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ISSUES TO IMPROVE THE PROSPECTS OF FINANCING NUCLEAR POWER PLANTS

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IAEA NUCLEAR ENERGY SERIES No. NG-T-4.1

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FOREWORD

A changing global environment with increasing energy consumption and a need for international energy security is influencing nuclear power projects and the means of obtaining financial backing for such projects. The development of a national nuclear infrastructure can provide significant benefits that influence financial resources. The effects of other factors — such as financing arrangements for capital intensive plants, international design acceptance, harmonization of codes and standards, and assurances of fuel cycle services — need to be considered. An improvement in international cooperation may lower investment risks and contribute to reducing costs. The effects of all these issues need to be assessed and means for supporting the application of nuclear power in the current changing social and commercial environment need to be developed.

A key question addressed in this publication is whether financing is the real barrier to nuclear power development or if financing difficulties are simply a consequence of other barriers. It recognizes that there is no single solution and that circumstances in different countries, with different starting points, ambitions and drivers, inevitably affect the balance of approaches followed. The importance of credible, practical, costed and substantiated plans is emphasized. Risks have to be mitigated through an effective strategy and the allocation of risks between parties must be logical. A project has to be demonstrably viable to attract financing.

There are three broad areas which must be addressed to improve prospects of investment in nuclear power reactor construction. The first area, and probably the most important, is government and utility commitment and preparedness to adopt and implement a nuclear power programme using internationally recognized standards of safety. The second area is the application of lessons learned from technological and project developments. The third area is financing itself.

The conclusions detailed in this publication are presented as a series of key mechanisms for improvement in each of these areas. Improving prospects for investment in the nuclear industry is, in large part, achieved by a combination of financial and strategic planning measures, which together create sufficient confidence among investors to support projects. Also, there are a number of wider actions that can be undertaken to improve the prospects for investment in nuclear power. These mechanisms and actions are presented for future consideration of how they may be best developed or adopted.

The IAEA officer responsible for this publication was X. Li of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Nuclear power plants require high levels of scientific, engineering and management knowledge, and the highest levels of safety and security in a business which has only existed for 50 years. Nuclear power is a worldwide business, not only in terms of operation with utilities, vendors and supply chains in an international market, but also with respect to safety, waste and spent fuel management, and non-proliferation. Nuclear power development also has political and societal implications. It necessarily involves government compliance with relevant international treaties and agreements in the field of nuclear power to ensure the health and safety of its own citizens [1].

These factors make nuclear power a challenge for investors to embrace. Investors need to understand the balance which can be reached between costs, time, return on investment, risks and uncertainties. Nuclear power projects share some of these factors with many other large infrastructure projects, but nuclear power projects are also associated with higher requirements for safety, and security and safeguards, as well as more uncertainty than other projects.

Therefore, investment decisions for nuclear power projects cannot be made only on the basis of project parameters. A complex combination of political, legal, technical and financial factors needs to be addressed. Recognizing that all these factors play a role in the decision making process regarding adoption of nuclear power, this publication aims to examine key factors relating to how they will impact the ability to attract investment, as well as suggesting major mechanisms to reduce risk and establish possible actions to improve prospects for financing.

However, this publication will not provide any financing structures for investment in nuclear power projects. Further discussion on this subject is provided in ref. [2].

In recent years, three major factors have arisen which signal the possibility of a significant renewal of interest in nuclear power as a prime energy source. The first is the rapid growth rate of emerging economies throughout the world, particularly in Asia and on the Indian Subcontinent. The second is growing concerns surrounding fossil fuels, security of energy supplies and climate change. Nuclear power is a virtually carbon free energy source which could be part of the solution. The third is that new technologies have emerged with improved design, licensing approaches and construction schedules, as well as more demonstrable standards of safety, potentially improving the prospects for investment. Renewed interest in nuclear power is coming from a number of countries with little experience in nuclear power technology.

There are significant early costs involved in introduction of an initial nuclear power plant. These costs arise from the first steps required to develop national capabilities to manage a nuclear power programme, including legal and regulatory arrangements. These costs have been called ‘funding’ to distinguish them from ‘financing’. They are unlikely to be supported by investors in the traditional sense and are generally provided for through government budgets.

1.2. OBJECTIVE

To provide practical information on key factors that might impact financing of nuclear power plants, on the main mechanisms to reduce risk and on possible actions to improve the prospects of financing for nuclear power projects, which will assist in establishment of the strategies to develop successful financing.

1.3. SCOPE

The scope of this publication includes the issues on financing of nuclear power plants once a decision has been made to introduce nuclear power as part of the national energy portfolio. Much of the discussion focuses on issues of government commitment, technology, capital cost, return on investment, physical infrastructure, fuel supply, spent fuel and waste management, and decommissioning. This publication emphasizes that a credible, practical, and substantiated strategy is important from initial nuclear power project development to operation and decommissioning. Nuclear power projects must be demonstrably viable to attract necessary financing prior to construction.

The target audience for this publication is decision makers, advisers, senior managers and economists in government as well as investors, utilities, industrial organizations and regulatory bodies in countries desiring to build a nuclear power plant for the first time. It would also be of interest to those who are either seeking to make a significant increase in nuclear power from a small but already existing base, or who are restarting a dormant programme.

1.4. STRUCTURE

This publication consists of seven sections along with this introduction. Section 2 provides an overview on the present day state of the industry and its international characteristics. Section 3 describes the key features of nuclear power projects viewed as particularly challenging for investors. Section 4 describes the main factors and investment implications which influence risk associated with the ability to finance a nuclear power plant. Section 5 describes the specific mechanisms which could be used to reduce the key risks perceived by investors. Section 6 describes possible strategic actions to improve prospects for investment in nuclear power plants. Section 7 provides conclusions.

2. BACKGROUND TO NUCLEAR POWER PLANTS

The first nuclear power plants were designed and built in the 1950s, primarily in France, the former Soviet Union, the United Kingdom and the USA. Different technologies evolved; the programmes and associated research and development were financed entirely by governments. The economics and politics of the time meant that the commercial and financial disciplines expected today did not apply.

During the 1960s and 1970s, designs evolved, leading to the first generation of commercial nuclear power reactors. In the USA, pressurized water reactor (PWR) and boiling water reactor (BWR) technologies were adopted in France and in the United Kingdom; graphite moderated, gas cooled reactors were preferred. The Russian Federation developed its own water reactor technology in the water cooled, water moderated power reactor (WWER) in combination with graphite moderation technology in the high power, channel type reactor (RBMK). Other countries emerged, including Canada, Germany, Japan and the Republic of Korea, adopting and adapting these first technologies or selecting their own in the case of Canada's deuterium uranium reactor (CANDU). During the 1970s, as technologies matured, more advanced designs became available and a second generation of nuclear power plants followed. Generally, these were aimed at improving the commercial parameters of nuclear reactors through higher power densities and/or higher temperatures, and by introducing additional safety features.

Significant programmes were committed to in a number of countries, largely supported by State owned utilities. In the USA, for example, private utilities were able to amortize the capital costs of plants in their selling rates. In support of these programmes, a number of design companies, architect–engineering companies, and associated engineering and manufacturing supply chains were established. Industrial financial stability was ensured by the size and continuity of major programmes, which also increasingly included export, backed by significant government support, both strategic and financial.

It had always been recognized that nuclear power is by nature international in the recognition of its origins, the complexity of its technologies and the potential implications of accidents. Controls and agreements over its development were therefore exercised through a number of international conventions and treaties, which introduced both obligations and responsibilities. The IAEA has been central in fostering the safe and peaceful development of nuclear power within these conventions and treaties.

The international nature of nuclear power plants became even more evident as a consequence of accidents, first at Three Mile Island in 1979 and subsequently at Chernobyl in 1986. By this time, over 400 reactor units were either operating or under construction throughout the world. After these two accidents very few nuclear power plants were ordered worldwide; a trend that continued until almost this century.

During the 1990s and in the early years of the 21st century, there has been significant drive to privatize utilities and deregulate electricity prices. This has led to a much stronger focus on the economics of nuclear power and, in turn, on the ability to build on schedule and within costs. Historically, the adoption of technologies and development of regulatory standards led to most projects experiencing uncertainties in scheduling and costs of a nature which would have been difficult for project financing organizers to tolerate. To this day, it is probably correct to say that there has never been a truly privately financed nuclear power plant built.

On a more positive note, and as a result of both economic and safety pressures, vendors have been developing third generation reactor designs with the aim of achieving lower and more predictable costs with increased levels of safety. Furthermore, commercial pressures on utilities worldwide, particularly over the last two decades, have led to significant pressure on operating reactors to increase availability and output and achieve extended life. All these factors have resulted in significant improvements in the economics of nuclear power as well as improved confidence in the technology.

The first years of the 21st century have brought other new challenges for which nuclear power may be part of the answer. Developing economies and the industrialization of many countries have resulted in the need for significant growth in electricity generation. Oil and gas prices have seen real and significant increases, which, together with a downward trend in nuclear generation costs, appears to give a positive cost advantage to nuclear power. Security of supply and self-dependence are increasingly important factors in energy policies and dependence on oil and gas for power production is becoming more risky and unsustainable for mid and longer term energy projections and strategies of certain countries. Fuel costs for nuclear power reactors remain a small proportion of generation costs. Furthermore, fuel supplies are available on the world market and fuel can be readily stockpiled for several years of operation. Finally, nuclear power offers the major benefit of being essentially a zero carbon emitter in a time of increasing concern about the impact of climate change. Economic comparisons between nuclear and other fuels (fossil and hydrocarbons) generally reap similar results, but exclude the benefit of nuclear being an essentially zero carbon emitter. Its inclusion in any meaningful comparison would show a significantly positive impact on nuclear economics.

In order to illustrate increasing pressures on industry to deliver products and services, it is worth noting that as of 20 June 2008, 439 nuclear power reactors were in commercial operation in 31 countries, generating approximately 17% of the world's total electricity, another 33 reactors were under construction, and 56 countries were operating around 284 nuclear research reactors. In the last five years, the number of countries declaring interest in building a reactor for the first time has increased from essentially zero to at least 30.

