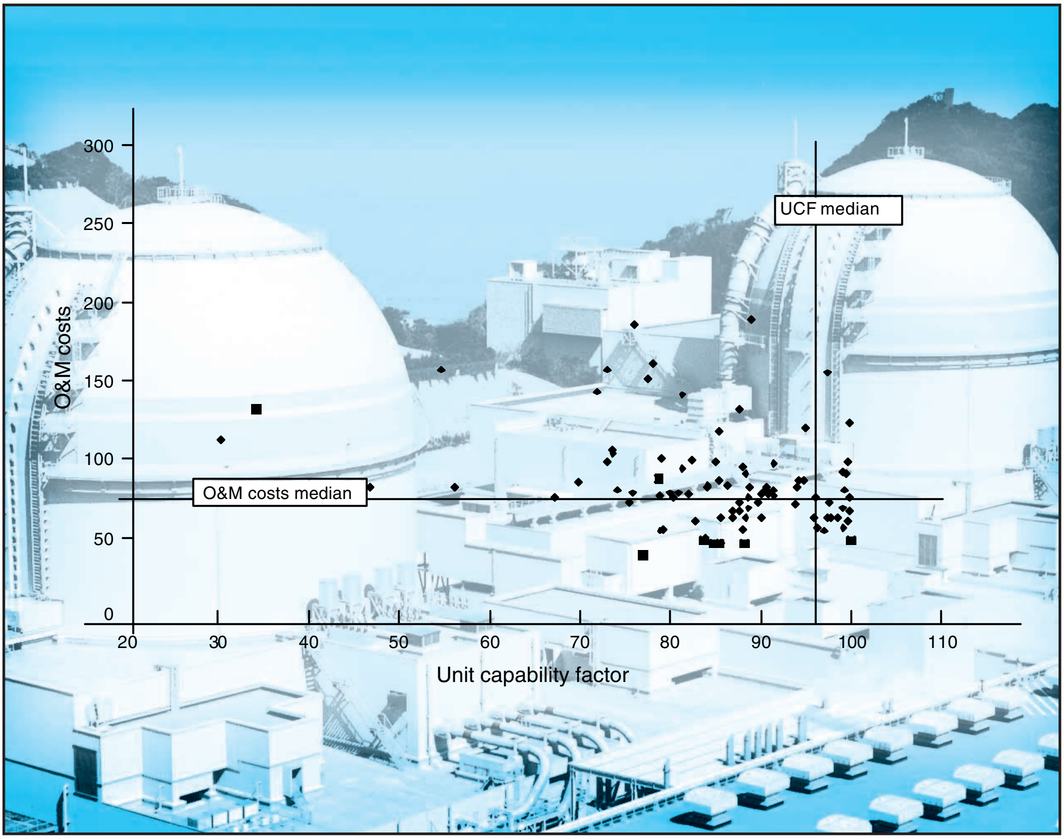

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Developing an Economic Performance System to Enhance Nuclear Power Plant Competitiveness

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 2002

DEVELOPING AN ECONOMIC PERFORMANCE SYSTEM TO ENHANCE NUCLEAR POWER PLANT COMPETITIVENESS

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FOREWORD

In 1999 about 16% of the world’s electricity was produced by nuclear power, and the total worldwide operating experience of nuclear power plants was over 9200 reactor-years. Some 16 countries are dependent on nuclear power for more than 25% of their electricity generation. In some countries deregulation of the electricity market has either happened or is currently ongoing, while in others it is planned for the future. Nevertheless, many countries are already facing open electricity markets and operating costs are under unprecedented pressure, with competition expected to come soon to the nuclear industry worldwide. To a certain extent, however, the industry has already prepared or is currently preparing to face competition.

This report is primarily intended for nuclear power plant and utility managers. It discusses the means and principal issues for the development of the nuclear economic performance international system (NEPIS), which should enhance nuclear power plant competitiveness.

The following issues are addressed:

— The major transformations occurring in the electricity generation industry that require reductions in operations and maintenance costs at nuclear utilities,
— The methods that nuclear plant management use to identify and justify the economic optimum level of a plant and its use of resources,
— The value of collecting cost and performance data and the analysis techniques that use that data,
— The cost data required to be collected,
— The difficulty of collecting data with existing cost accounting systems,
— The new cost accounting and collection systems that will be required,
— The cost effectiveness of the overall process.

This report also presents the preliminary results of a pilot project that was established to collect cost data on a few nuclear power plants and was used to verify the adequacy of the definitions and terminology set for NEPIS.

The IAEA wishes to thank all of the participants for their valuable contributions. The IAEA is particularly grateful to R. Richwine for his assistance and for his role as chairman of all the meetings held on this subject, and to the chairman of the Nuclear Committee of the Electric Utility Cost Group, J. De Mella, for his collaboration and assistance in preparing the final document. The responsible officer at the IAEA for this report was R. Spiegelberg-Planer of the Division of Nuclear Power.

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CONTENTS

1. INTRODUCTION

In many countries nuclear utilities are facing what is, for them, a new operating environment, one in which their operating costs are coming under unprecedented pressure. In the past the focus was on minimizing fixed costs by minimizing construction costs and maximizing availability, so that the fixed cost per kilowatt-hour was low. Now, with few plants under construction and little immediate prospect of further orders in most countries, the focus is on controlling total operating costs to ensure that existing plants can justify their continued operation. In some cases, notably the United Kingdom, nuclear power plants are increasingly having to compete directly, in an open energy market, with other electricity suppliers. In the United States of America data on operating costs are being analysed to determine whether the continued operation of nuclear power plants provides power to consumers at the least cost. These cost pressures are likely to intensify and spread to all countries as the trend to liberalize and introduce competition in the electricity supply industry widens. Coping with this competitive pressure is a challenge that the nuclear industry should meet if the nuclear option is to remain a viable one.

This competitive environment has significant implications for plant operations, including, among others, the need for the efficient use of all resources, including personnel, for the more effective management of plant activities, such as outages and maintenance programmes, for the greater use of analytical tools to balance the costs and benefits of proposed activities, and for the sharing of resources, facilities and services among utilities. There also appears to be a need to derive new indicators of performance, for example on operations and maintenance (O&M) costs. There is a strong need to optimize O&M costs to ensure the economic competitiveness of existing nuclear power plants, since as they get older costs tend to rise.

High availability has always been recognized as being one of the keys to nuclear competitiveness, as it allows fixed costs to be spread more thinly. However, high availability is not sufficient by itself to guarantee competitiveness. In general, low O&M costs per kilowatt-hour are the target, but the situation is different for every plant. In some cases availability can be maintained at the existing level with lower overall O&M spending by targeting expenditures more appropriately. Increased O&M spending would be justified if cost effective extra output is produced.

In meetings convened by the IAEA, experts from Member States discussed the major transformations in nuclear utilities needed to achieve O&M cost reductions, how to help managers identify and justify the optimum level and use of O&M expenditure, the value of collecting cost and performance data, what analyses could be done, what cost data should be collected in order to do these analyses, how difficult it is to collect these data with existing cost systems, what new system of cost collection is needed and if it would be cost effective.

The benefits of collecting O&M costs are compelling. It allows management to identify more clearly where and how costs are being incurred and sharpen its judgement to determine whether adjustments would improve the competitiveness of a plant. However, the centralized collection of these data and their use for comparisons between plants, perhaps owned by another utility or even in another country, does raise a number of important issues. These issues are discussed in this report.

Section 2 of this report discusses the factors that cause utilities to optimize O&M costs. Section 3 discusses the advantages of a nuclear economic performance international system and how to use an international system to make better decisions and improve the costs of nuclear power plants. Section 4 provides the basis for the database's design and implementation and includes the preliminary results of a pilot project to establish an economic performance international system. It also presents future issues and the uses of such an international system. Section 5 summarizes the conclusions of this report.

The annexes present one method to estimate optimal costs and performance, tables used for data conversions, definitions and the terminology used in the data collection.

2. TRANSFORMATIONS CAUSING UTILITIES TO OPTIMIZE O&M COSTS

2.1. TRANSFORMATIONS IN THE ELECTRICITY SUPPLY INDUSTRY

Over the past 10 to 15 years the way electricity supply systems are organized and operated has come under increasing scrutiny, and most electricity supply industries have undergone or are undergoing some degree of reform. Previously, as part of a 'regulatory bargain', utilities were guaranteed monopoly powers and the full recovery of costs in return for providing a reliable electricity service, available to all at non-discriminatory prices. This 'bargain' is being rapidly abandoned.

In the most radical reforms, such as those undertaken in the UK in 1990, the public companies were broken up and privatized (i.e. ownership was transferred from the national government to private shareholders) and the generation and supply to the final consumer (retail) sectors of the industry transformed from a monopoly to one run on free market principles. Electricity retailers now have to compete with each other to win customers, and power station owners have to compete against each other on an hour by hour basis.

In the USA the process began earlier and has been more gradual, starting with a toughening of the regulatory regime in the late 1970s that weakened the assurance of cost recovery. Prudence evaluations, conducted by state regulators, scrutinized the construction management practices of newly completed nuclear facilities and resulted in a substantial disallowance of the recovery of construction investments. Regulatory pressures continued in the 1980s with the growth of independent power producers, and now a number of states are moving towards a system similar to that adopted in the UK.

Deregulation will probably result in fewer operating organizations, owing to expected mergers and acquisitions. Opportunities will exist for high performing, economically competitive companies to be the electricity providers of choice. Nuclear safety and operational and economic performance across the industry have continued a favourable trend. The performance of US nuclear plants has steadily improved in terms of longer run times, reduced outage lengths and improved safety and economic performances.

Over the past five years the annual production costs for US nuclear plants have decreased. On average, production costs for the median performers have improved by more than 25%. However, despite recent US industry improvements there still remains a significant (30%) gap between the median and best performers. Significant opportunities for nuclear plant improvements will continue to exist through benchmarking and emulation of the best practices of the top industry performers.

