental organisations

A broad range of non-governmental organisations are active in nuclear energy policy. Many receive funding from governments, and participate actively in government processes, such as parliamentary committee hearings, environmental assessment processes, etc. Some of them have observer status at intergovernmental conferences, or serve as part of government delegations.

Much of their activity is directed to influencing government policy, primarily through mobilising public opinion. They have well-honed skills in this

area, through the media and through their own communications processes such as newsletters, e-mail and demonstrations. Some of them carry out their own research programmes.

They have had a profound influence on public opinion and public policy, representing themselves as defenders of the broader public interest against the supposedly narrower interests of the industry. Without necessarily accepting all their positions at face value, the public seems to appreciate the role they play as a kind of informal opposition, industry watchdog and independent source of opinion and advice.

With all these players, is there a healthy process for informing the public and for advising the government? Are the institutions up to the task? Do new forms of information provide opportunities for better-informed public debate or do they simply dumb it down? What can governments do to improve both public participation and the quality of public debate on a topic like nuclear energy that is highly technical, emotionally engaging, and pervasive in its impacts?

Policy instruments

The IEA study (IEA, 1996) lists five kinds of instruments that governments can use to influence energy policy.

Economics

Economic instruments include taxes and subsidies. The benefit of using economic instruments to influence the behaviour of individuals or organisations, as compared to command-and-control regulation, is that the government can establish goals and then let the agents decide how best to achieve them. This allows greater flexibility and ensures that agents will seek out the most cost-effective ways of meeting their goals, rather than having them prescribed by regulations. Indeed, studying the overall impact of economic instruments in the energy sector would be a major research programme in its own right. The following sections address some aspects especially relevant in the field of national nuclear energy policy.

Taxes and emission permits are means of internalising the external costs of an activity, costs that would otherwise be borne by citizens at large, now or in

the future. For instance, a tax on carbon emissions will encourage emitters to find cost-effective ways of minimising their emissions as passing the burden to consumers is an increasingly challenging move in competitive markets. Economic instruments could include tradable permit regimes. Where taxes influence price directly and let emissions find their own level, a permit regime establishes limits on emissions, and allows companies to trade emissions within those limits so that prices will find their own level.

Subsidies have the fatal attraction for governments that they can be targeted directly to worthy goals or firms. Industries that are emerging or being phased out, projects that stimulate national independence or regional development, or benefit specific groups of people, can all be designated to receive subsidies. The downside is that subsidies can be awarded for a range of reasons, some of which can distort the market, protect sectors or groups from competition, encourage unrealistic expectations, send the wrong price signals, and become a near-permanent drain on the treasury. Subsidies should always be carefully and targeted with well-defined specific goals, and they should be time-limited and reviewed regularly as to their impact.

The energy sector benefits from subsidies in different forms: R&D costs, of which nuclear has had a healthy share, at least until recently; direct subsidies or guaranteed markets for domestic coal; tax breaks on exploration or depletion for oil and gas; special levies or portfolio standards to promote renewable energy sources; government programmes to encourage conservation.

Areas of interest for the nuclear sector with respect to economic instruments currently include carbon taxes, which would favour nuclear and most renewable energy sources over fossil fuels. The nuclear industry in most countries already internalises most of the costs of operation through strict safety regulation, strict and exclusive liability for accidents, and by incorporating the costs of decommissioning and waste disposal into current electricity tariffs. In the nuclear industry's view, internalisation to the same degree of the costs of climate change, air quality and land use would help to create a fairer market regime.

International trade

Governments can impose export and import controls. Importing countries may want to limit imports in order to reduce dependence and protect domestic industries. Exporting countries may want to ensure that exports take second place to domestic needs or that they capture the full rents the exporting country feels entitled to, including the benefits of further materials processing within the

country. In general, as noted above, OECD countries have moved toward a greater degree of confidence in competitive international energy markets, including nuclear energy, to provide reliable supply. They are less interested in self-sufficiency and more focused on finding goods at the lowest cost.