In summary, the following key issues form the background for an increase in nuclear power plant construction:

— A critical worldwide shortage of energy; there are uncertainties associated with other energy sources and their economics, while nuclear industry developments during the last 10 years have provided the basis for a renaissance in nuclear energy at the beginning of the 21st century;
— A critical worldwide shortage in the capacity of human resources among vendors, architectural engineers, and in the underlying industrial infrastructure, including the supply chain and its major components;
— State of the art designs are available for competitive purchase; these have evolved in response to external pressure regarding safety, economic and financial concerns;
— The financing and overall management of nuclear power projects will be increasingly exposed to stringent market requirements.

3. MAIN FEATURES OF NUCLEAR POWER WITH RESPECT TO FINANCE

Nuclear power plants share many of the characteristics of other large capital intensive infrastructure projects, but have been perceived as having certain special and perhaps unique features which impact financing.

The obvious features of nuclear power projects are high capital cost, a long construction period and a long period of return on investment compared to other energy sources. Typically, a single, new, large capacity nuclear power unit could be expected to have a capital cost of more than several billion dollars to meet engineering, procurement and construction costs (EPC), excluding owner and regulatory costs.

The capital cost of nuclear power projects may be 60% or more of the levelized cost of electricity. The relatively high capital cost of nuclear power means that financing cost and construction time is critical, compared to gas and coal. For many gas and coal power plants, capital costs would be significantly less than those of a nuclear power plant, and construction time may be in the order of two years or less. But fuel costs for nuclear power plants are very much lower, about 15% of the levelized cost of electricity. Once a nuclear power project is built, its cost of production is more predictable than for gas and coal. The fuel cost of a gas or coal power plant is about 80% or more of the levelized cost of electricity.

Given all necessary regulatory and planning clearances, the typical time for construction of a nuclear power project is at least five years, although some companies offer four years for new standardized modular construction plants (both numbers do not include the period, generally 10–15 years, needed to develop the infrastructure required for the successful launch of a project). Thus, any return on investment can only begin after this period.

If return on investment is to be made through electricity sales generated by the new plant, then at least 10–20 years of operation, depending on national circumstances, would be required to pay back capital and interest. This has lead to investor concerns about long term sales guarantees, which may be more difficult to negotiate in a deregulated market than a regulated one.

In addition to the typical costs discussed above, nuclear power plants have historically experienced high levels of uncertainty. Uncertainties have arisen through a number of factors, including, for example, technology development, regulatory development, and associated regulatory and planning processes. All these uncertainties could delay construction time and increase cost, which will significantly influence the interest during construction (IDC) because of high capital costs, and impact confidence in investment. This is why emphasis is placed on eliminating uncertainties as much as possible before construction begins, such as minimizing schedules and firming up design. During the last ten years, the industry has placed emphasis on the need to eliminate regulatory and construction uncertainties before construction starts. Based on this, it is reasonable to expect that the industry will succeed in mitigating these uncertainties and increase investor confidence in nuclear power plants.

The second obvious feature of nuclear power projects is that governments play a crucial role in the adoption of nuclear power as part of the national energy portfolio and public perception; support should form an integral part of the decision making process. Decisions to construct a nuclear power plant, accept use of nuclear material on its territory and manage radioactive waste would require government support and acceptance in long term timescales, whether in regulated or deregulated electricity markets. For example, future costs of waste and spent fuel management and decommissioning must be considered in economic justification projections and incorporated into the overall business plan.

The third obvious feature of a nuclear power project is the putting in place of technical and human resources to support all stages of a project from conception, through construction, to operation, and eventual decommissioning. As discussed in subsequent sections, the obligations of a utility to manage its operations safely require a national commitment to education and training, probably coupled with technology transfer, to achieve and ensure competence of all personnel.

In summary, the main features of nuclear power projects, which will be discussed in greater detail in subsequent sections, are:

— High capital cost, long construction period and long returns on investment;
— High level of regulatory requirements and scrutiny, high safety standards, insurance and physical security;

— Long term government commitment and public support;
— Underpinning technical and human resources due to high requirements regarding operator qualifications. Therefore, strong owner collaboration through an open exchange of information and experience, and a definition of common requirements for the technology is needed;
— Low sensitivity of production costs to potential fluctuations in fuel supply, operation and maintenance costs. The high availability of operating plants provides for an operating period of 60 years, a very competitive range of operation.

4. KEY INFLUENCING FACTORS AND THEIR IMPLICATIONS

This section identifies the various factors which influence risk associated with the ability to finance a project. This review is based on the premise that creating a successful project essentially requires application of good risk management. Investors will need to see that risks have been properly identified, allocated and practically mitigated in order for financing to be available on acceptable terms. The principal risks fall into one of three categories:

— Political, legal and regulatory factors;
— Technical factors;
— Commercial and financial factors

4.1. POLITICAL, LEGAL AND REGULATORY FACTORS

Polical, legal and regulatory factors affecting financing of nuclear power are derived from national policy adherence to international treaties and agreements, government commitment and public support, and national regulatory organizations.

The government has an important role to play in meeting international obligations deriving from international legal instruments adopted in the fields of nuclear safety, security and non-proliferation.

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is an essential international treaty in the nuclear field. It aims at preventing the spread of nuclear weapons and weapons technology, at fostering the peaceful uses of nuclear energy, and further nuclear disarmament. The NPT commits non-nuclear weapon State signatories to the treaty to conclude and honour safeguards agreements with the IAEA, which plays a central role under the treaty. While recognizing the right of States to develop nuclear power for peaceful purposes, the NPT fosters the openness and transparency needed to ensure international confidence in the peaceful use of nuclear energy.

Conventions and international agreements in additional areas [3–7], for example, the 1997 Vienna Convention on Civil Liability for Nuclear Damage, the 1997 Convention on Supplementary Compensation for Nuclear Damage [8] and the Convention on Nuclear Safety [9], also place international obligations on State parties. In the field of nuclear liability, adherence to international agreements, backed by national legislation, should provide an adequate legal framework for the channelling of nuclear liability to the operator of a nuclear installation and possibly the setting of the amount and time limits of this liability [10].

Governments play an important role not only in adhering to these international agreements, but also in their implementation.

Ensuring sustained government commitment for the duration of a nuclear programme is another factor in attracting financing. Government commitment is perhaps best expressed through a national energy policy which articulates the role of nuclear power and through which the necessary national nuclear power development programme and regulatory, planning and educational/technical institutions are created and supported.

Sustained government commitment is linked to public acceptance, another factor affecting the financing of nuclear power: it is unlikely that investors will be attracted to a project which faces a lack of public support or a severely negative public perception. Governments can play a key role in informing their citizens about the pros and cons of nuclear power to influence public acceptance. However, it should be noted that public acceptance is directly related to the public's perception of risk, which can change over time due to many factors — some of which are beyond a government's control — including political, economic, social and psychological factors.

Government commitment flows from the government to the relevant regulatory, commissioning and planning organizations, whose tasks must be clearly defined within the project. National regulators are responsible for ensuring that owner/operators of nuclear installations design, construct and operate their facilities to high standards of safety and have the resources, both human and financial, to satisfy these obligations. Nuclear law and implementing legislation should make clear the authority and responsibilities of nuclear regulators and operators.

In summary, in order to adhere to international treaties and agreements, governments must play an important role in supporting transparency and commitment to the international legal framework regarding nuclear safety, security and non-proliferation; they must ensure sustained commitment for the duration of a nuclear power programme; they must inform their citizens about nuclear power to influence public acceptance; they must establish domestic nuclear law in order to provide the necessary legal framework and protection; and they should define the relevant regulatory and implementing organizations running the projects.

4.2. TECHNICAL FACTORS

4.2.1. Nuclear power plant design and construction

History shows that the development cost of nuclear power plants to reach the present level of technological maturity has been enormous. Four decades of research, development and capital expenditure on the scale of national budgets has been expended by those countries now operating nuclear plants. The corollary is that, during this time, the nuclear industry has been continuously subject to pressures to reduce capital costs and improve safety. Competitive generation costs have become an increasingly dominant driver. The result is that the fewer numbers of designs now available on the open market have the benefit of technology maturity, safety characteristics and features built on worldwide experience and at a cost base that is controlled and predictable for repeated units.

Experience from earlier designs has been used to develop cost effective manufacturing and construction methodologies. These often include modular factory construction of key systems to minimize site work and time. Maturity in safety understanding and operational experience have resulted in new safety approaches, some of which rely more on the inherent physical safety characteristics of reactors, and all of which have been subject to extensive licensing review. The result is that designs available for adoption today can be ordered with much greater confidence in controlled cost, with safety features which are universally recognized and licensable and which are capable of satisfying public demands for high levels of safety and security.

The most likely route to a new nuclear construction will be through the adoption of third generation reactor designs which are evolving from current second generation reactors. This approach would apply both to countries restarting dormant programmes building on previous technology experience, as well as to countries introducing nuclear power or substantially expanding a modest base. There are several examples throughout the world today, including China, Finland, France and, possibly soon, the United Kingdom and the USA.

This approach might appear technologically attractive, but what is the advantage for investors? Earlier generations of nuclear power reactors have been associated with increasing and uncontrolled costs and programme times. They have been subject to evolving safety standards which have driven design changes simultaneous to construction schedules. Even during operation, safety and engineering improvements have emerged which have resulted in additional expense and operational downtime. The ability to adopt a 'proven' design brings a higher measure of cost predictability. Efforts to accelerate construction through minimizing site work, with parallel modular work streams in controlled factory conditions, significantly reduces construction schedules and, thus, reduces overall project costs.

A more predictable licensing process is as significant as all of these approaches. History has shown that the regulatory process can be unpredictable. The greater sharing of safety approaches, codes and standards and their adoption by regulatory authorities significantly improves the transportability of designs across national borders.

The adoption of a licensing process, in addition to using common codes and standards, which clears safety issues prior to the major spend phase of projects (i.e. procurement, manufacture and construction) through, for example, single design and construction licenses, reduces the risk of unforeseen costs during build. Regulation is rightly a sovereign function and cannot be assumed in the project process or transferred to other countries. In a world nuclear power plant market, a key issue will be how a design license can be transported across national borders. This will depend upon how a national licensing process can best utilize results of the country of origin's licensing for imported designs.