By introducing a directive in 1996 the European Union (EU) laid down the rules of opening the electricity market in the EU area: from February 1999 each member of the EU should have started opening up its market, at least for the biggest customers. Each country has chosen its own pace, but the share of the market that should be open by 2003 will be, at least, a third of the total consumption.

In other countries, particularly those where demand growth is still rapid and the supply infrastructure is not fully developed, the transformation has been less extreme. Nevertheless, these countries are looking at the examples of the developed countries and adopting aspects of their reforms, such as weakening the generation monopoly and allowing at least large consumers to negotiate the purchase of power from suppliers other than the incumbent franchise supplier [1].

2.2. CHANGING PRIORITIES IN INVESTMENT APPRAISAL

The changes outlined in Section 2.1 have transformed the commercial context for nuclear power. Previously, decision making on electricity supply options was dominated by companies with monopoly powers that were able to make decisions on the basis of long term, large, centralized investment appraisals, tempered by strategic considerations on supply security.

In the past, when a nuclear programme was committed to, the total discounted generation cost of a nuclear plant was expected to be significantly lower than that of a fossil fuel plant. Such forecasts were founded on the anticipation of long term higher fossil fuel energy costs. In this context the competitive focus for nuclear power against other generation options was at the pre-construction phase and was dominated by attempts to minimize the expected capital costs and construction times. Such forecasts frequently proved inaccurate. Market competition against other forms of energy was generally only at the margin and not a major consideration. This meant that investments in new power plants carried little economic risk to the utilities because, if errors were made, they could pass the extra costs on to consumers. As a result, and because governments often set a lower rate of return on capital than private industry, new power station investments were generally required to achieve a relatively low real rate of return on capital (typically 8 to 10%)[1] and could be amortized over the licensed life of the plant (typically 30 to 40 years). This tended to favour capital intensive options, such as nuclear power, over lower capital cost options.

Once a nuclear plant was in service, a reasonable assurance of a full recovery of costs and return on investments meant that the incentives to minimize O&M costs and new capital expenditures were limited, and the decision of when to retire plants was largely left to the discretion of the utilities.

In the new context, however, the economic risk of investing in new generating plant lies much more with utility shareholders and project financiers than with consumers, and the economic life of an asset may be much shorter than the licensed life. As a result, a substantial ‘risk premium’ is appropriate in investment appraisals and the capital is recovered over a much shorter period. For example, in the UK recent power station orders have been required to make a 15% real rate of return on capital and the investment has been amortized over an eight year period.

Under such criteria it may be difficult for nuclear power to compete with other forms of generation and, as a result, all plans to build new nuclear power plants in the UK have been abandoned. In the USA no new nuclear orders are foreseen at present. Necessarily, the focus has shifted towards the operation of existing plants, partly to ensure that they are competitive and partly to maintain nuclear power as a viable option if and when economic circumstances are more favourable to it; nuclear power may become more cost competitive when environmental compliance costs are fully incorporated into fossil fuel’s total generation costs. A recent analysis carried out in 1995 by the Energy Information Administration (EIA) of the US Department of Energy reports that US companies moderately improved their voluntary efforts to address global warming in 1997, achieving greenhouse gas emission reductions of 165.6 t of carbon dioxide equivalent (7% more than in 1996). The report states that the largest reported emission reductions came from projects that improved the

[1] This value considers all invested captial; that is, it is the weighted cost of capital.

performance of nuclear power plants and thus reduced coal fired generation. Because nuclear power plants are invariably large box load facilities, even fairly small improvements in plant availability can lead to a sizeable reduction in fossil fuel consumption [2].

2.3. CHANGES IN PLANT OWNERSHIP

One of the side effects of the liberalization of electricity supply industries has been that the ownership of nuclear power plants has become less fixed. In some cases, such as the UK and Brazil, electricity liberalization has led to the break up of electricity generating companies, leaving their nuclear power plants in the hands of new companies. In others some owners are reviewing the nature of their business in the light of the new commercial environment, and if they see nuclear power plants as not part of their core business they may look to sell them. For example, in California some of the main utilities have sold their generating plants. Equally, other companies have acquired existing nuclear power plants in areas outside their franchise regions, for example PECO (Philadelphia Electric Company, USA) and British Energy (UK) have formed a joint venture to acquire and operate existing nuclear power plants.

Changing ownership is both an opportunity and a challenge. The new owners look at the plants with a fresh eye and may bring innovative new thinking to their operation, hence improving their performance. For example, the performance of the UK's nuclear power plants improved dramatically after they were placed in a new nuclear only company. However, some of the experience and knowledge of the specific details about a plant may be lost in the process of ownership transfer, to the detriment of plant performance.

2.4. INFLUENCE OF A NEW BUSINESS ENVIRONMENT ON PLANT DECISIONS

In the increasingly global economy that characterizes today's business environment, industrial consumers of electric power, in order to remain competitive, are demanding both low costs and high reliability. In the past, with government subsidies or territory monopolies, the electric power industry as a whole, and the nuclear power industry in particular, was less concerned with cost. Although in certain countries, including the USA and Canada, detailed O&M cost data have been available for in depth analysis, it has not been widely distributed and used throughout the world's nuclear community. Also, cost has not been given as high a priority as safety and availability, where international standards for data collection and analysis have been in place for many years and have been effectively used for overall plant improvements. Today, however, costs are much more closely scrutinized by local and national governments, the utilities' management and financial institutions to determine the economic competitiveness of all forms of electric power generation, including nuclear power. As the threat increases of a full deregulation of the electric power sector, with open markets and supplier choice, nuclear power will have to increase its focus on controlling and optimizing costs, in addition to maintaining high levels of safety and availability.

The influence of the increase in market pressures on generation costs can be better appreciated as the change in the basic paradigm in the electric power sector is better understood. The former general equation for electricity pricing in countries with a regulated, for profit, power industry was:

Price = cost + profit

Where cost was the actual incurred cost (construction plus O&M plus fuel) this was considered prudent (or not able to be proven imprudent) and profit was legally mandated and regulated. This led to a risk avoidance decision mindset since a successful high risk investment could only yield the mandated profit margin (12 to 14% in the USA), while an unsuccessful investment that was judged imprudent could be disallowed and the entire investment written off. Risk taking could only result in a reduction in the company's overall profit margin. Therefore, the management mindset was to avoid imprudent judgements by minimizing risk. Because there were no competitive pressures, the resulting electricity prices could vary greatly from one monopolistic territory to another, with no recourse for each area's customers since they were captive to their electricity utility. As customers began to demand lower costs and more supplier choice, increasing pressure was applied to deregulate and liberalize the electricity utility market. With these increased market pressures, the basic paradigm has changed. The new equation has profit as the dependent variable, such that:

Profit = price (market) – cost

Price is determined by a competitive market environment and cost is the net result on an electricity utility's costs as a result of all decisions, good and bad. Therefore, the high return realized from a series of successful high risk investments can be used to offset the negative return from unsuccessful ones. This will bring about an increased need to change from an avoid risk decision making mode to one where the decision makers identify, quantify and manage risk (risk in this context only relates to performance and cost, not to safety).

In the past the best solution for any particular performance problem was characterized by its technical superiority or its effectiveness in solving a problem.

While management sought to implement that solution at the lowest possible cost, it often was the only solution put forward. In the future, however, a nuclear power plant's management will need to identify an entire range of best practice solution options and their respective costs and impacts. The best solution will be characterized by its economic superiority or its cost effectiveness. Sharing information about these potential solution options will allow each plant to optimize its own O&M cost programme.

For countries where profit motives are not present there are still substantial pressures to reduce nuclear power plants' O&M costs. Numerous economic studies have shown direct links between a country's overall economic growth and the availability and cost of its electric power. By reducing costs and improving performance, nuclear power plants can contribute substantially to these countries' abilities to attract new industry. In addition, environmental factors such as greenhouse gases and other emissions are becoming more important. The total costs for fossil fuel generation could rise, creating increased opportunities for nuclear power to become the more competitive choice if nuclear power plants continue to improve their performance and reduce their costs.

2.5. POTENTIAL FOR PERFORMANCE IMPROVEMENT

In order to estimate the opportunity for performance improvements and O&M cost reductions at nuclear power plants data for US plants were plotted (see Fig. 1) [3]. This shows a comparison of US nuclear power plants' O&M costs against capacity factors.

It can be clearly seen that a wide variation in both capacity factor (an indicator of performance) and O&M costs exists between top performing[2] plants and poorer performing plants. In fact, the data shows that the range around the median O&M cost plants is ±50% (median about US $100/kW(e)/a, lowest about US $50/kW(e)/a, highest about US $150/kW(e)/a).

In addition, there is a comparable variation in capacity factors. If poorer performing and higher cost plants were to lower their costs and improve their performance to their optimum economic performance (see Annex I for a discussion of the optimum economic performance concept), the savings are estimated to be US $5000 million/a, with an estimated reduction of in excess of 80 million tonnes of CO_2/a (if the increased nuclear generation replaced coal fired generation). If these USA data were extrapolated to the worldwide collection of nuclear plants the

[2] In this section the word performance is used as a synonym of availability.

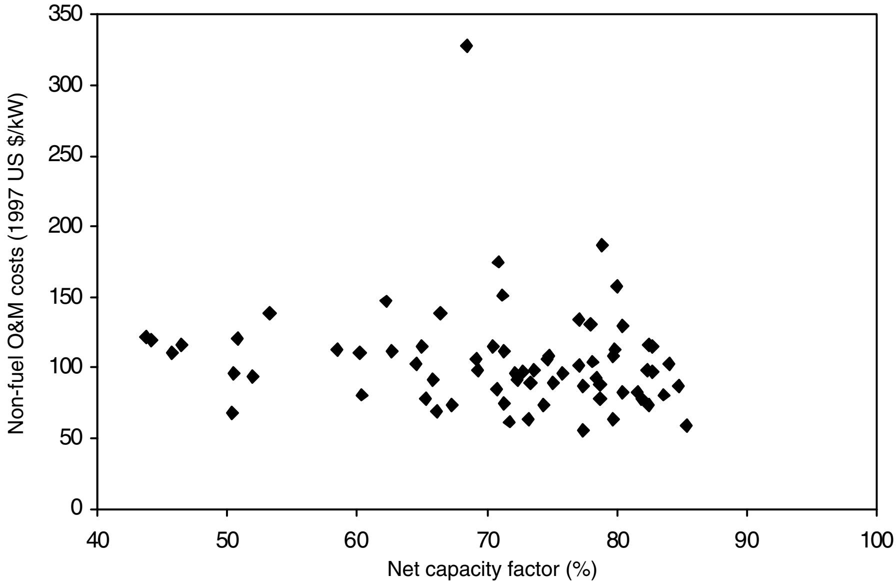

FIG. 1. US nuclear plant O&M costs plotted against capacity factors, 1993–1995.

potential savings would be of the order of US $20 000 million/a, with CO_2 reductions (replacing coal fired generation) in excess of 320 million tonnes/a.