Governments can also play an essential role in promoting trade. They can provide financing or guarantee loans through government export promotion agencies, and broker deals involving joint ventures with other countries. OECD countries have agreed to lend money for nuclear projects only at commercial interest rates as defined by the OECD, removing this factor from direct competition. They can still offer other amenities of various kinds, such as warrantees, training, regulatory assistance, etc. Through ministerial visits, public statements and other forms of support, governments can play a key role in the terms and acceptance of major contracts.

Ownership

Ownership of a nuclear company can provide a direct channel of influence for the government on the industry. It can decide the company's priorities and direction. However, there is increasing pressure for government companies to operate in a more business-like and transparent way, particularly if they are subject to market competition. This limits the degree to which they can serve other goals such as employment. In general, governments are now tending to provide an overall framework and set of objectives within which their companies can operate, but to leave them free to decide themselves how best to achieve those goals.

There is an interesting parallel between ownership and regulation. In both cases, they work best if the company is given an overall goal, including a need to change, and is then left free to pursue it in their own way. In both cases, the reason is that the company is likely in the best position to respond to challenges and to decide and implement the best course of action, since it has the incentive, the information, the people, and the review and feedback mechanisms to identify, compare and act on the range of options. An outside body trying to impose a detailed solution will be more likely to fail in these areas.

Government ownership can shade over into partnerships, alliances, and networks where the government plays the role of facilitator or of one financial contributor among others.

The other side of ownership is privatisation, which can mark an important government move to withdraw from intervention and to give more play to

market forces. Governments of NEA countries have successfully privatised uranium mines and refineries, enrichment facilities, nuclear power plants, radioisotope companies, and even R&D and waste management operations.

Regulation

Regulation, as noted throughout this document, is an indispensable function and responsibility of governments in order to ensure both effective economic markets and acceptable levels of health, safety and environmental protection. Because regulation has such a profound influence, governments are looking for ways to ensure that regulation is both effective and cost-effective. Traditional regulation and standard setting is expanding to include softer arrangements such as guidelines, self-regulation by firms and industries and various voluntary schemes.

Portfolio standards are a way of creating markets for introducing new technologies. These standards mandate that a certain percentage of activity in a given area should be carried out in particular ways. For instance, a certain percentage of new houses can be required to meet a high level of insulation standards, or a percentage of a new vehicle fleet can be mandated to meet low-emission standards.

Regulation is generally becoming less prescriptive, although demands for documentation are increasing. The tendency is to set clear regulatory goals and let licensees find their own ways of meeting them. At the same time, the importance of safety culture in nuclear and other organisations is becoming more recognised, as is the responsibility of senior management for ensuring its implantation within the organisation. Regulators are looking for new ways of assessing the effectiveness of management in implementing a safety culture.

The regulatory burden is always a concern to industry, especially so in competitive environments, and the nuclear industry is no exception. Recovery of the regulator's costs from industry, and the additional costs imposed by regulation on the industry, means that the actions of the regulator come under closer scrutiny. Regulators are under pressure to justify their regulations and the way they are enforced in terms of their impact on the reduction of real risks.

International standards and guidelines are becoming increasingly important, in nuclear energy as in other sectors, and governments are usually keen to influence these before they are finalised and agreed upon.

Research and development

R&D is clearly an area where the role of government is important. One challenge is to define what R&D should be carried out on a commercial basis by business or government firms operating in the nuclear sector and what should be funded by taxpayers. Generally, the government role is to fund riskier, longer-term, more fundamental R&D and to let the industry fund R&D that is more directly related to the market. However, governments are less patient these days about long-term payoffs and are looking at ways to have a more immediate effect, through partnerships with industry, on projects that bring near-term benefits.

Another challenge is the allocation of energy R&D resources among the different energy sources and technologies. Nuclear energy has had the lion's share of government funding for energy R&D in many OECD countries (56% in IEA countries in 1994, including countries that have no nuclear power programmes [IEA, 1996, Figure 2]). The issue now is how much nuclear R&D can be justified, in competition for public funds, to ensure the safety of reactors as they age, to clean up past legacies, or to prepare for the next generation of nuclear reactors and their the fuel cycles. There is concern that R&D funding and facility support for nuclear safety research is not keeping pace with the need to do research on ageing systems. Greater international efforts would allow to work more efficiently by sharing between several countries activities and expenses which would otherwise have to be supported on a national basis.