The line of development followed to date by most countries investing in nuclear power reactors has been to follow economies of scale and invest in large reactors, typically of 1000–1500 MW(e) unit size. Such reactors can only be sensibly accommodated within a substantial electrical grid network. Many costs, including design, regulation, operation, and licensing, amongst others, are sensibly independent or only moderately dependent on unit size. Thus the 'c/kW installed' cost can be significantly reduced and 'bigger is better' has become a maxim. It may be that for smaller countries with less substantial electrical grids which cannot support single large reactors, smaller unit sizes are appropriate. While 'c/kW installed' comparisons may suffer total capital cost, IDC and construction costs/times, amongst other factors, would benefit and may be more important.

In summary, especially for countries embarking on their first nuclear power project, the proven design approach might be expected to reduce investment risks, since project schedule and licensing processes could be more predictable. It may also be attractive for some countries to consider the possible benefits of selecting smaller unit sizes which may require some development. The concept of proven design also applies to the operational phase and adds to investors' and users' confidence that the unit will operate effectively over a long period at high availability rates. Good operational experience of predecessor plants will also increase the credibility of revenue stream projections, as well as operational and maintenance costs.

4.2.2. Physical infrastructure

Physical infrastructure issues may be outside the control of an investor but have an important bearing on the overall coherence and success of a nuclear power plant project and, therefore, must be addressed at the planning stage to ensure they are properly managed. In countries with existing nuclear power plants, it should be expected that most measures have already been put into place.

Physical infrastructure issues relate mainly to the availability and suitability of proposed site(s), including their connection to the electrical grid. Grid connection is important not only to deliver electricity to the grid but also to provide off-site power to the operation of safety equipment in the event of shutdown or an emergency trip of the reactor. The availability and reliability of grid connections are important factors which will need to satisfy economic and safety criteria.

Site suitability includes a number of features but of principal concern are:

— Soil and sub-soil suitability;
— Cooling water provisions;
— Seismic characteristics;
— Groundwater and airborne pathways for radioactive discharges in normal and accident conditions;
— Natural and human-made hazard effects;
— Security;
— Transportation routes/construction logistics;
— Site licensibility;
— Proximity to national borders.

These features will need to be addressed and planning authorities satisfied in order to grant permission to use the site for construction of a nuclear power plant prior to an investment decision. Some features will be 'go or no-go nuclear power' in nature. Some features may impact on design and require modification, which again would have to be quantified and justified. For further physical infrastructure conditions see Ref. [11].

4.2.3. Fuel supply

Fuel supply is an integral part of nuclear power production. In terms of cost, it accounts for about 15% of the levelized cost of electricity. The quantities of fuel required are relatively modest compared to fossil fuel operations, and fuel security can be more readily attained, given the possibility of stockpiling several years' supply. These aspects are both strategically and financially attractive.

Despite this, concerns remain about the integrity and reliability of the fuel supply. In order to better understand the financial implications of the fuel supply, different elements need to be considered. These can broadly be listed as:

— Natural uranium production;
— Conversion;
— Enrichment;
— Fuel fabrication.

There is a world market for uranium, but a host country may have its own indigenous supply. The spot price for uranium was more or less stable at below $10–20/lb[1] for a long period in the late 1980s and 1990s. Since 2000, the market has seen more significant fluctuations from less than $10/lb to over $130/lb and then back to $50 (October 2008). The price increase reflects the truth that the time when uranium could be procured from earlier production is coming to an end. Further, it reflects a renewed interest in nuclear energy, plant life extension and upgrading of existing reactors. Fluctuations could be due to specific extraction problems in some parts of the world and the introduction of speculative purchasing to the market. However, the raw material price still represents a modest part of overall production costs.

Conversion and enrichment are activities limited to and controlled by relatively few companies in the world and which are subject to political and governmental controls. In spite of the small number of suppliers, it is unlikely that access to these activities would become a restrictive factor. The prices of conversion and enrichment have been increasing slowly and have not reflected the fluctuations affecting uranium. A market with a limited number of suppliers always implies a financial risk, but there is no evidence that this is significant.

Fuel fabrication is central to fuel supply. The required standards and quality for fuel are just as high as those of reactor design. The integrity of fuel assemblies plays an important role in both the economic operation of a reactor as well as in its safety performance. Thus, fabrication by experienced and qualified companies of a product compatible with reactor design and safety is vital to project success. Fabrication, therefore, is most often associated with reactor vendors. In order to minimize risk and achieve best fuel competition, utilities should try to buy fuel from different vendors. For most reactor types, more than one vendor is available. Fabrication under license has proven feasible and could, in principle, be incorporated in the transfer of technology in relation to reactor design, providing the possibility for a country to build its own fabrication capacity, if economically attractive.

In most countries, owners/operators do not simply purchase integrated fuel assemblies. They contract separately for natural uranium, conversion, enrichment and fuel fabrication in order to ensure competition and supply diversity at each stage.

4.2.4. Spent fuel and waste management and decommissioning

Costs and financial arrangements for spent fuel and waste management and decommissioning form elements of the levelized cost of electricity of a nuclear power plant which occur after the production of revenue has ceased. The expected cost is typically 5–10% of the levelized cost of electricity. Different funding schemes have been developed to ensure that adequate funding for these activities is available when needed.

Waste and spent fuel management has an important impact on the public acceptance of nuclear power. It is essential that governments clearly identify who is responsible for these matters in the short and long term. The responsibilities falling on plant owners can be quantified as part of the economic evaluation of the project.

[1] 1 lb (US) = 0.45 kg.

Normally, the plant owner is fully responsible for decommissioning and dismantling of a facility, while different approaches are taken for the management of spent fuel and radioactive waste. In some countries, the plant owner is also fully responsible for this, while in other countries the plant owner pays a fee for the State to take over the responsibility. To estimate economic impact, it is necessary to have a plan, which may include defining timescales for decommissioning stages, technologies to be applied to all waste treatment, packaging and interim storage of total waste, the route for disposal or re-use of fuel and the possible transfer of long term responsibility for waste management and disposal to the State [12, 13].

4.3. COMMERCIAL AND FINANCIAL FACTORS

The provision of debt for a nuclear power project is in principle no different than any other major infrastructure project. Debt is needed to pay project costs, including design, manufacture of components, procurement, construction, installation and commissioning. A return on investment to recover debt is established from the operation of the completed project.

The capital cost of a nuclear power project makes the debt burden typically higher than most major projects (several billion dollars for a single unit), the time to begin generating revenue typically longer than most major projects (about five years for construction), and the time to repay capital plus interest from revenue longer (about a further 10–20 years).

The first generations of nuclear power plants were financed largely through government debt, accompanying a strategic decision to adopt nuclear power as an energy source. It is assumed that unless a government wishes to completely take on the whole cost, debt in some form would be incurred.

Debt may be supported by the national government, other national investment banks, export credit agencies, multilateral financing institutions, private investment and commercial banks. What is appropriate and available will depend upon individual circumstances, but the simple features of any debt arrangement are essentially:

— How does the lender ensure that the debt is used to cover the cost of goods and services properly and that spending is executed effectively?
— How is risk distributed and how is risk/reward calculated?
— How is the risk of delays and budget overruns covered?
— How will the debt be repaid? What are the assets backstopping the debt?

These risks are normally addressed by a combination of measures that can include:

— Establishing the creditworthiness of the borrower.
— Establishing the availability of a government guarantee.

In addition, governments, international agencies and investment banks will have other criteria which may impact financing for nuclear power plants. The World Bank, for example, currently has a policy not to provide debt for any nuclear power projects. Carbon free energy sources are increasingly being adopted because of concerns over climate change. Nuclear power currently gains no credit from its essentially carbon free nature. Renewable energy projects may qualify for certain debt programmes and attract certain financing benefits, while fossil fuel projects may increasingly carry the burden of carbon taxes. However, nuclear power appears to be evaluated as no better than neutral and, for many investors, is viewed negatively. Influential criteria may be the downside risks for nuclear power, and these need to be addressed.

During execution of a project, a variety of costs are incurred. The spending profile and debt profile for nuclear projects is typically a standard ‘S’ curve with low initial expenditure during early design finalization and site preparation, a rapid increase in gradient as procurement and construction get underway, and levelling off as the project reaches completion with commissioning. Principal spending during execution typically includes:

— Engineers’ costs;
— Architect–engineering support;

— Vendor activities;
— Equipment procurement, and;
— Construction materials and manpower.

In most cases, these costs will be covered by the overall financing but controlled through contracts between owners and contractors. In many cases, such contracts will be for services and equipment imported from overseas and foreign exchange risk needs be considered. The general principle is the same in that the seller needs to ensure services are properly provided while the buyer needs to ensure payment is properly implemented.

In principle, controls for these risks are best handled through properly constructed contracts with financial arrangements and schedules which manage cash flow and exposure. Care must be exercised in allocating risk, taking into account who can best manage each risk and how best to structure any contingency funding. Transferring all risks to an EPC contractor under a fixed price contract, for example, may simply result in a significantly elevated price which includes all possible risks and contingencies. More appropriate risk allocation, with the owner managing specific risks and retaining contingency provisions, may be more attractive.

Refinancing at completion can be an option for re-evaluating and reallocating risk after construction is finished and commercial operation has begun. At this stage of a project, costs are essentially determined and the risk profile shifts from construction risks to operational risks. This can be an opportunity to recalibrate the balance sheet of a project, restructure its ownership and change the risk allocation, given that the project will have begun to generate revenue.

Appendix II provides a more detailed financial consideration and discusses the principal advantages and disadvantages of possible financing structures.

5. MECHANISMS TO REDUCE INVESTMENT RISKS FOR NUCLEAR POWER PROJECTS

This section identifies specific mechanisms whereby risks can be controlled and mitigated. This is particularly important for the first nuclear power unit and risk profiles should progressively change and moderate for second and subsequent units as knowledge and experience build.