Substantial improvements in safety and technical performance have already been achieved through, among other means, the development and application of international standards and definitions, data collection and analysis, and shared best practices. Nevertheless, the international community needs to develop international standards and definitions so as to allow the exchange of information on best practices to improve nuclear power plants' economic performances.

3. APPLICABILITY OF A NUCLEAR ECONOMIC PERFORMANCE INTERNATIONAL SYSTEM

This section itemizes some of the ways that a new nuclear economic performance international system will be used to improve the cost competitiveness of today's nuclear plants as well as future nuclear plant designs. As the database is implemented and matures, new techniques and methods will be developed that will take even greater advantage of the information it will contain.

In order to design properly a cost effective economic performance data collection system it is necessary to have a good idea of what will be done with the data after they are collected. If too much data are required to be input a costly burden for power plant staff is created, but if too little data are collected it will be impossible to make meaningful analyses. A balance between these two extremes should be achieved, and hence the uses of the database need to be decided upon.

The guiding principle is that data collection, compilation and analysis should result in better decision making by someone in the chain of authority throughout the life of a nuclear power plant, from its design through to decommissioning.

By looking at the ways technical performance and safety databases have been previously used to improve nuclear power plants, a great deal of insight can be obtained regarding the ways a new international O&M cost database will be used. Reviewing how cost data have been used in some countries where it is available will also give additional ideas.

3.1. PLANT BENCHMARKING

One area that available data have been used effectively is in performing benchmarking studies; that is, comparing one unit's performance with others having similar characteristics. Numerous benchmarking studies have been carried out at individual utilities as well as at the national and international level. In performing benchmarking studies it is vital that a large number of power plants provide their data so that a balance can be reached between the need for data from a large population of units and the requirement that those units have similar characteristics. The joint World Energy Council/International Union of Producers and Distributors of Electrical Energy (UNIPEDE) Committee on the Performance of Generating Plants has published demonstration benchmarking studies that indicate how to achieve that optimal balance with a high degree of statistical confidence [3, 4].

Benchmarking studies have been used extensively to help identify and quantify opportunities for improvements in safety and technical performance for the individual units being benchmarked. At the plant system or equipment level these studies can help target the areas within a plant that offer the greatest potential for improvement, thereby allowing plant and support staff to focus on specific areas. It has also helped focus research and development activities towards those areas that offer the greatest benefits.

Benchmarking has also been used to give an early warning of threats to the benchmarked plant that similar plants have previously experienced, along with details of successful and unsuccessful actions taken by the affected plant in responding to those problems. This allows the alerted plant to move from a reactive into a more proactive, anticipatory style of management.

Benchmarking can identify plants within peer or 'sister' groups that have achieved a superior performance. Direct communication between plants' staff, along with site visits, has allowed benchmarked plant staff to identify proven best practice techniques that they should consider for implementation at their own plant. In addition, the development of industry best practice databases can allow a more effective exchange of knowledge and experience. Of course, in many areas industry best practice is not limited in application to technical peers.

An international cost database can be expected to achieve many of the same positive results by using the benchmarking techniques and methods developed for technical performance and safety. Since 1995 some cost benchmarking on nuclear plants has been performed by electric utilities in the USA that are members of the Electric Utility Cost Group Nuclear Committee (EUCG–N) and by the Nuclear Energy Institute. The EUCG–N has pioneered the application of benchmarking techniques to cost data for nuclear plants, which has resulted in new insights into the process of optimizing costs without negatively impacting on either safety or performance. In fact, these studies have shown that often the top technically performing nuclear plants also have the lowest O&M costs. Also, other industry groups in the USA, notably the North American Electric Reliability Council's (NERC) Generating Availability Trend Evaluation Working Group, have studied the costs and performance of fossil fuel plants; NERC has published two reports that show those results [5, 6].

One method that has evolved is the use of a statistical method known as frontier analysis to estimate the optimum economic performance that power plants could expect to achieve if they were using industry best practices (Annex I shows a sample demonstration of this technique).

By comparing the technical performance of a unit at a particular activity level against the costs for that activity, plant staff can gain a much better understanding of which areas should be studied in order to improve the cost effectiveness of a plant.

3.2. NUCLEAR POWER PLANT PERFORMANCE OPTIMIZATION

Improving the economics of a nuclear power plant requires a comprehensive understanding of the relationship between O&M spending and the performance of a plant. It should be recognized that there is a real cost associated with poor performance (e.g. the lost opportunities for receiving revenues and higher than necessary generation costs), as well as the corrective maintenance cost associated with repairing equipment. In addition, there is a mutual interaction between O&M spending and the performance of a plant. Too little proactive (preventative) O&M spending results in a high frequency of unplanned breakdowns, with high corrective maintenance costs and the high costs associated with unavailability. The practice of too much O&M spending can put the plant past the point of diminishing returns.

The goal, therefore, is not to minimize O&M costs or to maximize performance (e.g. availability) but rather to minimize the total cost by optimizing O&M costs.

Adding to the complexity of this task is that optimization requires that only industry best practice O&M techniques and methods are used, since less cost efficient methods will not allow a plant to be on the frontier (the optimum availability and cost, see Annex I). Therefore, the use of benchmarking techniques, as discussed in Section 3.1, will give a top-down perspective of where, relative to its frontier, a plant stands and what potential improvement in cost and performance is possible.

In order to achieve this potential improvement, however, individual day to day decision making should be enhanced (bottom-up). A typical improvement methodology consists of three basic steps:

— Identification: identifying all the potential improvement options for addressing plant problem areas.
— Evaluation: economic justification and prioritization of the options identified.
— Implementation: choosing an economic option and comparison of the expected and actual results.

By following this type of process the best use of a plant's limited resources (i.e. money, time and human resources) will allow a plant to optimize its costs and performance.

An international O&M cost database will directly support this optimization process by providing insight into each of the three steps listed above.

3.3. STAFF AWARENESS

A second area where an international economic performance database will be used is to help increase the awareness of an electric utility's nuclear staff of the need for change. As discussed in Section 2, nuclear operators find themselves increasingly involved in a new market style business environment that requires dramatic changes in the mindset of their employees. Moving from a technical to an economic style of decision making and management will require new types of information, the type of information that will be compiled in a new international economic performance database. Also, new decision support tools will need to be developed and implemented that combine the performance impacts of O&M options with the economic impacts of those options in order to find which option is the economic optimum for any specific plant. Helping nuclear power plant personnel to recognize the needs and the new decision processes of an economic style of plant management is of vital importance in optimizing a plant's O&M costs and performance. Another outcome resulting from an increased awareness of plant staff is an increase in the identification of potential solutions from the employees closest to the problems, tapping the creativity of all of the staff.

3.4. MANAGEMENT CULTURE

Changing management culture styles to become consistent with optimum economic decision making is also necessary and is an area in which a new international economic performance database can play a substantial role. Ensuring a direct link between overall corporate objectives and specific plant goals necessitates changes in the current methods for evaluating and rewarding plant management. In many countries where market style businesses are well advanced, the management goals system has already evolved into one that uses economics much more extensively than in the past. Incentives based on economic performance have begun to replace ones based solely on technical performance, and obviously require appropriate economic performance data. Setting these goals is greatly enhanced by international cost comparisons. Other management methods and techniques, such as total quality management, quality circles, reliability centred maintenance and shared inventory programmes, would also greatly benefit from a database. Another area where these data could be of value would be in providing management personnel with additional training and development in economic performance oriented management methods, and in monitoring their improvement to evaluate the training programmes' effectiveness.

3.5. PLANT LIFE MANAGEMENT

Other areas that would be able to take advantage of a new international economic performance cost database are plant life extension studies. It is increasingly recognized that plant life is not simply a technical issue, but that it must be evaluated as an economic issue. Having access to O&M data at a wide variety of plant sites would enable decision makers to anticipate the long term O&M costs associated with continued plant operation and to choose the optimal life management programme that would enhance a company's overall cost competitiveness.

3.6. NEW PLANT DESIGN

As information about ongoing plant costs are collected and analysed, incorporating these data back into a new plant design process would allow for the nuclear power option to become more cost competitive with other technologies. Industry studies have shown the positive effect this feedback has had in the improvement of the availability of subsequent generations of maturing power generation technologies. By applying the same principles to the new cost data, new generations of nuclear plants can be expected to become more cost competitive. At a time when global environmental concerns are reaching new heights of public awareness, nuclear power can expect to become an increasingly important part of the future energy supply mix if it can demonstrate that it can become cost effective.

3.7. NUCLEAR POWER PLANT PLANNING STUDIES

In order to assess the long term role of nuclear power, or any other energy resource, power system analyses are traditionally used. The principal objective of such analyses (or power planning studies) is usually to determine the structure of a long term capacity expansion plan for the considered country or utility with due regard to the relevant economic and non-economic factors and constraints.

Sophisticated techniques of power system modelling are used for such studies. However, the results obviously depend on the quality of the input data, including the O&M costs of nuclear power plants. Although they are only part of the total system costs, the assumed prognosis of O&M costs may noticeably influence the resulting optimum share of nuclear power, especially in cases when relatively large investments in O&M are expected (e.g. safety related backfittings of a plant or preparations for lifetime extensions). Therefore, it is important to have reliable forecasts of nuclear power plant O&M costs based, to the extent possible, on actual experience. In this respect, the use of an O&M database as the basis for developing O&M cost projections for supporting nuclear power planning studies is another promising application area.