Another issue is how the nuclear R&D fits into national innovation systems generally. This includes the new institutional forms that are different from the traditional government laboratories: partnerships or strategic alliances with industry, universities and other networks within governmental bodies, centres of excellence.

Public information and participation processes

These are addressed in Chapter 3.

Decisions, actions and statements of government policy

Decisions, actions and government statements of policy will influence public opinion and the market, and be fed back, perhaps amplified, into further government processes. A clear and reasoned statement of the government's policy intentions with respect to nuclear can be very helpful to all concerned. Clear leadership positions or funding decisions, whether for or against nuclear

energy, or leaving support conditional on external factors or future developments, are instruments that can both test and influence public opinion. The response of the public and the market will in turn influence government thinking on future policy.

International agreements and co-operation

International agreements and co-operation may be effective instruments of nuclear policy. International organisations like the NEA and the IAEA play an important role in providing access to exchanges of information and reviews of experience. Treaty commitments, international agreements, international standards and guidelines, and consensus statements of the type developed within the NEA can be helpful to individual countries. For instance, the nuclear safety and waste conventions developed through the IAEA provide guidance to countries for their own legislation and supply a forum for reviewing national programmes and demonstrating commitment to safety (IAEA, 2003). The NEA plays a similar role in developing the international nuclear liability conventions (NEA, 2003). Governments may find it easier to advocate difficult measures if they represent obligations based on an international consensus.

Arrangements for technical assistance, technology transfer, and co-operation on joint R&D or safety projects can also be of help, especially for those countries with small, or new, nuclear energy programmes. However, co-operation can also benefit the countries with large nuclear energy programmes as well, as their demands are greater, and they are often in need of facilities, funding and expertise that can only be provided internationally.

Training and education and manpower policies

One of the critical challenges facing the nuclear industry over the next decade is to renew its workforce. The demographics tend to emphasise the prevalence of older workers and professionals, who will be retiring soon. A manpower policy is needed that will recruit a new generation of workers, primarily professionals, into the industry and maintain their skills through lifelong learning. This is industry's responsibility but the pursuit of government responsibilities, e.g. safety, calls upon the same resources. Renewal presupposes an adequate pool of potential employees at a high level of preparation before they enter the industry. Nuclear energy needs highly skilled people across the entire spectrum of occupations. Thus a whole range of government policies in education and training are brought into play.

As these policies are not likely to be developed on the basis of the nuclear industry's interests alone, the nuclear sector will have to co-operate with other sectors to make sure that the needs are met. This will involve efforts to bring out the best abilities of all components of the national society, through adequate education and training.

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5. THE NEW CONTEXT AND THE ROLE OF GOVERNMENTS

New context

The new context, resulting essentially from market deregulation and the recognition of sustainable development goals, raises challenges for meeting the three energy policy goals simultaneously: competitive markets, energy security and environmental protection. These energy policy goals are difficult to achieve together, as each mechanism requires both short- and long-term actions and as each has potential conflicts with the others. Furthermore, energy has become increasingly international, from both regional and global perspectives that force individual countries to make domestic trade-offs in terms of freedom of choice of energy options.

Competitive markets are seen in some countries as a means to encourage efficient production and reduce domestic electricity prices. Because of the opening of electricity markets to international competition, government's role is changing. Policies to foster competition at the domestic level can be complicated by competition at the international level.

In addition to trade and industrial competitiveness, energy policy in many countries is driven by existing natural resource availability, extraction costs, energy security requirements for imports, and domestic environmental regulations. Markets alone are not capable of incorporating these policy requirements into electricity generation choices. It is the role of government to create the framework that incorporates these external factors into marketplace considerations.

What is the government's role in the frameworks of energy policy, electricity markets, nuclear energy policy, and regulatory policy? Governments now have a wide choice of policy tools ranging from strictly macro-economic market regulation, through investment and tax incentives, to environmental standards and their enforcement, that affect the availability of electricity generation.

Energy policy framework

All governments have an obligation to implement realistic policies that will meet the three main goals of energy policy, and indicate what mix of approaches they will use. They need to invest in the necessary technologies, infrastructure, and programmes that will get them there.