5.1. POLITICAL, LEGAL AND REGULATORY MECHANISMS

Even without providing direct financing of nuclear power projects, the government is seen as playing a central role in any decision to adopt or restart a nuclear project. Government involvement and support is crucial in a number of areas, such as:

— Supporting the adoption of nuclear energy;
— Ensuring manageable transparency of a nuclear programme;
— Becoming a party to relevant international legal instruments in the field of nuclear safety, security and non-proliferation;
— Enacting national legislation, establishing necessary regulatory, legal, insurance and other institutional arrangements to support and control nuclear power and implement international treaty obligations;
— Encouraging public acceptance of the overall benefits of nuclear power;
— Creating a national climate in favour of investing in nuclear power to encourage investor confidence;
— Providing or actively supporting the provision of suitable sites for nuclear power plants and for repositories, including handling the practical processes for selection, evaluation, planning (site approval), licensing (safety approval) and preparation;
— Establishing a strategy and defining responsibilities for management of wastes arising both during operation and decommissioning, as well as for spent fuel management;

— Ensuring a regulatory process which meets the high and internationally agreed levels of nuclear safety;
— Providing conditions to investors or owner/operators wishing to invest in nuclear power, including financial guarantees of their performance, power sale conditions etc., particularly for the first unit;
— Providing support for education programmes to develop in a timely manner required personnel for the overall programme;
— Recognizing the need to ensure confidence in long term returns especially for investors in a deregulated electricity supply market, and;
— Fostering and actively encouraging the development of an effective safety culture, particularly through appropriate educational, development and international exchange programmes.

There are a number of direct and more specific mechanisms whereby the government can increase investor confidence. A number of these are listed and discussed here, some of which are examples of current and emerging practice, including:

— Enactment of a special nuclear law. This is necessary to regulate the conduct of legal or natural persons engaged in activities related to nuclear power plants and the use and control of nuclear material;
— Articulating an energy policy which specifically addresses and endorses the use of nuclear power as a valid contributor to the whole, providing strategic value in terms of cost, diversity, security and environmental benefit with corresponding environmental/ emissions credits;
— Providing support on financial guarantees, especially for the first few units. Note that the Chinese government essentially underwrote the financing of its first units, including early operation to reach a position for subsequent units, which could be assessed with more confidence by investors. It is also notable that the US Department of Energy has introduced the concept of a multibillion overrun guarantee covering a number of the first new reactors if built in the USA. Guarantees may be necessary both for construction and early operation to ensure sufficient confidence in operational performance and thus eventual return on investment;
— Especially in deregulated markets, introducing a mechanism to ensure longer term revenue streams for nuclear power plants. Some countries are considering long term power purchase agreements (PPA, 60+ years) (see Section 5.4 for a description) to fully utilize the economic lifespan of plants and avoid early decommissioning due to lack of appropriate revenues, and;
— Funding support or guarantees for early physical infrastructure and licensing work to facilitate vendors in their ability to satisfactorily meet safety and licensing requirements.

5.2. TECHNICAL MECHANISMS

A number of specific mechanisms for risk management arise directly from technology selection. The foremost mechanism is the adoption of proven designs for the first nuclear power unit. A definition of ‘proven’ should embrace the following:

— A design based on several years of operating experience by a similar plant;
— Proven constructability in a valid and commercially reasonable time schedule fully considering the capabilities of the supply chain;
— Avoidance of first-of-a-kind (FOAK) technical, schedule and licensing risks;
— Regulatory acceptance (licensability) in its country of origin, and;
— Competitive selection criteria places it above a peer group of alternative nuclear technologies.

This is not to say, however, that innovation or enhancement is not acceptable. Without innovation or at least enhancement, improvement and development cannot occur; these are essential to nuclear power plant design, as they are for any other technology.

The reactors most likely to be offered in a competition will include some developments of existing designs. Third generation designs rely heavily on the experience of existing operating reactors but do include some additional and changed features. These features have to be managed with a view to specification of requirements and with technical assessment, including any impact on licensing. Simply, it must be recognized that where innovation is introduced, further risk mitigation measures may be needed to ensure confidence.

Once an appropriate technology and strategy to manage design risk have been selected, there needs to be a clear strategy to manage risks related to construction and physical infrastructure. The major mechanisms which apply here include the following:

— Confirming site suitability and preparing and obtaining necessary clearances and permissions;
— Establishing a schedule that ensures regulatory issues which may arise from national assessment of the selected design do not significantly distort the original design basis and are cleared before a construction commitment is made;
— Ensuring that necessary infrastructure improvements are identified and completed without becoming critical issues either for the construction work or investment decisions;
— Verifying the schedule with respect to risks regarding the supply chain and subcontractor quality and availability;
— Ensuring timely and proper implementation of the owner/operator's scope, which is often associated with site preparation.

The strategy and plans for fuel supply should be developed on the same timescale as investment plans for the plant. This will ensure that all aspects of material supply, conversion, enrichment and fabrication are considered and finalized contractually. This may involve security considerations and diversity of supply, including local fuel fabrication.

The strategy for spent fuel, waste management and decommissioning will need to be prepared consistent with government policy to ensure that responsibilities are clearly defined and a clear funding scheme is developed. Possibilities range from paying a fee to the government (the US system) to letting the full responsibility for financing stay with the utility (most European systems). In the latter case, funds can be set up internally in a company on the balance sheet (German model), as segregated funds within the company (French model) or as funds under government control (Swedish model).

5.3. COMMERCIAL AND FINANCIAL MECHANISMS

There is an imperative is to establish and develop a well founded business and financing plan over time. This should, as a minimum, identify and define:

— The technology selection process and justification of its results;
— A procurement strategy, which will detail, in particular:
  • The process for sourcing equipment and supplies;
  • The process of evaluation and competition which will determine price and schedule with confidence;
  • The contractual arrangements to be put into place for the design, procurement, construction and commissioning of the new build project;
— A commercial strategy, which will detail, in particular:
  • The corporate structure for promoting the project, including details of the contractual arrangements between various stakeholders and participants for each phase of the project's life;
  • The funding strategy for raising capital (equity and debt);
  • Financing actions to anticipate possible substantial cost overruns;
  • Lender requested agreements involving the State and utilities concerning: maintaining retail electricity tariffs, and achieving certain corporate financial performances during the term of the debt;
  • Support from financial institutions;
  • Corporate and ownership structure;
  • Electricity sales strategy and arrangements which, together with the above, will determine financial feasibility;
— The fuel cycle strategy and associated fuel costs;
— The waste and spent fuel strategy;

— The decommissioning strategy;
— Requirements for and cost of infrastructure improvement;
— Requirements for and cost of utility preparation and staffing (training, recruitment, etc.);
— The strategy for technology transfer and local supply, and;
— Government support.

Parallel to such a business and financing plan, it is necessary to develop a strategy for ownership of a project and for contracting of necessary services. This strategy may consider design and construction phases separately or together with the operational phase. This strategy must consider relationships with vendors, architect–engineers, other utilities, manufacturers and constructors who may interrelate with the financing plan. It is necessary to determine an appropriate plan for a project, involving balancing equity and debt between partners and between various ownership structures. A project may be owned by the government or may be a government owned utility, a private utility, a joint venture with corporate structure, or a joint venture between corporations and municipalities. No one model is 'right' for a nuclear power project. Normally, vendor and architect engineering services are contracted. Sometimes a vendor may choose to participate in equity and seek part of return on investment through that route. Whatever model is chosen, investors will also be concerned about the long term (60+ years) stability of the model in order to benefit from the economic lifetime of a plant.

A recent example in Finland, the Olkiluoto 3 plant, incorporates corporate financing including equity participation of a group of major consumers. In exchange for a share of the equity, consumers have, in effect, guaranteed a long term supply of electricity which will not be vulnerable to market cost fluctuations. It illustrates the type of strategic approach to risk management which can be taken and embedded in ownership arrangements.

With respect to both financing and contracting for services, as part of a process to 'de-politicize' agreements and to increase stability and improve confidence, the use of third party countries for contract law and dispute resolution through arbitration or litigation is seen as a potential means of risk mitigation. An effort to make the contract more neutral will help to reduce country specific risks and to include political risks to suppliers and technology providers.

5.4. CONTRACTING STRATEGIES

Most of the risks discussed above will be reflected in the project contracting strategy adopted by owner/ operators. There are many possible strategies for different phases of a project depending upon the strengths and contributions of different contractors, ownership structure, and financing arrangements. It is important that a successful strategy is developed at the earliest opportunity, alongside plans for financing, in order to ensure investor confidence.

EPC contractors and vendors may be encouraged to take on an ownership stake in the project entity (or debt), though they may resist such an idea, as their business relates to design and construction, not operation and equity risk. EPC contractors and other vendors are traditionally in a much better position to manage risks involving, for example, supply and costs of material, labour, programme, and design change, and this should be reflected in risk allocation.

Owners may perceive technical, commercial and other advantages in encouraging EPC contractors, vendors and other major suppliers to collaborate in connection with the construction contracting structure. This may be best achieved through encouraging participants to find the most sensible risk sharing arrangements with partners of choice rather than by force. For example, design risk may be assumed and managed by the design vendor, while the construction risk can be assumed and managed by the EPC contractor. However, in any case, the owner would need to be satisfied that the contractual structure and risk sharing arrangements sensibly allow the owner to control construction risk as a whole.

The project programme needs to reflect a strategy to manage risks associated with external stakeholders. Certain risks may be outside the control of construction contractors and owners, such as legislative, licensing and regulatory risks. It is important, therefore, that project programmes are arranged to avoid major expenditure commitments until the project has satisfied the external requirements of such stakeholders. This may be an area in which the State can be a partner in underwriting or risk reduction.

When nuclear fuel is first loaded into a reactor, risk allocation certainly changes. At this point, regulatory authorities will wish to see a competent and licensed owner/operator take over the project. However, the EPC contractors will continue to have warranty obligations until the end of the warranty period.

Some countries are considering long term PPA to fully utilize the economic lifespan of plants and avoid early decommissioning due to lack of appropriate revenues. A PPA is an agreement to sell electricity at a pre-established price for a prolonged period. A PPA supports loan arrangements for a project and defines the source of repayment to investors in a project. For the owner, it provides a guarantee of future revenue; while for the electricity purchaser, it provides a guaranteed supply at an established price.

Contracts for fuel supply and O&M services are also important for an investor insofar as both have significant impacts on cost during operation.

Finally, depending upon how the government has determined where responsibility lies for waste and spent fuel management, as well as decommissioning and their associated costs, these have to be factored into an investment model.

6. MAIN OPTIONS TO IMPROVE THE PROSPECTS OF FINANCING NUCLEAR POWER PROJECTS

This section describes a number of options to improve the prospects of financing nuclear power projects.

6.1. POTENTIAL FOR ENVIRONMENTAL CREDIT

Nuclear power is increasingly considered a valid energy source bringing diversity and supply security at economic cost with little or no impact on climate change; however, it still requires some action to be considered attractive. Nuclear power is not included in the Clean Development Mechanism (CDM) and Joint Implementation (JI) provisions of the Kyoto Protocol. Nuclear power will have financial benefits if greenhouse gas emissions (primarily carbon dioxide) involve penalties (carbon tax or auctioned emission permits). Movements to change current perceptions should be recognized as being vital for encouraging financial investment.