4. ESTABLISHING THE NUCLEAR ECONOMIC PERFORMANCE INTERNATIONAL SYSTEM (NEPIS)

4.1. ISSUES TO BE ADDRESSED IN DESIGNING NEPIS

Designing a data collection system for O&M costs that is consistent and comparable across international boundaries presents numerous challenges, some of which are unique and some where direction can be gained from examining other databases that measure performance factors such as availability, efficiency and safety. These issues should be addressed and resolved during the database's design, so that data elements can be identified and collected in order to make meaningful comparisons and to develop appropriate benchmarks. Central to the issues unique to a cost database is the question of currency conversions. Since most countries have their own currency, a method needs to be developed that allows conversion to some international standard currency so that reasonable comparisons can be made. Also, since the cost data will be trended and compared over several years, country specific inflation rates should be used to normalize the data. In addition, differences between an individual country's labour rates, productivity levels, materials costs and the costs needed to comply with country specific regulatory requirements should be able to be accounted for, and the costs data adjusted accordingly.

Another issue is the question of the accounting method that will be used for data collection. Historically, most nuclear utilities have used a functional approach to O&M cost data accounting (e.g. maintenance, operations and engineering). In the USA the EUCG–N has developed and maintained a functional O&M cost database that has been widely used by US and some non-US companies since the mid-1980s. Today, new accounting systems that employ activity based costing (ABC) and activity based management (ABM) techniques are becoming more widely used because, in some cases, of the ability for the ABC/ABM cost data to be used more effectively by management for improving processes and lowering O&M costs. The EUCG–N has recently developed and implemented an ABC O&M cost database. A number of US utilities actively support and participate in providing ABC data annually. Currently, the EUCG–N maintains both the functional and ABC O&M databases and has the facility to compare information between them.

Other cost data issues, such as the level of detail, plant cost data by station and consistently accounting for general office support, need to be resolved. In addition, the impact on costs due to various nuclear technologies should be determined by a proper peer group selection. Important for peer group selection are the reactor type, plant size in MW(e) (for economics of scale), geographic group, vintage of the plant (i.e. its ageing), planned outage cycle (its major overhaul or refuelling cycle), etc.

Issues where guidance can be found from other established databases, such as the IAEA Power Reactor Information System (PRIS), include the need to be compatible with existing databases; the intention to include cost data from some international operators should also be considered. The question of the confidential treatment of sensitive cost data in an increasingly competitive environment should be addressed and resolved to the satisfaction of the contributing members. Finally, the questions of the monetary cost conversions, the language of the database and the frequency and timing of updates should be addressed.

4.2. SETTING UP NEPIS

4.2.1. Standardizing the cost basis

A particular problem in making any comparison of international costs is converting expenditures incurred at different times, in local currencies, to a common basis. Currency exchange rates can be volatile and may not reflect accurately the differing resource costs between countries. Particularly in countries where inflation is high, care should be taken to ensure that distortions are not introduced by mixing expenditures incurred at different times. While this is a problem, it is one faced by many organizations and methods do exist, such as the use of purchase power parity exchange rates, that can cope with these problems.

Specifically for the purposes of NEPIS, the approach to monetary conversions needs to take into account the following requirements:

- As database updates are supposed to occur annually, the costs conversions should be made at yearly intervals; that is, there should be only one reference date for every year (e.g. 1 January).
- The method should have the practical capability of converting any given currency to one reference currency in any given year in the past.
- The approach should be reasonably simple in order to permit the prompt collection of initial data and to allow for regular annual updates without substantial practical difficulties.
- The approach should be transparent for both data providers and database managers who are not experts in macroeconomics.
- The approach should include some set of default values specified by the database developers as well as the opportunity to modify the default values by the data providers (if they have more accurate information).
- Data should be collected in each country’s currency.

When making comparisons across years, care should be taken to minimize the effect of short term currency fluctuations or inflation. A simplified approach would be that implemented following the method applied for a similar task, as shown in Ref. [7]:

- The selected base date for cost comparisons is 1 January of the latest year, that is for the year for which a database update is implemented. The selected reference currency is the US dollar as at 1 January of the given year.
- For the conversion of national cost data to a selected base date, national gross domestic product (GDP) deflators should be used. This is a less accurate approach than using producer price indices and labour cost indices, but it makes

the task realizable in view of data availability for all the countries that may be members of the database project.

— For the conversion of national costs as at 1 January of, for example, 1997 into US dollars as at 1 January 1997 the average 1997 exchange rate should be used. The use of the annual average is intended to minimize the possible effect of short term currency fluctuations. Again, this is known to be less accurate than the use of relevant purchasing parities but is considered justified at this stage in view of its simplicity and transparency.

An example set of cost conversion factors determined in accordance with these assumptions is given in Annex II. Such factors should be prepared and entered into the database for each operator or utility participating in the project.

One should note, however, that this approach is mostly appropriate for developed countries. Developing countries and countries that are in a period of economic transition sometimes represent a special case, as their national currencies may undergo relatively large changes and statistical data on GDP deflators are not always available or reliable. For these countries a slightly different procedure will be applied, as suggested in Ref. [7]:

— The original estimate in the national currency at a given date is converted into US dollars at the same date using either the market exchange rate or, if possible, other, more accurate, conversion factors (often national assessments for countries in transition are already made in US dollars using one or other conversion method);
— The obtained dollar value is converted to US dollars of 1 January of the reference year using the US GDP deflators for the relevant year.

It is understood that the described approach has weaknesses, particularly in respect of using such country aggregated parameters as GDP deflators and average exchange rates. Therefore, at a later stage following the experience of using the database and suggestions from the database's users, a more rigorous approach with the use of producer price indices and purchasing power ratios should be considered. However, for the initial development of the database the described simplified approach is considered to be the most appropriate.

4.2.2. The cost accounting method

As a starting point O&M costs should be collected on a functional basis, currently the most common method used by nuclear plants worldwide. However, the consultancy group recognizes that other accounting methods, specifically ABC or ABM, may potentially offer value to management for minimizing total generation costs. Therefore, it is recommended that concurrent with the development of a functional database ABC approaches be reviewed and evaluated for future consideration. In the meantime, a functional/ABC process matrix that translates costs from one system to the other should be considered. The EUCG–N has developed such a matrix, which is currently used to translate data from its nuclear ABC process database to its EUCG functional database. During the implementation of an economic performance international system, a similar matrix to translate international and functional O&M to ABC categories based on the experience of the EUCG–N should be considered.

4.2.3. Compatibility with existing databases

Since the EUCG–N has successfully implemented both functional and ABC databases in the USA it is prudent for the IAEA to draw extensively on the experience of the EUCG–N's functional O&M cost data collection process, which will help to ensure that a new international system is appropriate for the needs of all member countries. In doing so, the existing EUCG nuclear O&M functional database structure and category definitions will be used a starting point from which to modify the cost categories and definitions that are most useful for all participating operators and utilities. Existing data from US as well as non-US nuclear plants might therefore be available for economic comparisons and process improvements.

4.2.4. Adjusting for technological differences

Every nuclear power plant is unique. Obvious differences include the reactor type, nuclear steam supply system (NSSS) vendor, number of units on site, age and size. If comparisons between plants are to be useful, great care should be taken to ensure that any differences in the level and direction of O&M expenditure that are simply a result of intrinsic technological differences are adjusted for, either by selecting an appropriate peer group or by normalizing the data.

Selecting an appropriate peer group may lead to a very small group if an exact match on technology is sought. However, if a particular activity is being examined, for example training, the relevant peer group might be much larger. There exist mathematical techniques, such as multivariable linear regression analysis, that can be used to estimate the data adjustments necessary to make comparisons possible. Experience with the PRIS database has shown that as data accumulates and the database matures, new methods of analysing the data emerge that allow more precise international comparisons. In addition, experience with analysing data for the USA suggests that management differences, rather than technological differences, may account for many of the cost differences between plants. The process for peer group selection used by the Joint World Energy Council/UNIPEDE Committee on the

Performance of Thermal Generating Plant should be considered for application to this issue [1].

4.2.5. Terms of access and confidentiality

As the electricity supply industry becomes more competitive, cost data acquires greater commercial sensitivity, and hence the submission of O&M cost data in some standard format to the IAEA would clearly have to be done on a voluntary basis.

Membership of an international database will be restricted to operators of nuclear power plants and utilities in IAEA Member States that are in possession of data relevant to an international database.

A member will provide together with an application for membership the willingness to provide data. Members that have fulfilled these requirements and have supplied data will have access to the international data to the extent that they have provided data at the same level of detail. The IAEA will release information from the database to non-members only after obtaining clearance from the data providers and their utilities.

Members who have access to NEPIS should use the data only for their own analysis or evaluation. Data made available between members will be provided in such a way that no identification of companies or organizations is possible.

4.2.6. Data collection, updates timing and validation process

Data will be collected through a computerized survey that will be designed to allow operators easily to enter, change, update and submit information on the annual O&M costs incurred by a nuclear generating plant. The survey program, provided on diskettes, and an instruction manual will be supplied to members. The program contains data entry forms, on-line help and instructions, and is designed to run on a single user PC. If, however, a member does not have the facilities to collect data electronically, data acquisition sheets will be provided. The data will be typed in by the IAEA and sent back to the member for verification.

The database will be updated annually. The survey program and/or questionnaire data sheets for updated information will be sent out by 31 December and should be returned to the IAEA by the end of March each year. English will be adopted as the language of the database.

A database review and verification team formed by the IAEA Secretariat and the EUCG–N will review submittals prior to the distribution of the database. The team will also prepare all documentation related to NEPIS. In order to facilitate this process a self-validation feature will be included in the NEPIS database survey update program. This self-validation feature will automate many of the verifications made by the review team. The process of data validation should take no longer than two months, allowing a quick distribution of the database to all users and data providers.