One of the key roles of governments when framing energy policy is minimising interference in the marketplace while levelling the playing field for all options. The energy policy goals have remained more or less the same for most OECD countries for more than a decade. The challenge of achieving them in the long term becomes more evident as governments increasingly balance their environmental goals with energy security and market prices.

Global demand for energy services will continue to increase, doubling by 2050 in most scenarios. Currently the price and availability of fossil fuels are regarded as acceptable and the cost of environmental protection is affordable. However, in the long term, the Kyoto Protocol limits on greenhouse gas emissions may become legally binding and further constraints may be agreed.

The impacts of fossil fuel burning on air quality and global warming may lead to tighter emission reduction targets which would increase the costs of energy sources generating atmospheric emissions and make alternatives more attractive. New and expanding environmental considerations bring governments to take a new look at existing electricity generation technologies that produce little or no carbon or other atmospheric emissions such as nuclear and renewable energy sources.

Energy security and diversity of supply remain a major objective in OECD country energy policies especially in the context of continued increase of oil and gas imports from the former Soviet Union and the Middle-East. If OECD country consumption and import of fossil fuels would become unsustainable in the coming decades, governments would have to consider policy measures recognising the value of programmes for energy security and diversity of supply which market forces cannot deliver.

Electricity and transport are the fastest growing energy sectors globally. Electricity can be produced from a wide variety of sources, whereas for transport, oil is highly favoured for continuing use in vehicles, and difficult to displace.

Switching to different transport fuels and systems such as hydrogen fuel cells will ultimately require a non-carbon-emitting source to produce the hydrogen. A combination of nuclear and renewable energy sources could play an essential role in this regard (Ballard, 2003).

Four approaches are suggested (Grimston and Beck, 2002) for reconciling the increasing demand for energy at reasonable costs with the environmental impacts of fossil fuels:

- Efficiency and conservation.
- Renewables.
- Nuclear energy.
- Carbon-capture and sequestration.

Each of these approaches can help to achieve the three goals of energy policy when applied cost-effectively. Each is applicable to the electricity sector.

Given the different advantages and weaknesses of each of the four approaches, it seems reasonable to look at all of them as possible elements of an overall policy, and to see what can be done in each case to ensure that they make an effective contribution to the goals of energy policy.

Electricity market framework

The OECD as a whole, is beginning the process of electricity market liberalisation and/or privatisation. The twin objectives of lower prices and improved performance are driving governments to reform their electricity regulations, and to encourage ownership diversification (either horizontally or vertically). Some countries are more concerned about international competition than fostering internal domestic competition. The government's role and responsibility in each of these areas is different. Even where markets are working well, security and environmental goals require government action to complement market-based incentives, especially for long-term investments.

Experience to date with privatisation underscores the need for governments to adopt a coherent process. On the one hand, it has to create companies that are not saddled with historic liabilities and that are free to compete. On the other, it has to ensure real competition, with a sufficient number and balance of players. Privatising an incumbent monopoly may lead to excessive market power. One may not want all the nuclear plants to be grouped in a single company, but economies of scale may mitigate against companies with single nuclear units. Mergers and acquisitions, possibly involving foreign companies, may alter the competitive landscape very rapidly. Markets evolve with new economic instruments, new technology and new distributions and forms of ownership.

The interdependence of economies means that some decisions and operations will move to a regional scale, beyond traditional jurisdictions. Utilities will plan and operate over these larger scales. There is a risk that headquarters may become isolated from the nuclear operations, and senior

management attention is a prerequisite for safety culture. Access to transmission will ensure greater competition among different energy sources, technologies and management styles. Governments will have to manage the transition to this new world, and monitor the market to ensure fair competition. They will also have a role in looking at security and diversity of supply, from a more regional perspective involving all the countries in the region, and in dealing with the impact of electricity on environment.

Nuclear energy policy framework

Governments have a role, and a responsibility, to develop a clear and reasoned nuclear energy policy as the context evolves, and to demonstrate its coherence with the overall energy policy and the approach to its three main goals. Governments of countries committed to the continued use of nuclear energy should ensure that nuclear energy can fulfil its assigned function. They should analyse on a comparative basis all the electricity generation options on a cost benefit basis for the entire fuel cycle beginning with resource extraction at the frond-end and continuing through operation of the facility to the management of the waste at the back-end.