6.2. USE OF INTERNATIONAL AND REGIONAL FINANCING INSTITUTIONS

There are a number of existing international and regional financial institutions, such as the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB), which could, in principle, support investment in nuclear power. It is noted that the World Bank and certain export credit agencies (ECAs), based upon specific policy decisions, are excluded from financing of nuclear power projects. However, nuclear power remains competitive with many other candidates for funding. It is clear that mobilization of international and regional financial institutions, if viable, is a long term task that will most likely require:

— A positive record related to construction and operation of the new plants;
— Political support.

6.3. PROVEN TECHNOLOGY AND COMMON STANDARDS

The adoption of proven technology and international ability to license designs are key elements for a first nuclear power unit. There are enough historical examples of developing designs, extended programmes, licensing uncertainties and national variations to illustrate the problem. Therefore, key to improving the prospects for financing nuclear power plants should include consideration of IAEA safety standards [14–23], together with use of validated safety methodologies and data, and for licensing purposes, greater recognition of the country of origin's approval. In respect to country of origin licensing, greater reliance could perhaps be placed on design certification from the country of origin as a means of defining how a particular design satisfies necessary safety requirements. A wider consensus on safety standards and cooperation between country of origin regulators and the buyer country would encourage such reliance. In that respect, regulation of the buyer country could then be focused on other issues, including:

— Design integration with specific site conditions;
— Standards of construction;
— Standards of operation.

6.4. FUEL SUPPLY

The importance of developing a strategic approach to the fuel cycle has been recognized and some discussion has occurred on the various elements involved in natural uranium extraction, conversion, enrichment and fuel fabrication. Most countries operating nuclear power plants have not developed their own fuel cycle capabilities. The reasons for this include economics of the fuel cycle, as well as, so far, a functioning market for fuel cycle elements. While the world uranium market is mature with a number of providers at each stage of the fuel supply process, there is still some concern regarding the availability of different fuel supply services. One approach to hedge against fuel supply problems has been to diversify supply to the extent possible and rely largely on long term contracts.

7. CONCLUSIONS

Nuclear power plants require high levels of scientific, engineering and management knowledge and the highest levels of safety and security in a business which has existed for only 50 years. Therefore, nuclear power projects provide a most significant challenge to those able and willing to finance them.

After several decades in which few nuclear power plants were ordered, there appears to be the possibility of a worldwide renaissance. This is driven by a number of factors but principally increasing global power needs, rising fossil fuel costs, the desire for a diverse and secure energy supply and recognition of the potential environmental benefits of an energy source with little or no carbon emissions. The appetite for new nuclear power plants appears to be equally strong throughout the world. Previously developed but dormant programmes in the USA and Europe have begun to compete for resources with the growing Asian and Indian Subcontinent markets. The limited number of orders in recent decades will mean the industry's capacity to respond to significant expansion will be limited, at least at the beginning of any such renaissance. The same applies to the financial and insurance community where certain limitations of resources coverage can be expected. Thus, countries and utilities wishing to build nuclear power reactors will have to be well prepared and present well conceived plans, including adoption of the highest and internationally recognized standards of safety, to compete successfully for talent, resources and money in order to entice investors, vendors, architect engineers and specialist component suppliers to support their projects.

There are three broad areas which must be addressed in order to improve the prospects for investing in nuclear power reactor construction.

The first area, and probably most important, is government and utility commitment and preparedness for the adoption and implementation of nuclear power to the highest internationally recognized standards of safety. This is seen as a sovereign activity requiring both long term national commitment and a willingness to embrace international institutions which support the development of nuclear power for peaceful uses. This publication examines the issues behind required commitment and implementation, and provides guidance on necessary measures. These include political, legal and regulatory measures, as well as specific infrastructure conditions.

Nuclear energy has a worldwide impact and calls for the highest standards of safety. Establishing a safety culture which inspires confidence in national and international communities is essential to gaining the confidence of investors. Therefore, the establishment and operation of an effective and predictable regulatory system and process is one key to success. Only national governments can take ultimate responsibility for key strategies concerning the fuel supply and waste and spent fuel management.

The second area is application of lessons learned from technological and project developments. To date, most nuclear power plants have been, to some extent, developmental in their nature and all have been government backed, at least to some degree. Therefore, encouraging institutional or private investment in new sites will only be possible if a utility can demonstrate that the historical technology and project risks have been understood and properly mitigated. This publication identifies a number of measures by which confidence in design, permitting process, construction and operation of nuclear projects can be strengthened to encourage financial investment.

The third area is financing itself. Although nuclear power plants share many of the attributes of other major projects, they have characteristics making them a greater challenge for the investment community. Principal among these are high capital costs, technical and scheduling uncertainties, and the potentially long period before a return on investment can be secured. These, coupled with the need for investors to take into account non-financial aspects, including, for example, public acceptance, result in the need for some innovation in investment. This report considers some factors in the structuring of projects, contracts and mechanisms to ensure return on investment.

The conclusions of this publication are presented as a series of key mechanisms for improvement in each of these areas. Improving the prospects for investment in the nuclear industry is, in large part, achieved by a combination of financial and strategic planning measures, which together create sufficient confidence for investors to support projects. There are also a number of wider actions that can be taken to improve prospects for investing in nuclear power. These are aimed at a higher level and are designed to promote the adoption of nuclear energy as an effective and efficient energy option. These include, for example, the benefits of formally recognizing nuclear power's virtually carbon-free characteristics and the value of encouraging international institutions, such as the World Bank and certain regional investment banks and export credit agencies, to recognize the potential contribution of nuclear power. Others are concerned with international encouragement to maintain consistent and practical standards, methods, data and processes in the development of nuclear power and with the establishment of appropriate safety cultures in countries wishing to adopt nuclear power as an option. These mechanisms and actions are presented for future consideration of how they may best be developed or adopted.

Appendix I

NUCLEAR AND NON-NUCLEAR INSURANCE

I.1. NUCLEAR INSURANCE

When considering insurance risks for large power projects, there are certain areas that must be addressed: injuries to people involved in construction, injury to third party property, and damage to the project itself. Once nuclear fuel is introduced into the facility, nuclear liability and nuclear damage, including decontamination, must also be addressed. The construction risks and insurance requirements associated with large nuclear plant construction are only different from non-nuclear large power construction projects because of the introduction of nuclear fuel onto the site.

Unique to the nuclear industry, however, is the limited capacity of the insurance market to cover potential losses, due to the fact that the amounts required by the nuclear industry to cover both third party exposure and on-site property damage are commercially significant. As a result, nuclear insurers have organized themselves in nuclear insurance pools which are the only entities able to maintain the capacity to support the owner/operator market.

Another consequence of this limited capacity, is that there is no insurance market for EPC contractors, their subcontractors, and technology/equipment providers (T/E providers) for the provision of post-fuel load insurance to cover nuclear damage to the project and the facility site. The net effect of this market reality is that the EPC contractors, their subcontractors, and T/E providers have historically refused to take responsibility for such risk, recognizing that, without an insurance backstop, pricing such risk into contracts would be prohibitive. With the assumption of such risk by the owner/operator, economic efficiency can be achieved, as risk is allocated to the one party that can insure against it. Furthermore, the owner/operator can spread the cost of such risk over the lifecycle of the project.

Unlike a major coal fired or gas fired power project, where an EPC contractor would wrap the project (through a builder's all risk policy) and the single point of responsibility would be the owner/operator, it is expected that the new round of nuclear power plant construction will involve, vis-à-vis the owner/operator, a division of responsibility (and, thus, liability) between the main EPC contractor and the NSSS provider. With such a division of responsibility, it might not be feasible for a party other than the owner/operator to provide the traditional builder's all risk coverage noted in the detailed insurance description below. Thus, similar to the post-fuel loading allocation of risk, one would expect to see a similar allocation of risk, whereby the owner/operator has a project wide builder's all risk policy, resulting in a more economically efficient result. Instead of the EPC contractor and NSSS provider taking insurance to cover their portion of the risk, with each having to obtain coverage relative to the overall value of the project, one project policy might cover all parties supporting development and construction of the project, thus eliminating overlap and lowering project costs.

Given insurance costs and market limitations, the owner/operator has been traditionally viewed as the party in the best position to bear certain nuclear-specific insurance costs. In being the party best positioned to buy the insurance, the natural corollary is that the owner/operator is then in the best position to assume the risks being insured through the coverage obtained. Third party liability is generally designated as operator liability; however, other risks covered by insurance (chiefly, nuclear damage to the asset) are subject to a limited marketplace. By taking these 'other risks', the owner can effectively lower the cost of the project through the consolidation and alignment of risks. Without this assumption of risk by the owner, other parties (the EPC contractor, its subcontractors, and the T/E providers) no longer have to price such risks and, correspondingly, purchase insurance (to the extent available) to cover such risks, thereby lowering the overall cost of the project. Given the high costs of a nuclear power facility, such 'deal efficiency' will help make the business case more defendable and achievable.

I.2. NON-NUCLEAR INSURANCE

Various non-nuclear insurance requirements are also relevant for nuclear power plants. Examples of such insurance required for large power plant construction include:

(1) Workers' compensation (WC) and employer's liability (EL) covers injuries and/or disease, other than nuclear damage, to employees involved in construction of the plant.
(2) Commercial general liability (CGL) insurance covers bodily injury and includes third party property damage arising from construction activities. Coverage would include completion of a a period of operations after the project is finished.
(3) Excess liability insurance (excess insurance) in excess of EL and CGL coverage and is at least as broad as the underlying coverages.

Note that in lieu of WC/EL, CGL, and excess insurance provided by each contractor, a project insurance programme can be arranged by the facility owner or general contractor to cover all parties. Such programmes are usually rated on the basis of actual losses incurred, resulting in a lower premium when good safety programmes reduce total losses.