4.2.7. Database structure

Initially, data collection will focus on O&M costs. The database will comprise four parts, containing information on stations and plants, and detailed information on functional cost accounts for non-outages and for outages. The detailed functional cost accounts will be divided into operations, maintenance, support services, plant administration, total direct costs, total indirect costs and capital costs. Each cost account will be further broken down into resource categories that include labour, materials and outside services. Additional data on nuclear power plant performance indicators such as capability factors, energy availability factors, energy production, refuelling outage durations and cost information (e.g. capital, insurance and decommissioning) will also be included. Some of this information is already available in the IAEA PRIS, which will be linked to NEPIS. Detailed data to be collected and the definitions and terminology for the database are presented in Annexes III–V.

4.2.8. Database administration

The administrative functions for the setting up of NEPIS will be carried out co-operatively by the IAEA and the EUCG–N.

The principal functions for the management of NEPIS are:

- To ensure that the NEPIS database's rules and procedures are correctly and efficiently implemented and to take the necessary actions for the efficient operation and continued improvement of the database;
- To integrate all input from the members into the NEPIS database program and to identify and correct errors;
- To develop and subsequently update and maintain, in consultation with members, all authorizations, standards, formats, instructions, definitions, rules, procedures, questionnaires, spreadsheets and guidelines that will be used for preparing and processing the input and creating and utilizing the output;
- To arrange the training of the members' personnel in the preparation of data so that they can easily enter, change, update and submit information on all the O&M costs incurred;
- To set up regular consultation meetings to evaluate data reports and to discuss proposals and recommendations from members on the procedures for regulating the database's operation.

4.2.9. Data distribution

It is desirable to establish a consistent and comprehensive framework for sharing and using information. The aim is to provide a true and full picture of the economic performance of a given plant. Evaluating economic performance requires the definition of appropriate indices and the means to share but maintain full confidentiality of the data.

NEPIS will be distributed annually and within three months after the data are gathered. The users will access the database through a front end interface that has features for selecting information based on specified criteria but that does not identify plants' names, operators or utilities. The reporting period will follow the calendar year, from 1 January to 31 December. Historical records will be retained.

4.3. IMPLEMENTATION OF NEPIS

4.3.1. Pilot project

A pilot project undertaken during 1999 collected cost data from five nuclear utilities in diverse geographical locations. The project reviewed and evaluated the definitions and terminology used against the data collected and refined the process before the database is implemented worldwide.

The pilot project ensured the exchange of information among its members during the data collection and review process. It could also be the basis for a training programme implemented later for other operators during the international data collection stage.

4.3.2. International data collection

International data collection will be open to all operators of nuclear power plants after the pilot project is successfully implemented. Training programmes to offer support when the members prepare the data input may be held.

It will include the establishment of a network of expert contacts within members of the programme that can provide objective help to others experiencing problems in their particular field of expertise. Continuous evaluation and refinement of the entire programme should be assured during the process of implementation of the international database.

The development of standard cost data benchmarking and other analysis processes, together with automated training programmes, will help members achieve the maximum value from the database. This could include links to a performance database such as the IAEA's PRIS to enable members to perform trade-off studies to try to determine their optimum economic level of performance.

Another key element necessary to improve the economics of a plant is the identification and sharing of information relating to its optimum economic performance. This should be a continual process that takes account of changes to a plant, for example its ageing, changes in the grid of which the plant is part and the development of new methods that improve industry best practices.

4.3.3. Future considerations

Prioritization of the main issues, validation processes, and measurements of operational and economic performance are important issues that need to be considered when developing and implementing an international economic performance database. Being the first international initiative in this area, it is recognized that enhancements will be required. Some issues that need to be addressed in the future have been identified and are briefly discussed below.

4.3.3.1. Development of economic performance indicators

There is a strong need to understand the financial management system of each country. The development of economic performance indicators will contribute to a better understanding of the financial management systems that each country uses, and will enable better use of the international system. These indicators could be used for comparisons within the industry as well as among individual plants.

4.3.3.2. Benchmarking

Benchmarking should be used to analyse economic performance data at the international level. Cost benchmarking assists members to achieve the optimum level of performance. This process could focus, among others, on:

— Optimizing O&M costs;
— Identifying high and low cost areas in O&M activities;
— Establishing the cost impacts of extended outages, for example due to regulatory requirements or backfittings;
— Identifying refuelling costs.

To help disseminate the economic benchmarking analysis process using the international system, a pilot benchmarking/process improvements study needs to be further developed. These standard benchmarking processes will enable each user to choose a simple function/process and to identify trends and areas that need improvement.

4.3.3.3. Communicating best practice

It will be important to disseminate the results of the benchmarking throughout the nuclear industry. This could be done by identifying O&M best practice plants and encouraging the spread of O&M best practice quickly and efficiently to all other plants. Changing plant operators towards and increasing their understanding of an economic performance oriented culture will require them to be made aware of how their performance compares with other nuclear operators and competitors.

The industry should therefore be provided with both summaries of surveys positioning the distribution of performance (top quartile, median, etc.) and useful tools based on the database, which will enable each operator to work out specific analyses based on the framework of the confidentiality agreement.

4.3.3.4. Decommissioning costs

Another future consideration is to expand the database to include decommissioning costs. A number of nuclear units in the world have been subject to premature power cessation and decommissioning. With the advent of utility restructuring and competitive market pricing of electricity, this situation is likely to continue in the future as electric utilities continue to re-evaluate the economic options for continued nuclear power plant operations.

Although cost estimates for nuclear plant decommissions are required by various regulators, the consolidated information needed for a comparative economic analysis and process optimization has not been readily available. The OECD Nuclear Energy Agency, the European Commission and the IAEA are jointly preparing a standardized list of items for costing purposes for the decommissioning of nuclear installations. The inclusion of decommissioning cost estimates as well as actual cost values and decommissioning performance measures in NEPIS will help to ensure optimization of the decommissioning process.

4.3.3.5. Economic lifetime, refurbishments and safety upgrade assessments

The economic viability of nuclear unit lifetime extensions can be assessed through comparative analyses of O&M costs, capital costs and operational performance measures. This is especially important in countries where the deregulation and privatization of the utility industries requires an in-depth knowledge of the benefits and risks associated with nuclear plant investments. The economic benefits of nuclear plant lifetime extensions can also be evaluated and optimized.

As the nuclear power industry deregulates and is required to compete with other generation options, a sense of evaluating and understanding the various economic and performance benefits associated with the alternatives to implementing upgrades will also be required.

4.3.3.6. Other issues

Some long term objectives in the development of an economic performance international system could be to set up a group of international experts in the use of cost data and to study externalities, for example assessing the economic benefits for the environment through the proliferation of nuclear power.

4.4. PRELIMINARY RESULTS OF THE PILOT PROJECT

The pilot project was undertaken during 1999 and collected cost data from five nuclear power utilities, in Brazil, the Czech Republic, France, the Republic of Korea and the USA. Although all the units studied were pressurized water reactors, they were of different designs and sizes. Pilot project data were collected according to the definitions and terminology established for NEPIS presented in Annex III.

Data were collected on a unit basis for the year 1998 in the national currency and converted to US dollars using the annual average exchange rate. The results were compared with EUCG–N 1998 data for US nuclear power plants.[3]

Data analysis considered the median, first and third quartiles for O&M costs per kW(e), production costs, capital costs and unit capability factors. The unit capability factor definition, adopted by the World Association of Nuclear Operators (WANO), the IAEA and UNIPEDE, is the ratio of available energy generation to a reference energy generation. The available energy generation is the amount of energy that could have been produced considering only the limitations under the plant's management's control. The reference energy generation is the amount of energy produced if the unit operated continuously at full power under reference ambient conditions (i.e. the reference power multiplied by a reference period in hours) [8].

The results presented here are preliminary. As this is the first data collection using international definitions, the validation process will ensure the reliability and accuracy of the results and show which type of analysis can be done, and will demonstrate the applications and usefulness of international data collection.

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[3] The EUCG–N sample includes about of 80% of all nuclear power utilities operating in the USA.

Considering that only one year of data is available in this sample, a more appropriate benchmarking could have been to analyse non-outage O&M costs only, but since the data were not yet fully validated it was decided against doing this. When data are available, analyses should be done within a three year period, which will enable a better identification of industry trends.

Figure 2 presents total O&M costs per kW(e) plotted against unit capability factors. The best performing plants are those in the bottom right quarter. The median value for the EUCG US plants' O&M costs is 78.7%/kW(e) and the unit capability factor is 88.7%. Three of the sample are among the best performers — those whose unit capacity factors and O&M costs are better than the median value. Only about 25% of all units are among the best performers of all the units considered in this analysis.

Using the frontier analysis method, a liner regression curve could be drawn to identify the minimum total cost and the optimum economic unit capacity factor (see Annex I). Some of the plants in the sample are among the best economic performers, while others might need to improve their O&M costs to reach the median performers.

Figure 3 presents the O&M costs in US $/kW(e) for the units included in the pilot project and compares them with the median,[4] first quartile and third quartile values for the EUCG–N sample. The median value for the EUCG–N sample is US $82.3/kW(e), the first quartile is US $72.9/kW(e) and the third quartile is US $99/kW(e). Total O&M costs are similar for most of the units of the sample (there are two exceptions). It might be that these are single units in an operating utility, which will rise the O&M costs mainly due to plant administration costs. Unit J presented the highest O&M costs in the sample; this could be due to the impact of major backfittings or an O&M process recovery in 1998.

The highest performing units in this sample could potentially provide benchmarking opportunities or demonstrate best practice (process improvements) to the more poorly performing units.

Trends in the relative performance of the components of O&M costs are similar to the total O&M performance across all units in the pilot project, except for maintenance costs where all units presented very close values (in US $/kW(e)). Values for the components of O&M costs are shown in Figs 4 to 7.

Capital costs in millions of US dollars for the pilot project plants are presented in Fig. 8. The values for the EUCG–N sample are: (a) the median of US $16.153 million, (b) the first quartile of US $9.003 million and (c) the third quartile of US $21.882 million. Most of the units in the sample presented better capital costs than the median EUCG–N value. Three units had capital costs higher

[4] First quartile represents the top 25% of the sample, second quartile or median value represents 50% of the sample and third quartile represents 75% of the sample.