NEA member countries have different situations and policy positions with respect to nuclear energy, and their decisions on nuclear energy will reflect these differences. Some of the suggestions in this report may not apply to all countries with a nuclear energy deployment policy. Obviously, changes in political parties present in the governments and public referendum can alter the future of a country's nuclear energy policy at any time.

Governments of countries continuing to rely on nuclear energy or wishing to keep the option open should first ensure that the policy and regulatory framework in place is adequate for existing reactors to achieve and/or maintain high levels of safety and performance, and for operators to undertake refurbishment and life extension activities efficiently whenever relevant.

Next generation reactors with improved technical, safety and economic characteristics are a legitimate target for government R&D support, to the extent that they can help to achieve the goals of energy policy in the long term. Relevant R&D topics in this regard include natural resource management, non-diversion and non-proliferation, safety and economics. This support should be given in conjunction, and in competition, with R&D for other sources on the basis of their respective contributions to these goals. The support to nuclear energy R&D should be coherent with the government's overall approach to innovation, including the education and training of highly skilled people.

Governments have a role in designing effective management processes for nuclear waste, to ensure fairness, transparency and public participation, even if the funding and operation of waste management facilities is left to other entities. Alternative options including long-term storage followed by disposal and the possibility of monitoring and retrieval should be considered. Process clearly defined including milestones and results, are a prerequisite for countries wishing to go ahead with nuclear energy. To the extent that waste management issues are social and ethical as well as technical, the government should ensure that adequate resources are devoted to these aspects.

Countries planning to keep the option open should take a close look at what this entails in practice. While existing nuclear plants are generally very competitive in terms of production costs, replacing nuclear capacity is not a straightforward issue. It may require some government measures in licensing and waste management regulation, etc. It may also require specific actions to maintain the skills and motivations of the nuclear workforce. These investments should be balanced against the costs of losing the option.

Countries who do not wish to intervene in technology choices for electricity generation or are planning to phase out nuclear energy should review the mechanisms they have chosen to meet the goals of energy policy, in terms of how they see the energy mix evolving, along with the impacts on security of supply, cost and environment. Governments should monitor that eventual reduction of nuclear industry capabilities over the next few decades will not hamper nuclear safety or investments in refurbishment and waste management and disposal, and that human resources in regulatory bodies and the industry will remain adequate.

Governments should look closely at the alternatives to nuclear energy for electricity supply. In most cases, the de facto alternative is natural gas or coal. These will increase the burden of emissions at a time when governments should be committed to reducing them dramatically. Some argue that the electricity sector should not have to bear the main burden of emission reductions. But electricity and transport are the fastest growing sectors. Electricity is amenable to alternative sources that are carbon-free, such as nuclear and renewable energy sources. Transport is much less likely to find an economic and emission-friendly alternative to oil in the near term.

Countries without nuclear energy should also have a clear and detailed idea of how the various goals of energy policy can be met, domestically and internationally. Even if they do not want to generate electricity from nuclear energy as a source themselves, they may want to import it from other countries or to contribute to its development elsewhere. They might contribute to a

discussion on what it would take to make nuclear energy acceptable internationally. It may be efficient for some countries to specialise in nuclear energy, while others focus on wind or biomass, but all countries have an interest in the safe and efficient operation of nuclear facilities worldwide.

Regulatory framework

The challenge for governments in the regulatory area is to maintain high standards of safety while ensuring that regulation is effective, focused on real risks and compatible with the regulatory approach for other energy sources and industrial activities.

Regulators will also have to find ways of assessing and encouraging the role of senior management in inculcating a safety culture in operating organisations, and in maintaining a focus on safety as a high priority over time. This could be a relevant topic for NEA to investigate, perhaps in co-operation with other OECD Directorates that also have an interest in regulation.

In countries relying on nuclear energy and generating radioactive waste, governments and regulators have to design and encourage public processes for the siting and environmental assessment of waste repositories and to develop criteria for waste management facilities operating far into the future. Governments should be prepared to monitor the raising and management of the large funds necessary to carry out waste management and disposal activities in the long term. The regulation should cover also clearance levels providing clear and transparent criteria for the release of sites after the decommissioning and dismantling of shut down nuclear facilities.