(1) Auto liability insurance covering the use of automobiles.
(2) Construction equipment insurance covering loss or damage to equipment used in the plant construction.
(3) Builder's all risk or erection all risk insurance, covering physical loss on damage to the plant under construction from all causes to the extent not excluded. Insurance limits can be the Total Insured Value (TIV) based on a probable maximum loss (PML) within an individual participating insurer's underwriting limits. Coverage is on a quota share basis, with individual insurers accepting a fixed percentage of risk, as determined by their allowed capacity. Policies include coverage for off-site storage and in-land transit. Coverage typically runs through 'cold testing' and 'hot testing' from non-nuclear steam. If delay in start-up (DSU) coverage is required by financing entities, it could impact the coverage capacity of individual insurers. DSU coverage is only triggered in the event of physical damage covered by the builder's all risk policy.
(4) Marine transit insurance would also be required, covering loss or damage to material or equipment while in transit worldwide to the plant site. Policy limits are the total value of any one shipment plus an allowance for freight and insurance. Replacement cost limits may be considered for equipment with high value and long lead time. DSU related to transit loss may also be required.
(5) Other insurance may be considered based on need, including professional liability insurance related to the engineering/design services of the project. Marine liability would be needed if the plant location involves unloading of equipment from a navigable waterway.

Appendix II

MAJOR FINANCIAL CONSIDERATIONS

Over the past 30 years, most power plants constructed throughout the world have been financed in the debt markets using one of two basic structures: (1) full recourse or ‘balance sheet financing’ or ‘sovereign financing’ and (2) limited recourse or ‘project financing’. And, while there has been extensive use of project financing structures for the development and construction of thermal, hydro and wind power stations in both industrialized and emerging countries, no nuclear power plant to date has been financed using a project financing structure. Rather, nuclear power plants have been constructed on the strength of the balance sheet of (that is, the general creditworthiness of) the sovereign government or utility ultimately constructing and operating the facility and, in the case of some countries, with strong support and commitment by the government.

This appendix explains these two financing structures in detail and evaluates some of the issues that arise when they are applied to the construction of a nuclear power plant.

II.1. BASIC DESCRIPTION OF FINANCING STRUCTURES

II.1.1. Full recourse structure

In full recourse financing, there is a creditworthy entity — such as a substantial power utility or a sovereign entity — which assumes 100% liability for any debt service payment obligation under the financing. As a result, lenders evaluate and rely on the general credit of that entity for repayment of loans and price the financing in line with its general creditworthiness. Therefore, the entity assumes direct responsibility for much of the structuring and implementation of the project and the costs of project construction are paid for out of the general cash resources of the entity, including proceeds of the loan agreement with the lenders. After construction of the project is complete and the operational phase begins, the output of the project is sold in accordance with the entity’s normal business arrangements and all revenues from the sale of project capacity and energy are paid directly to the entity. The entity is directly responsible for all cost overruns and other liabilities, both during the construction and operation phases. All amounts due under the loan agreement are repaid to lenders from the general cash resources of the entity, thus lenders have ‘full recourse’ to such an entity and all of its assets in a legal matter regarding such payments.

One variant of the full recourse structure which has been occasionally used in the nuclear power industry is ‘end-user’ financing, where a group of large creditworthy power consumers join together in a partnership, or shareholders in a separate entity, to finance building and operation of a nuclear power facility so as to provide a stable long term supply of power to end users. In this variant, the end users take responsibility for the debt service obligations of the partnership or entity that has constructed the nuclear facility.

II.1.2. Limited recourse structure

In contrast, limited recourse financing uses a special purpose vehicle (usually referred to as the project company, which is by definition an entity with no credit history). The project company undertakes the development, financing, construction and operation of a facility and serves as the ‘borrower’ under the limited recourse financing.[2]

In a limited recourse structure, lenders and other holders of debt look principally to future revenues generated by a project as the sole source of funds from which project debt will be repaid, and the collateral securing the debt is confined to the assets of the project itself, in particular the contracts of the project and the subsequent project revenue stream.

[2] Note in this respect that ‘public private partnerships’ or ‘PPP’ structures are ownership arrangements (where various ownership and risk responsibility issues are shared between public and private sectors), not a separate form of financing.

II.2. BENEFITS OF FULL RECOURSE FINANCING

Depending upon the details of a particular project, full recourse financing has a number of advantages, including the following.

— *Access to the borrower's full assets/business.*

As indicated above, the benefit of full recourse financing from a lender's perspective is that recourse under the financing documents is against the full array of assets of an operating entity — not just the assets of a single project company. Typically, full access means that the pricing (i.e. interest rates and fees) of the financing will be cheaper than normal project financing. The principal enquiry of lenders is for a credit analysis of the entity and its business as well as its prospects once a project has been constructed.

— *Limited lender interference.*

From a borrower's perspective, lenders in a full recourse structure have less oversight and control over the business decisions of a nuclear power project. As long as the entity maintains its fundamental creditworthiness, it should be able to conduct its affairs as it sees fit. In some cases, loan agreements contain covenants requiring a borrower to maintain core business activities and creditworthiness.

— *Ease of execution*.

Given the complexity, project financing is usually time consuming and comparatively expensive: it often requires longer negotiation and documentation time, carries higher interest margins, fees and costs for due diligence, negotiation and documentation than full recourse financing. In contrast, full recourse financing can often be completed more quickly and with much less difficulty.

— *Alignment of interests.*

As discussed further below, there is a perception in the financial community that in certain countries it will be necessary to have substantial sovereign credit support (even a form of full sovereign guarantees) for the financing of new nuclear power stations (at the very least during development and construction). To the extent that the 'borrower' under such financing is a sovereign entity — such as a State owned utility — there would be an alignment of interest between the sovereignty in its capacity as developer and regulator of the nuclear industry and the same sovereignty — subject to budgetary limits — in its capacity as guarantor of nuclear project indebtedness. In past cases, this kind of alignment has sometimes provided a form of political risk mitigation.

II.3. BENEFITS OF PROJECT FINANCING

The principal benefits of project financing are the following:

— *Off balance sheet' status and borrowing restrictions.*

Although full recourse financing clearly appears on the balance sheets of an operating utility or sovereign entity, it is possible with project financing (particularly where the debt has been extended on a truly non-recourse basis) to structure the transaction so that project debt is included on the balance sheet of a project company, but not necessarily on the balance sheets of its parent companies. Given the very large costs of constructing a nuclear facility, this is a substantial benefit, because the balance sheets of many utilities may not be able to support the debt required to undertake a nuclear project.

— *Risk allocation.*

The advantage of limited recourse debt from the perspective of ultimate project sponsors is that lenders, by implication, absorb some risk of project failure and/or underachievement. Put another way, the financial consequences of a major project setback — such as loss of revenue or political/natural force majeure events — will be shared by project sponsors and lenders. Project sponsors can limit their downside risk to the value of their equity investment in the project and the scope of any applicable sponsor support obligations. As a consequence, in the case of a non-recourse project, they can undertake the major capital expenses of a nuclear project without running the risk that project failure will jeopardize the overall credit standing of the company.

— *Leverage.*

Since project financing usually involves a large debt component, a project company is able to pocket excess revenues generated by a project and thereby leverage more profitably its rate of return and expand the use of limited equity resources. In other words, since lenders only receive interest and principal (which are relatively fixed, even though the interest rate is higher than for full recourse credit), sponsors can retain upside revenues earned if the project is a success. Since sponsors' downside risk is capped, they are better able to achieve targeted rates of return on equity — which may be of particular importance in the nuclear industry given the high costs involved. While the advantages of leverage are magnified in inverse proportion to the level of equity required for a project, project lenders will expect, in return for accepting limited recourse debt, to see a significant levels of equity in a project both to ensure adequate sponsor commitment to the project's success and to provide an equity revenue cushion to protect project debt service payments. The amount of equity required for a new nuclear power project is a topic of intense discussion. For comparison purposes, however, it is not uncommon for project lenders in the power industry to require a minimum equity commitment of at least 15–20% of total anticipated project costs (i.e. a debt–equity ratio of between 85:15 and 80:20).

— *Private sector participation.*

For policy reasons, some States prefer to take over project financing so that certain important sectors of the local economy (such as power generation, telecommunications, infrastructure supply and industrial production) can be managed in part by experienced professional corporations without the installation State being obliged to incur related costs and burdens. A combination of involvement by both States, which is discussed in Section III.5, is more likely.

II.4. RISK CATEGORIES

In project financing, the timely flow of payments back to participants upon which the financing/commercial structure is based is dependent upon successful project completion, timely commencement of commercial operations, and smooth, economically efficient operation and maintenance of facilities. As such, parties must identify and address risks and contingencies which affect each project participant at each phase of project construction and implementation. This section provides a general overview of common project finance risks and some strategies used to mitigate them.

II.4.1. Commercial risks

— *Utility/sponsor risk.*

If the utility/sponsor does not have the ability to carry out the proposed project or if no utility/sponsor is taking a leading role, the project will most likely be unsuccessful (e.g. delays, overruns). Accordingly, the utility/sponsor's commitment and capability to carry out a project is particularly important. In this respect, it is critical that the utility/sponsor has good credit, experience and a strong track record with similar projects. Additionally, lenders will evaluate the utility/sponsor's long term strategy in the sector and its ability to provide financial support in order to gauge the utility/sponsor's capability of completing and operating a project successfully. In order to maintain utility/sponsor leadership in a project, lenders will often require that the utility/sponsor retain all, or substantially all, ownership shares in the project company and/or management control of the project during the life of the debt.

— *Completion/construction risk*

'Completion' relates to the need to complete a project on time, within budget, in accordance with anticipated technical specifications and with the capability of producing the projected capacity and energy.

Project finance lenders typically expect the bulk of completion risk to be absorbed by experienced, reliable, well capitalized construction firms through a turnkey construction contract. Often called EPC contracts, these agreements oblige contractors to complete a project so that it is capable of meeting pre-set performance criteria by a designated date in return for a fixed date. However, as described further below, the unusual completion risks associated with nuclear power projects probably mean innovative construction arrangements need to be devised.

— *Operation and maintenance risk*

This broadly describes the risks related to continued operation of a project. In order for a project to be successful, the operator needs to be able to produce energy at full capacity and at reasonable cost. Risks include, for example, the long term stability of operating costs, the competence of the project manager or operator, the quality of labour, and the maintenance of the physical plant. It is common in project financing to have long term O&M (operation and maintenance) agreements with seasoned, reliable operators to ensure that the project is operated and maintained properly at a reasonable price.