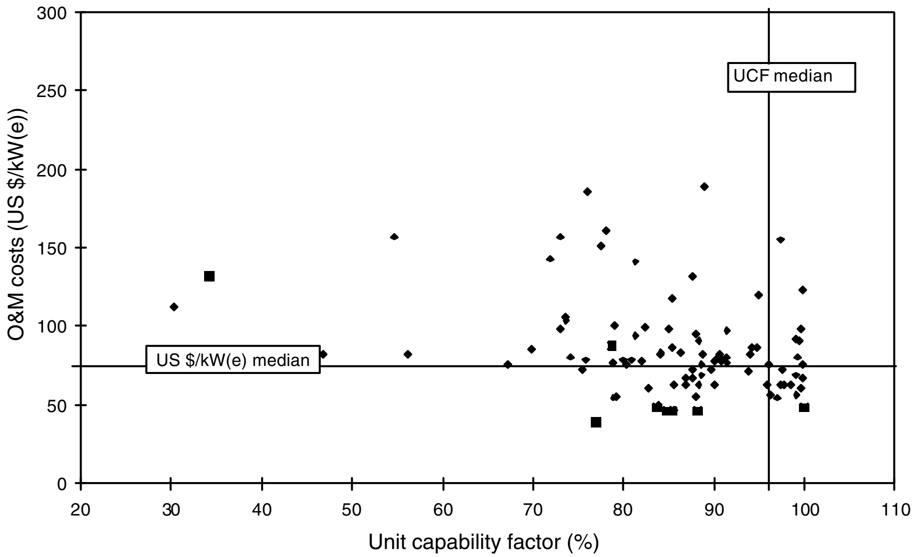

FIG. 2. Total O&M costs per kW(e) plotted against the unit capability factor.

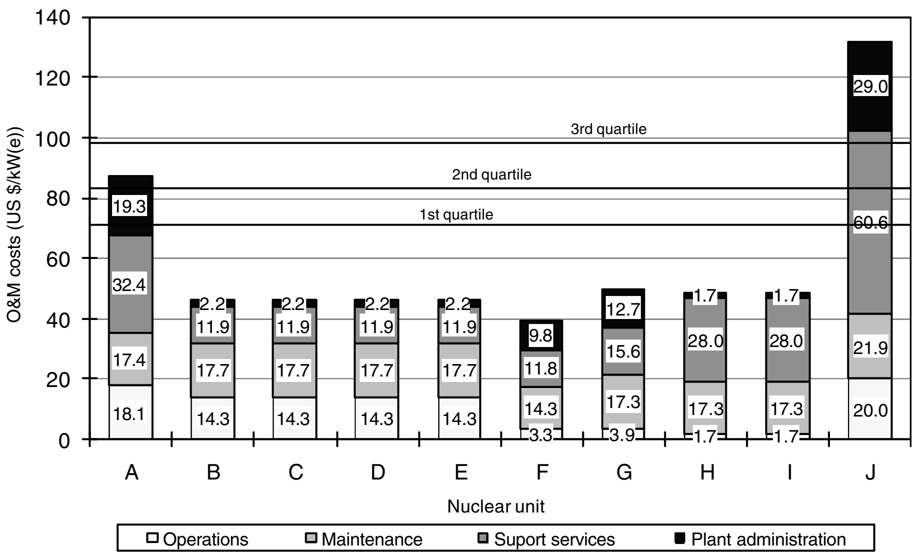

FIG. 3. O&M costs per kW(e) for the pilot project units.

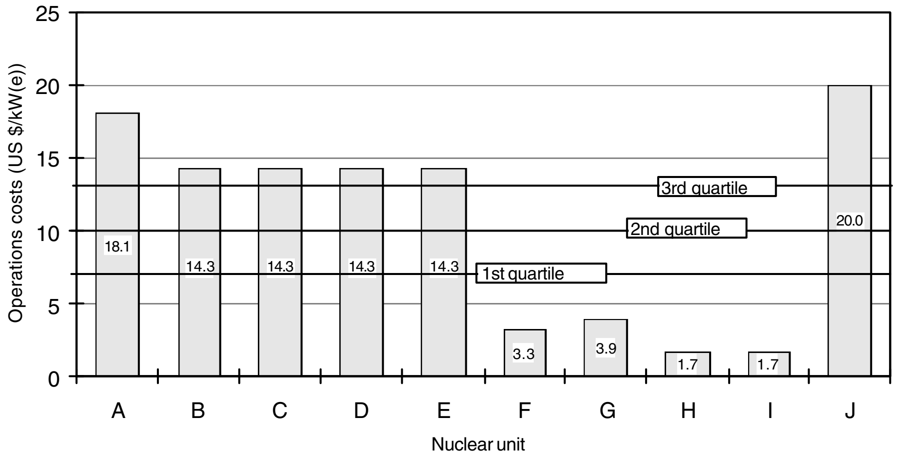

FIG. 4. Operations costs.

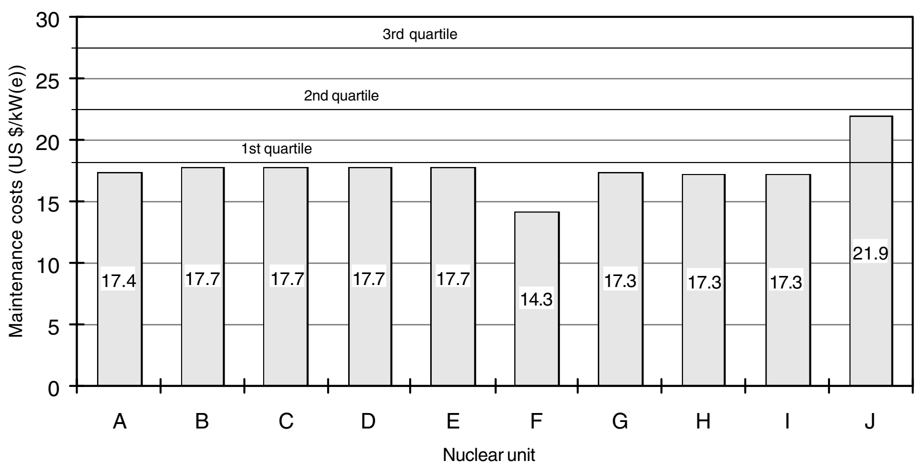

FIG. 5. Maintenance costs.

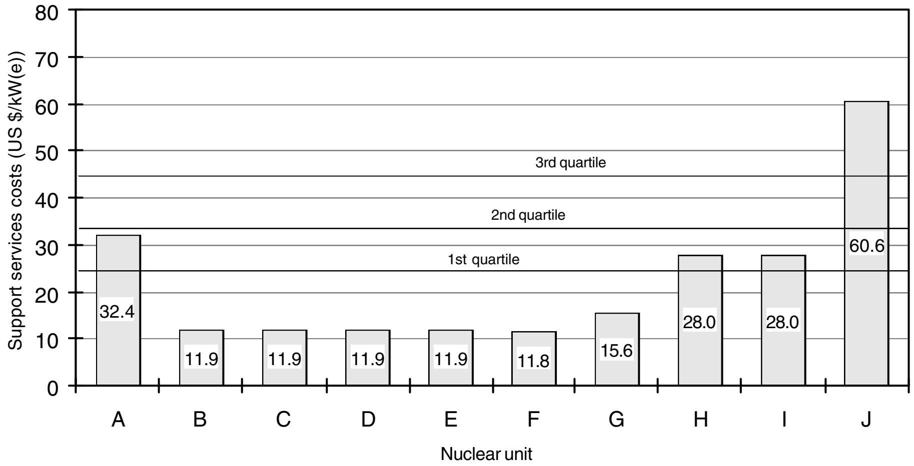

FIG. 6. Support service costs.

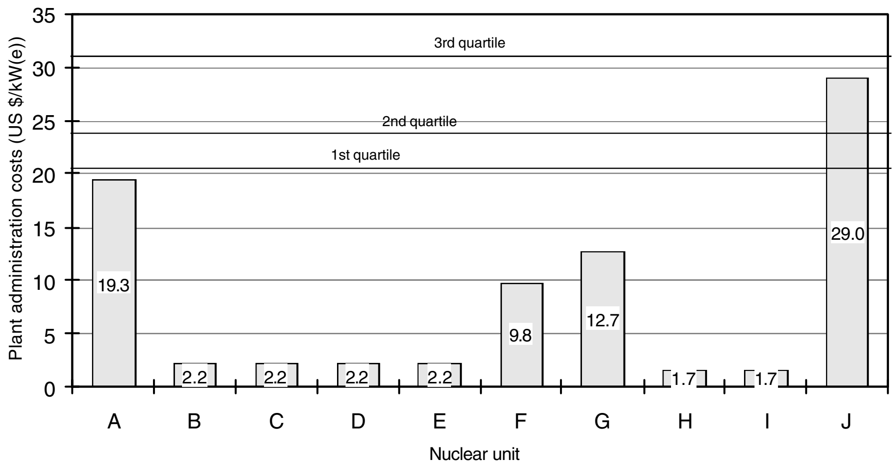

FIG. 7. Administration costs.

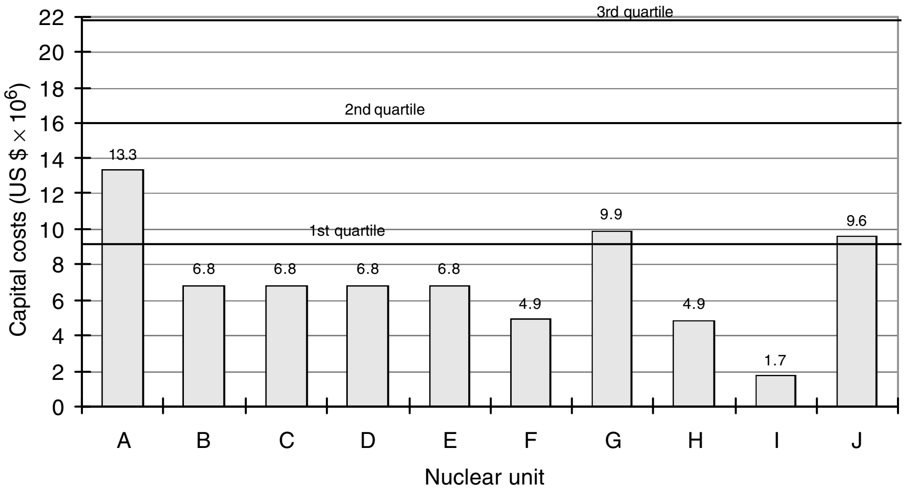

FIG. 8. Capital costs.