While a sound technical base will be essential for effective regulation, a broader approach to social and ethical issues will also be required. To the extent that issues nuclear energy are seen as social rather than technical, adequate resources should be dedicated to their resolution. This will require new forms of public information and participation.

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6. CONCLUSIONS

Governments keep an essential role in energy, electricity and nuclear energy policies in the context of privatisation and market deregulation. While, in some countries, governments may not exercise as much direct control through ownership and economic regulation, they still have the basic responsibility for creating policy frameworks within which market forces can function and public policy goals can be achieved. So, with fewer direct instruments governments will need alternative measures.

The most important role of governments is setting the overall policy for economy, energy and the environment, with an adequate base in legislation and institutional competence. They should have clear strategies for achieving all three main goals of energy policy over the coming decades: secure supplies, competitive costs and acceptable environmental impacts. In particular, they should design and implement means to meet climate change and air quality goals in the context of current and prospective market dominance of fossil fuels.

While privatising and opening markets to competition, governments have the responsibility to make sure they follow coherent procedures. For markets, they have to ensure fairness, access, transparency, and effective regulation; moreover, they should provide the public goods that markets may not otherwise deliver. In the electricity sector, for example, governments should ensure through incentives or other means that generating and transmission capacity and reserve margins are adequate.

Governments have a role in looking at the long term, to compensate for the high discount rate and short-term perspective of competitive markets, through appropriate tax incentives or other mechanisms. They should carry out long-term, fundamental R&D, keeping in mind sustainable development objectives. Government funded R&D in the field

of energy should be assessed on the basis of its contribution to achieving the three energy policy goals.

Governments should take leadership on long-term energy policy issues, provide clear justification for preferred options, and ensure that the public is adequately informed on, and is given adequate opportunities to participate in, energy policy making and key energy decisions. Processes for decisions should incorporate the best scientific information as well as a broad spectrum of public views. Governments should ensure that they, and the public, can continue to access basic information about energy that may not flow as freely in a privatised regime.

In order to be in a position to treat all energy sources and technologies, including nuclear energy, on equal footing, governments should sponsor studies that compare the full life-cycle costs and impacts across the spectrum of energy sources and uses. They should endeavour to internalise the external costs of all energy supply chains on an even basis. For example, regulation and liability regime for radioactive waste should be in line with those for other activities.

Regulation of nuclear safety and radiation protection remains a core function of governments. Accordingly they should guarantee the existence of an independent, competent regulator with adequate resources and authority, and seek to keep radiological releases at the lowest reasonable level. Governments looking to a future contribution from nuclear energy should ensure that regulation is prepared to deal with issues of refurbishment, up-rating, life extension and decommissioning of existing reactors as well as new reactor designs.

Governments have a role in setting up public processes for the siting and approval of all nuclear installations. In particular, they should ensure that flexible, stepwise policies are in place for the long-term management of radioactive waste, that funds and institutions are available to carry out the plans and that the implementation progress efficiently towards meeting waste management goals.

The emphasis placed now on the safety culture of organisations, beginning at the most senior levels, brings in the need to ensure good governance. Beyond regulation, governments should look to other means of influencing the behaviour of operators and investors. Economic instruments will be important in this regard. Nuclear regulation should be in line with modern regulatory practice across the government, allowing nuclear energy to compete fairly.

Governments clearly have a lead role in the field of non-proliferation and national security. This includes responsibility for the physical security of critical infrastructure, including nuclear facilities. They should also ensure that designers of new fuel cycles and reactors designs consider resistance to diversion and proliferation as a key goal at the earliest conceptual stage.

Intergovernmental co-operation will continue to be an essential function in nuclear energy. Concerns about nuclear safety and environmental impacts can be effectively addressed through international co-operation and technical assistance. The harmonisation of safety and radiation protection standards is helpful in increasing public understanding, especially in emergency situations. Joint projects on future reactor designs can make effective use of limited resources. International consensus and state-of-the-art reports can make significant contributions to public discussions.

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