— *Fuel/feedstock risk*

Feedstock risk is the risk that basic inputs (e.g. fuel supply, water, backup power, etc.) necessary to generate power cannot be procured either domestically or through imports in the quantity and quality needed, and at an economically viable price (including purchase costs, duties/taxes and transportation expenses). Long term supply contracts with principal suppliers are essential to ensure that a project has adequate feedstock supplies in the necessary volume and quality, at prices consistent with financial projections for the facility.

— *Market/price risk*

The ability of a power project to service its debt depends on its ability to sell its capacity and energy at an economically viable price. Consequently, the most important aspect of power project financing is securing a reliable stream of project income sufficient to cover production and maintenance costs and debt service payments and to provide an acceptable equity return.

Long term contractual sales arrangements — such as 'take or pay' power purchase agreements for power generation plants — are the most common means of mitigating revenue risk in that they provide a guaranteed stream of project revenue for at least the amortization period of the debt. Power purchase agreements need to be entered into with a credible and creditworthy counterparty, or, in the case of projects involving State owned utilities or power purchasers, be completed with the protection of adequate sovereign guarantees or undertakings.

The basic idea of a take or pay power purchase agreement is that the power purchaser agrees to purchase a minimum quantity of the project company's capacity and energy production at an agreed upon price for a period of time which at least matches the term of the debt. If the power purchaser is unwilling or unable to 'take' the minimum capacity quantity, and the project company is willing and able to deliver, the purchaser is nonetheless obligated to pay for the capacity as if delivery had occurred. As such, take or pay agreements mitigate sales volume risk. Additionally, price fluctuation risk is often passed on to the power purchaser, through such mechanisms as fixed tariff or 'capacity charge', which cover the debt service. The take or pay contract effectively assures the availability of an adequate stream of revenue as long as the project is properly producing output.

— *Environmental risk*

Environmental problems can affect every project participant in a power project. A failure to comply with environmental regulations will not only create significant liability and cash burden for a project company and operators, but also potentially for sponsors and lenders. For example, project cash flow may be affected by the imposition of environmental cleanup costs, delayed environmental permits causing startups to be postponed, and catastrophic accidents leading to a shutdown. Any one of these events could severely impair debt servicing and equity payments. Lenders' security can also be jeopardized when hazardous waste contamination or other environmental liability adversely affects the underlying value and quality of the project site. Further, if a lender exercises enforcement rights under project documents and directly or indirectly assumes project operations, it may become responsible for pre-existing and continuing environmental liabilities under the laws of certain jurisdictions (including the USA). Most commercial financial institutions require that the ventures they finance be constructed and operated in accordance with a set of environmental standards known as the 'Equator principles'. It is to be noted, however, that at this time the Equator principles do not apply to nuclear power plants.

II.4.2. Economic risks

— *Inflation risk*

Inflation has the potential to adversely affect a project's economics by causing increases in construction and operation and maintenance costs while revenues do not increase at the same pace. During construction, the risk of inflation may or may not be addressed depending on whether the construction is handled by a fixed price contract. Inflation has also an impact on debt interest and thus on IDC (interest during construction) and consequently on capital costs. Other construction related fees and costs (e.g. local salaries and spare parts), for which a fixed price arrangement is neither feasible nor appropriate, should be estimated conservatively in the projected cash flow model. During the operation phase of a project, inflation risk can sometimes be passed on to the power purchaser by factoring inflation into the product price.

— *Exchange rate risk*

Similarly, currency fluctuations may have a large impact on a project. During the construction phase, financing sources and uses of funds should have matching currencies as much as possible. Revenue should be denominated in the same currency as debt service during the operation phase. Take or pay power purchase agreements often have some price mechanism so that the power purchaser bears the risk of currency fluctuation.

II.4.3. Political risks

In order to mitigate the political risks described below, it is crucial that the State acknowledges the importance of a project for its economic development. Additionally, it is critical in connection with a nuclear power project that the State makes a long term commitment and renders support for a project through financial support, monetary compensation, and/or confirmation that it has no intent to take any actions that would have a materially adverse effect on the project in question. Political risks are typically seen to be the following.

— *Political violence and expropriation*

Nationalization, expropriation, sabotage, riots, terrorism, attacks, war, etc., may cause physical damage or the cessation of the construction, startup or continued operation of a nuclear power project.

— *Convertibility and remittance risk*

Currency exchange controls and restrictions on remittances of foreign currencies in the host country may have a deleterious effect on a project, particularly when debt service payments are denominated in a foreign currency.

— *Changes in the law and policy of the State*

Much of a project's financing structure integrity depends on the enforceability of contractual obligations. For projects undertaken in areas where the legal system is either still under development or where project participants cannot obtain standard legal protections available elsewhere, the reliability of such obligations is brought into doubt. Any arbitrary change in relevant policy framework may also cause an adverse effect on the project.

II.4.4. Force majeure risks (flood, earthquake, etc.)

This is a key risk for which there is no 'obvious' allocation; ultimate allocation will be subject to negotiation between the parties and there is no 'model' per se to be followed.

II.5. CHALLENGE OF FINANCING NUCLEAR POWER PLANTS

It is to be noted that even in the case of the conventional power sector, project financing is an effective option when related parties in the sector in a country (government, utilities, sponsors, etc.) accumulate successful track records so that investors feel comfortable sharing part of the risk. Accordingly for nuclear plant projects, it might be the case that the State and sponsors should consider a 'staging approach' for financing nuclear power projects in a country — i.e. at the first stage, projects will be financed on a full recourse basis, and project financing will be considered for the next stage based on sufficient track records in full recourse financing phase.

While the foregoing risks have been satisfactorily addressed through a variety of arrangements for non-nuclear power project financing, there is a widespread view that nuclear power facilities present unique challenges for project financing. Further, even when full recourse financing structures are used, nuclear power transactions require special solutions to a number of key issues facing the industry. The principal issues currently cited by financial institutions are the following:

— *Need for regulatory certainty*

Given that financial institutions lending to a nuclear power station need to be highly confident that the station will be constructed 'on time, on spec and on budget' (particularly in the case of project financing), there is a critical need to ensure that the regulatory environment is sufficiently developed and stable to prevent material changes midstream. Accordingly, financial institutions will likely require regulatory certainty as a condition to contemplating financing of a nuclear power station. This will be particularly true of the first several projects undertaken under by any nuclear construction programme, as lenders will be sceptical until a successful track record has been established.

— *Cost overruns in general*

Generally speaking, nuclear power projects have a history of cost overruns and, in response to this, substantial analysis has taken place to try to identify whether such cost overruns are the result of design and regulatory changes during the construction process, difficulties in the construction process itself or other causes. Given the difficulties in finding and eliminating a clear single cause for such problems, it is likely that lenders to a nuclear facility will expect to see some form of completion guarantee which may comprise contingent equity commitments (from the sponsor or the State or both) to cover possible cost overruns regardless of cause. In this respect, certain States have contemplated structures in which the State would indemnify nuclear power projects for any losses incurred as a consequence of regulatory delays or regulatory related litigation.

— *Fuel cycle concerns*

Financial parties — as in any financing — expect that nuclear fuel supply will be contractually secured on a long term, economic basis. However, there are additional fuel issues for nuclear power plants which lenders will be concerned about. These issues are related to the overall problems of spent fuel management and plant decommissioning and the attendant costs and liabilities that project owners (and their lenders) may be subject to. Clearly, these two issues raise a large number of economic and public policy questions which go beyond the scope of any single nuclear power plant and, in a number of jurisdictions, these questions are being approached on a national or global basis. Yet, in order for individual financing to close, it will be necessary for these questions to be addressed in a sensible and credible manner.

— *Environmental liability*

It is axiomatic that the full array of environmental permission, risk management and liability issues will be of central importance to any financial institution looking at a nuclear facility.

— *Limitations on nuclear liability*

While, as discussed in the other appendices, there are nuclear liability regimes to organize and limit any liability claims relating to nuclear accidents, the costs and capacity of providing the requisite insurance and caps on liability are of concern to financial institutions, as well as would-be equity stakeholders, and factor into financing decisions.

— *Supply chain concerns*

As a result of the atrophy of the nuclear construction and equipment supply industries, there is currently not a large supply of manufacturers qualified to make components and equipment at the high standard required by the industry. While this creates a significant problem for the industry as a whole, each individual project will be faced with an assessment as to whether supply constraints will prevent construction from proceeding at the anticipated pace and cost based on whether project sponsors (other than a few ‘first movers’) will be stuck in a supply queue. It is also likely that contractors, in their contractual arrangements with project developers, will try to limit their exposure to this risk until a robust supply chain has been re-established.

— *Public safety and security concerns*

Nuclear power facilities are particularly subject to public safety and security concerns. For example, in light of increased attention to security issues, nuclear power plants will also need to be protected against certain security risks. In this respect, lenders will expect to see that the State, project participants and the public as a whole are fully supportive of nuclear power and that the State’s nuclear power programme as a whole is accepted.

II.6. NEED FOR GOVERNMENTAL SUPPORT

An overarching requirement for the successful financing of the next generation of nuclear power plants is sustained government involvement. This is likely to consist of several distinct elements.

First, for the country implementing a nuclear programme, project participants will want to be comfortable that the government has created a sensible and credible set of solutions to deal with the various issues facing the nuclear industry and that those solutions are sufficiently politically and economically stable (with sufficient public support) to remain intact over the full life of the facility.

The host government is generally required to play many important roles which may include:

- As the authority, to invite and attract local and foreign investors and to initiate the project;
- As the authority, to grant business/investment and nuclear safety related licenses and necessary approvals related to the project in a timely manner;
- As a contractual party, to execute (or a supervisor of related governmental entities should execute) contractual obligations properly (e.g. power purchaser, feedstock supplier, etc.);
- As a party indirectly related to the project, to construct (or improve or maintain) related infrastructure in a timely and proper manner (e.g. transmission network, port facilities, etc.);
- As a policy maker, to not substantially or adversely change important industrial policies, laws or regulations for at least the duration of the loan period (e.g. amend price formula of feedstock, offtake contracts, or abolish favourable treatment to the project);
- As the final backstop, to ultimately take over a failed project;
- As a grantor of support, to provide binding/non-binding support to sponsors and lenders (e.g. to keep related entities financially sound, recognize the importance of the project to the government, grant various types of support to the project, etc.).