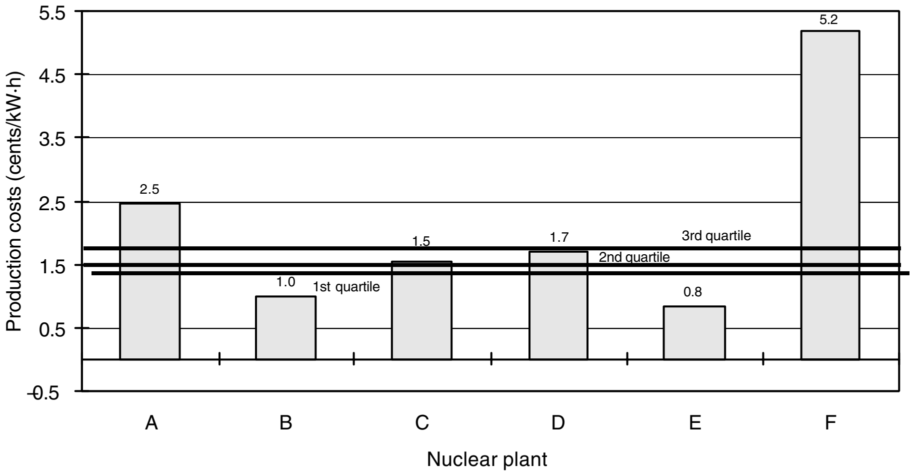

FIG. 9. Production costs.

than the other units. Because the units were not identified, no conclusions could be made on why capital costs were higher in some units, but it might be that major backfittings and component replacements were carried out in 1998.

Production costs at the plant level in cents/kW·h, including nuclear O&M and fuel costs, are presented in Fig. 9. The median value for EUCG US plants is about 1.7 cents/kW·h, while that for the first quartile is 1.5 cents/kW·h and for the third quartile is 2.1 cents/kW·h. All but two of the plants in the sample had production costs better (lower) than the median.

The results represent the first attempt to analyse international cost data in several countries. They considered only one year of data, which allowed only limited conclusions to be drawn. More detailed conclusions could be made with a more representative sample and when more years of data become available.

5. CONCLUSIONS

There are many benefits in collecting O&M costs. It allows management to identify more clearly where and how costs are being incurred and where adjustments to its O&M programme would improve the competitiveness of a plant. It is clear that the value of the centralized collection of these data and their use for benchmarking and identifying O&M best practice far outweighs the cost of their collection and the risks of sharing them.

The establishment of a common framework for the analysis of cost data at the international level has contributed to the understanding of regional differences in accounting systems and the identification of when and where costs are incurred, and might help to correlate performance targets and costs.

The first step to implement NEPIS was the verification of the definitions and terminology to be used; this was achieved through a pilot project in which five countries participated. The pilot project successfully validated the first cost data collected and verified the adequacy of the definitions and terminology. As a second step data were collected for the years 1998 and 1999 in ten countries: Argentina, Brazil, the Czech Republic, France, Hungary, India, the Republic of Korea, Mexico, Slovakia and the USA. The next step, initiated in 1999, comprised the development of benchmarking analyses and establishing a correlation between national performance targets and costs.

As environmental concerns intensify about other electricity generating technologies, nuclear technology is again becoming widely considered as a part of the global generation mix. However, as market pressures grow nuclear plants need to become more cost competitive in order to be economically viable, without comprising their safety record. Without the proposed international economic performance database each nuclear utility will be left on its own to confront increasing cost reduction pressures.

By establishing the new database the IAEA will enable the nuclear industry to collect, share and analyse cost data, perform economic benchmarking, and identify and communicate best practice. In this way the IAEA will play a vital role in ensuring that nuclear technology continues to play an important part in meeting the growing energy requirements of the world.

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Annex I

USING FRONTIER ANALYSIS TO OPTIMIZE COSTS AND PERFORMANCE

When capacity factors are plotted against O&M costs for a group of plants, the resulting graph will often show a wide scatter of data points. Figure I–1 shows the US nuclear plants' annual non-fuel O&M costs (adjusted to 1997 US \$/kW) plotted against their net capacity factors for the three year period 1993 to 1995.

If a linear regression statistical analysis is attempted, the resulting equation will often have a very low correlation coefficient, indicating a very poor fit of the data. Advanced statistical techniques using the theory of frontier analysis yield a much more satisfactory result.

Figure I–2 shows a frontier curve derived from the data in Fig. I–1. This curve is called a frontier curve because it is drawn through the data points of the plants achieving various levels of net capacity factor for the lowest O&M costs (note that the costs are in US \$/kW, not US \$/kW·h, and that the plants on the left hand side have lower capacity factors with the same O&M costs as frontier plants on the right side of the curve; these plants are hence not really on the frontier, but are said to have inefficient operations).

Plants with the same capacity factors but with higher O&M costs are not achieving their maximum potential, and are said to be in the interior. A plant in the interior could therefore potentially decrease its costs without decreasing its capacity factor, or increase its capacity factor without increasing its costs. Studying the O&M practices used by plants on the frontier (i.e. those with the best practices) could give valuable insights into the methods that could be employed to reach the frontier. However, reaching the frontier does not resolve the question of where on the frontier is an individual plant's economic optimum (i.e. a plant's point of diminishing returns or the point where extra expenditures do not bring in an equal amount of value).

To find a plant's optimum economic point it is necessary to superimpose the value of an increase in capacity factor (or the cost of a decrease in capacity factor). Whereas units of similar design have similar frontier costs, each individual unit will have a unique value (or cost), depending on the economic conditions in the system in which it operates. Figure I–3 shows the curve of a unit's cost against a capacity factor decrease from a theoretical maximum of 100%. Adding the frontier O&M cost curve to the capacity factor cost curve gives the total cost curve (see Fig. I–4); a unit's optimum economic goal is where the curve is at its minimum. Dropping down from this point to the frontier O&M cost curve shows the minimum costs necessary to achieve this goal (Fig. I–5).

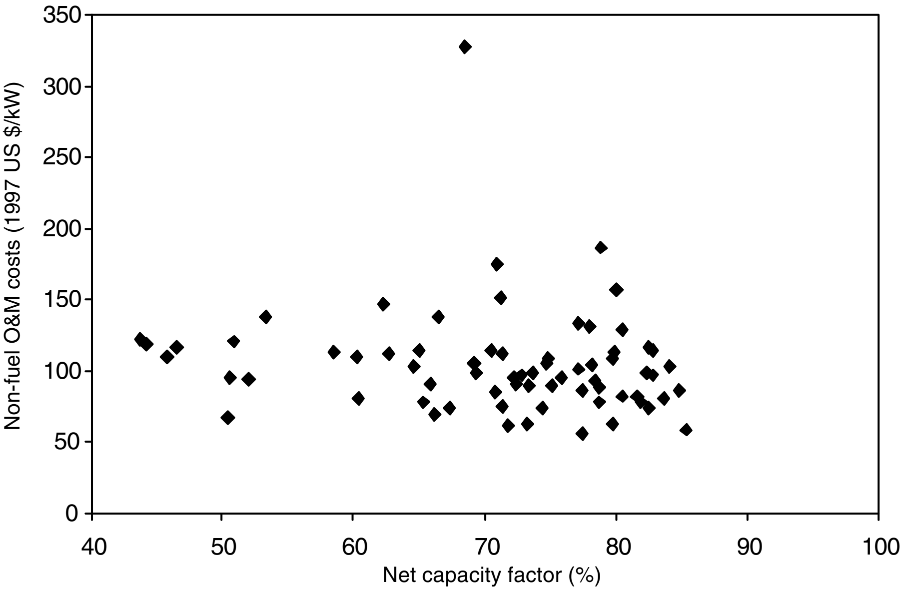

FIG. I–1. US nuclear plant O&M costs plotted against capacity factors, 1993–1995.

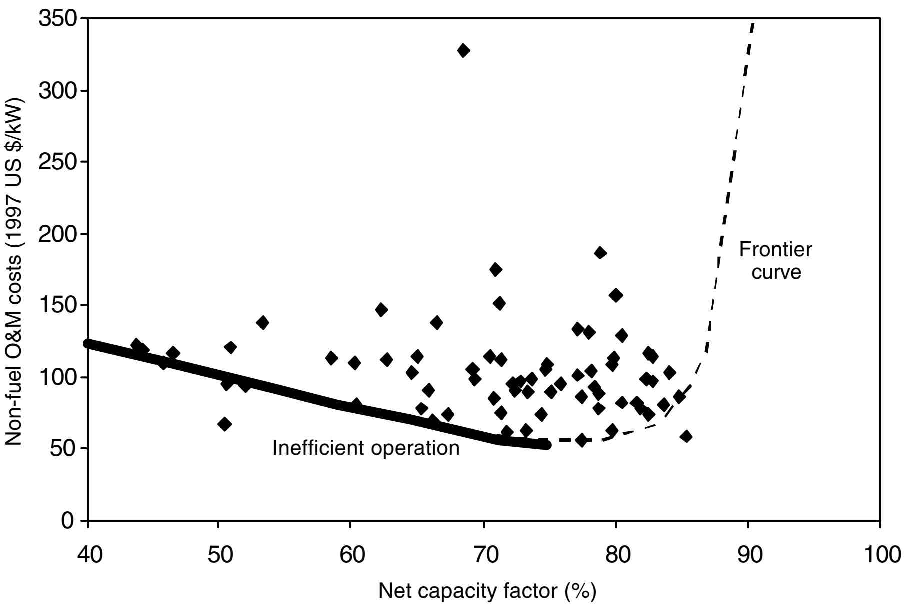

FIG. I–2. Frontier curve.