It can be concluded that project financing does not represent the structure currently applicable for nuclear power plants in countries targeted to launch nuclear programmes. Strong involvement and commitment will be needed from host governments in a number of areas. From the investors' viewpoint, government support is a crucial prerequisite for investment in the nuclear power sector, regardless of the financing structure.

It is likely that host countries will need to provide significant financial and non-financial support to the projects themselves. This support can take a wide array of forms, from full financial guarantees of the project debt to targeted financial instruments under which the government assumes responsibility for key risks (such as changes in law or costs of spent fuel disposal and decommissioning). Therefore, corporate financing with various degrees of government support (depending on country and project specifics) is currently the realistic scenario for the financing structure of nuclear power plants.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA Nuclear Energy Series No. NG-G-3.1, IAEA, Vienna (2007).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Financing of New Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-4.2, IAEA, Vienna (2008).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Evaluation of the Status of National Nuclear Infrastructure Development, IAEA Nuclear Energy Series No. NG-T-3.2, IAEA, Vienna (2008).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Managing the First Nuclear Power Plant Project, IAEA-TECDOC-1555, IAEA, Vienna (2007).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Infrastructure for a Nuclear Power Project, IAEA-TECDOC-1513, IAEA, Vienna (2006).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Potential for Sharing Nuclear Power Infrastructure between Countries, IAEA-TECDOC-1522, IAEA, Vienna (2006).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, International Conventions and Agreements, http://www.iaea.org/Publications/Documents/Conventions/index.html

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, The 1997 Vienna Convention on Civil Liability for Nuclear Damage and the 1997 Convention on Supplementary Compensation for Nuclear Damage, IAEA International Law Series No. 3, Vienna, (2007).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, The Convention on Nuclear Safety, IAEA, Vienna (1994).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Overview of the Modernized IAEA Nuclear Liability Regime, Vienna (1997).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Technical, Economic and Institutional Aspects of Regional Spent Fuel Storage Facilities, IAEA-TECDOC-1482, IAEA, Vienna (2005).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Predisposal Management of Radioactive Waste Including Decommissioning, IAEA Safety Standards Series No. WS-R-2, IAEA, Vienna (2000).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Programme Planning: An Integrated Approach, IAEA-TECDOC- 1259, IAEA, Vienna (2001).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Strategies for Competitive Nuclear Power Plants, IAEA-TECDOC-1123, IAEA, Vienna (1999).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Choosing the Nuclear Power Option: Factors to be Considered, IAEA, Vienna (1998).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Financing Arrangements for Nuclear Power Projects in Developing Countries: A Reference Book, Technical Reports Series No. 353, IAEA, Vienna (1993).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidebook on Research and Development Support for Nuclear Power, Technical Reports Series No. 298, IAEA, Vienna (1989).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing Industrial Infrastructures to Support a Programme of Nuclear Power: A Guidebook, Technical Reports Series No. -281, IAEA, Vienna (1988).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Promotion and Financing of Nuclear Programmes in Developing Countries, IAEA, Vienna (1987).

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Energy and Nuclear Power Planning in Developing Countries, Technical Reports Series No. 245, IAEA, Vienna (1985).

[22] INTERNATIONAL ATOMIC ENERGY AGENCY, Expansion Planning for Electrical Generating Systems, Technical Reports Series No. 241, IAEA, Vienna (1984).

[23] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Standards, http://www-ns.iaea.org/standards/

DEFINITIONS

architect–engineer. The project participant who provides integration of design for the complete power plant and manages the construction and commissioning of the project for the owner/operator.

debt. Money borrowed to finance a project, which creates a debt that is then subject to repayment of capital with interest under agreed terms.

design certification. The process of achieving a statement from a licensing authority regarding the acceptability of safety characteristics for a design (as opposed to a built reactor).

equity. Ownership in the project based upon the amount of capital provided by the owner(s).

financing. The financial support and arrangements needed to pay for a part of or the total costs of a project.

funding. Financial support to institutions which are key for the preparation, development and implementation of a nuclear power programme.

joint and several. Liabilities sometimes shared by partners where each accepts responsibility for the default of the others, thus providing an entity or owner contracting with the partners a simpler focus on redress.

levelized cost of electricity. All capital, fuel, operating, maintenance and waste management costs associated with the generating plant over its lifetime divided by the total cost of the estimated output in kWh over the lifetime of the plant.

licensing. The process carried out by a competent, independent regulatory authority to grant permission to an applicant to construct or operate a nuclear power plant, based on submission of a license application which demonstrates compliance with design certification and regulatory requirements as they relate to nuclear safety as well as other aspects of operation.

overnight costs. EPC costs plus owners' costs. Owners' costs include land, cooling infrastructure, administration and associated buildings, site works, switchyards, project management, licences, etc.

owner. The purchaser of a nuclear power plant, which may also be a utility.

planning consent. Approval needed from the relevant authority in respect to agreed suitability of a site for the building of a nuclear power station.

PPA. power purchase agreement between a utility and power purchaser which contracts for the guaranteed supply and sale of electricity produced over a prolonged period.

programme. The adoption of a decision by a government to build nuclear power reactors, together with all the implications of ownership, regulation, management, waste and fuel supply.

project. The plan for design and construction of a nuclear power reactor and its execution.

proven. A mature design with extensive operating experience.

third generation. Refers to Generation III (3+) Advanced Reactors. Generation III reactors have a standardized design for each type in order to expedite licensing, reduce capital costs and reduce construction time. They have a simpler and more rugged design, making them easier to operate and less vulnerable to operational upsets, they also have higher availability and a longer operating life (typically 60 years). There is a reduced possibility of core melt accidents, resistance to serious damage that would lead to radiological release from an aircraft impact, as well as higher fuel burnup to reduce fuel use and the resulting amount of radioactive waste.

unit cost or EPC cost. Typically, the capital cost of a nuclear power reactor within EPC responsibility (i.e. excluding infrastructure costs, etc.)

vendor. The designer and supplier of a nuclear steam supply system.

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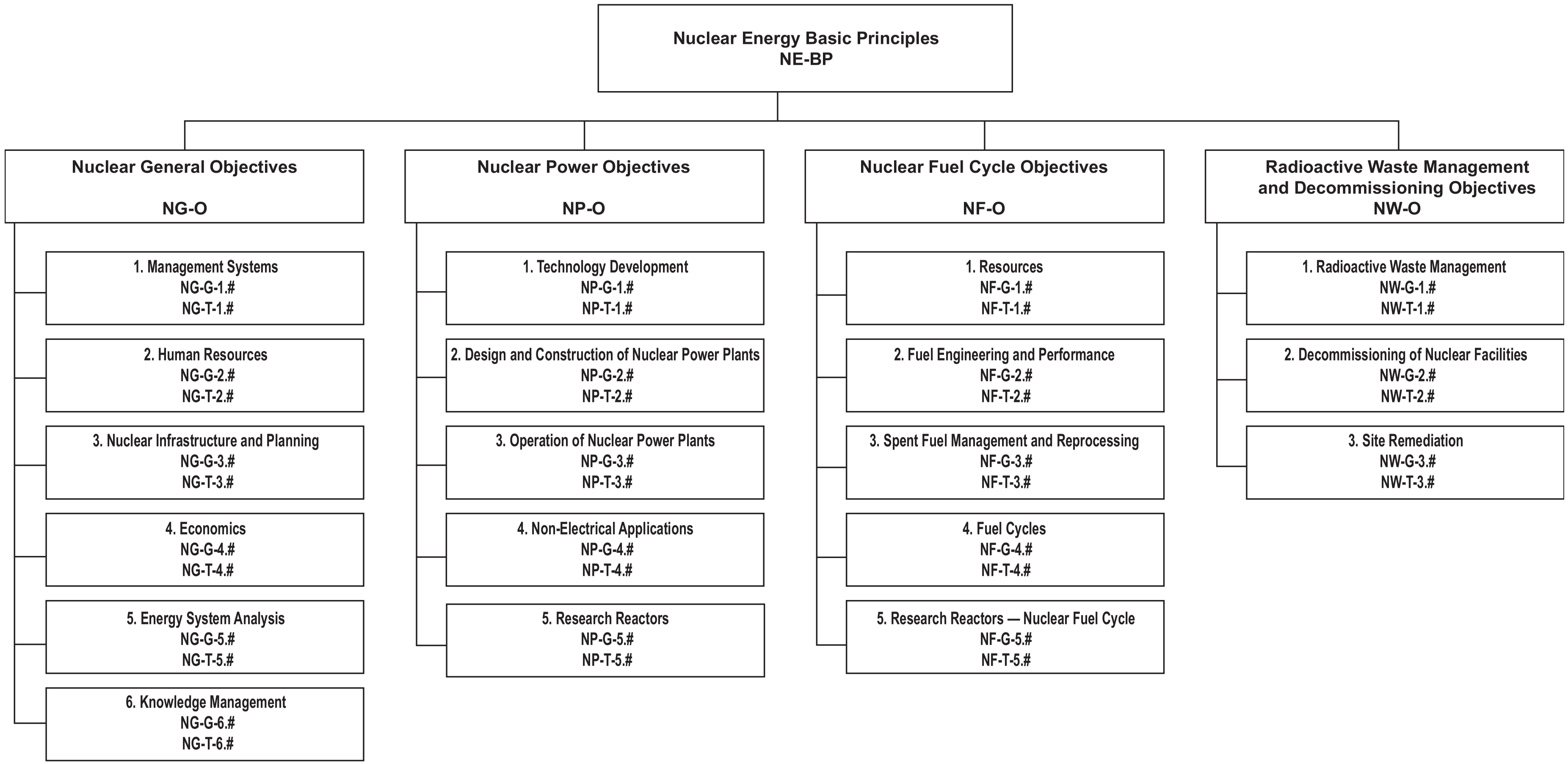

Key

BP: Basic Principles
O: Objectives
G: Guides
T: Technical Reports
Nos. 1-6: Topic designations
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Examples

NG-G-3.1: Nuclear General (**NG**), **G**uide, Nuclear Infrastructure and Planning (topic **3**), **#1**
NP-T-5.4: Nuclear Power (**NP**), Report (**T**), Research Reactors (topic **5**), **#4**
NF-T-3.6: Nuclear Fuel (**NF**), Report (**T**), Spent Fuel Management and Reprocessing, **#6**
NW-G-1.1: Radioactive Waste Management and Decommissioning (**NW**), **G**uide, Radioactive Waste (topic **1**), **#1**

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