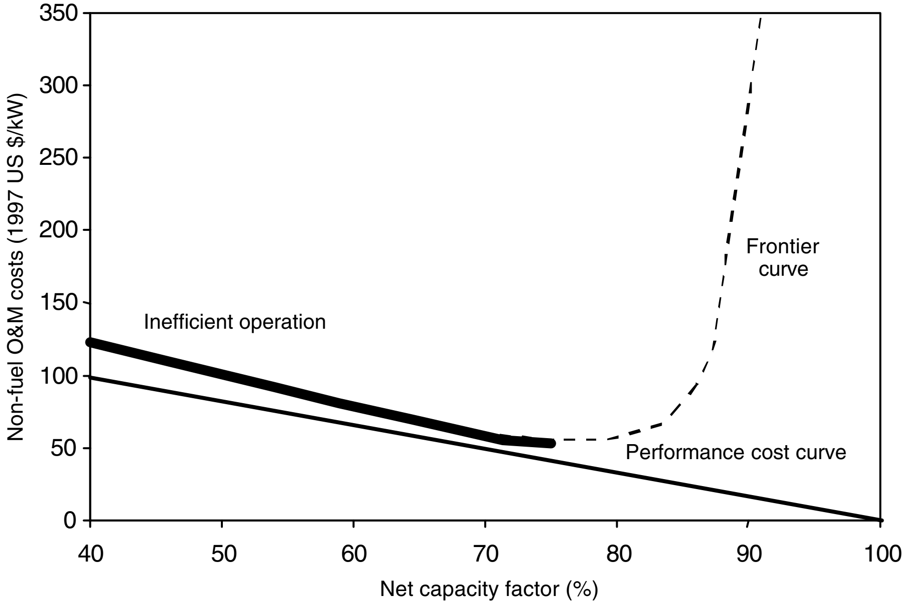

FIG. I–3. Performance cost curve.

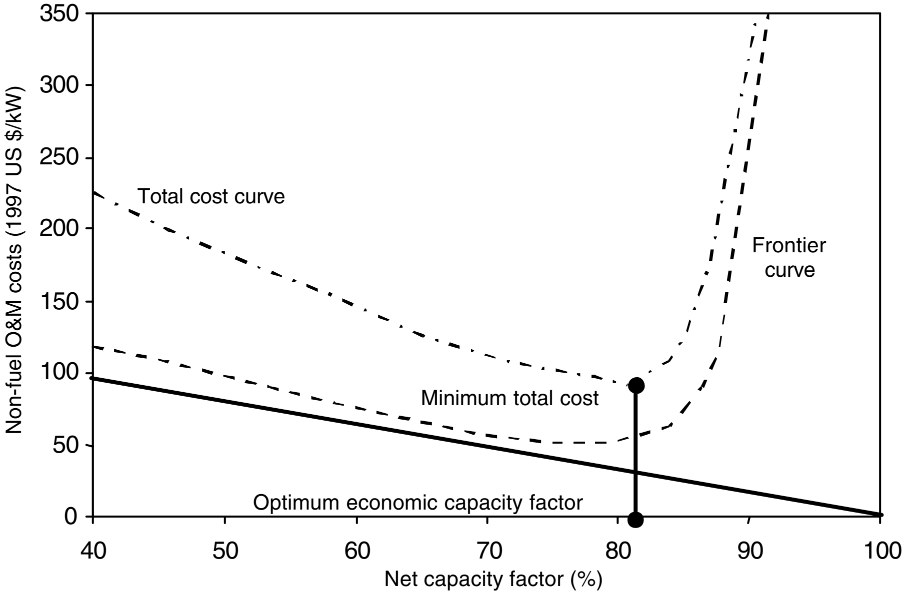

FIG. I–4. Total cost curve.

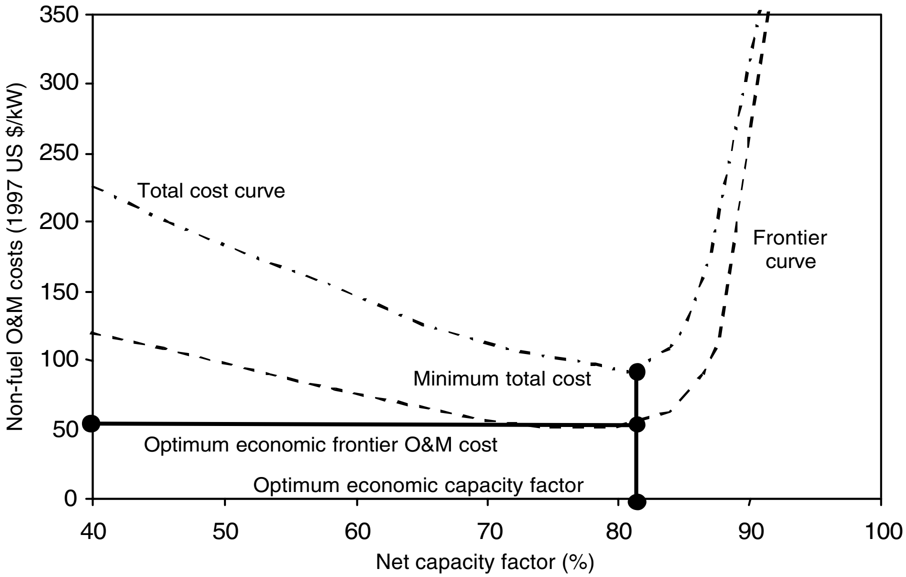

FIG. I–5. Optimum economic frontier O&M costs and capacity factors.

The above example shows the approach from an overall plant cost point of view. The process can also be applied at lower levels (i.e. activity levels) by plotting the activity cost against an appropriate performance measure for that activity.

Annex II

MONETARY CONVERSION TABLES

II–1. GDP DEFLATORS

The different methodologies used for cost conversion factors such as GDP deflators, producer or consumer price indices were often responsible for the differences in the results of the pilot project. Table II–I presents GDP deflators for various countries. The table was prepared from an OECD assessment made in 1997 [II-1]. Table II–II presents the same countries as in Table II–I, but taken from an IMF assessment [II-2]. Table II–III summarizes the differences between the two sets of GDP deflators.

In some cases the publications used assumed values for exchange rates that are not presented in Table II–I. Table II–IV summarizes these cases, giving an opportunity for the reader to check the calculations made.

The existence of GDP deflator uncertainties should be kept in mind when using international cost comparisons. It is one of the reasons why this report relies on the most readily available GDP data instead of using the more detailed price escalation indicators, such as producer and consumer price indices, that are theoretically more suitable for the task but are also more uncertain and less readily available.

In the pilot project presented in this report exchange rates were provided by the countries themselves.

II–2. PPP INDICES

PPP indices are a better monetary conversion factor to use when analysing economic matters. The GDP PPP is gross domestic product converted to international dollars using purchasing power parity rates.

An international dollar has the same purchasing power over GDP as the US dollar in the USA. GDP measures the total output of goods and services for final use within the domestic territory of a given country, regardless of the allocation to domestic and foreign claims. The gross domestic product at purchaser values (market prices) is the sum of the gross value added by all resident and non-resident producers in the economy plus any taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources.

Table III–V provides the GDP PPP in current international dollars as published in Ref. [II-4].

TABLE II–I. ASSUMED COST CONVERSION FACTORS

	GDP deflators (per cent change from the previous period)													Exchange rates (national currency units) per US $ as at 1996
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Belgium	5.2	6.1	3.6	2.2	2.1	4.6	3.1	3.2	3.6	4.2	2.3	1.7	1.6	31
Canada	3.1	2.6	2.4	4.7	4.6	4.8	3.1	2.9	1.2	1	0.7	1.5	1.3	1.36
Finland	8.8	5.4	4.5	4.7	7	6.1	5.9	2.5	0.7	2.4	1.3	2.4	1.2	4.6
France	7.5	5.8	5.2	3	2.8	3	3.1	3.3	2.1	2.5	1.5	1.6	1.2	5.12
Italy	11.6	9	7.8	6.1	6.8	6.3	7.6	7.7	4.7	4.4	3.5	5	5.1	1543
Japan	2.6	2.1	1.8	0.1	0.7	2	2.3	2.7	1.7	0.6	0.2	–0.6	0	108.8
Germany	2.1	2.1	3.2	1.9	1.5	2.4	3.2	3.9	5.6	4	2.4	2.1	1	1.5
Netherlands	1.4	1.8	0.1	–0.7	1.2	1.2	2.3	2.7	2.3	1.9	2.3	1.6	1.3	1.686
Spain	11.6	7.7	11.1	5.9	5.6	7.1	7.3	7.1	6.9	4.3	4	4.8	3.1	126.7
Sweden	7.6	6.6	6.9	4.8	6.5	8	8.9	7.6	1.1	2.6	2.4	3.7	1	6.71
UK	4.6	5.7	3.3	5	6	7.1	6.4	6.5	4.6	3.2	1.6	2.4	3	0.641
USA	3.8	3.4	2.6	3.1	3.7	4.2	4.3	4	2.8	2.6	2.4	2.5	2.3	1

Source: Ref. [II–1].

TABLE II–II. GDP DEFLATORS ACCORDING TO IMF ASSESSMENTS

	GDP deflators (per cent change over the previous year; calculated from indices)													Exchange rates (national currency units) per US $ as at 1996
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
Belgium	5.1	6	3.8	2.3	1.8	4.5	3.3	2.4	3.5	4.1	2.7	—	—	31
Canada	3.1	2.6	2.4	4.6	4.7	4.8	3.1	2.9	1.2	1.1	0.7	1.5	1.3	1.36
France	7.5	5.8	5.2	3	2.8	3	3.1	3.3	2.1	2.5	1.5	1.6	1.2	5.12
Germany	2.1	2.1	3.2	1.9	1.5	2.4	3.3	3.7	5.5	3.8	2.3	2.2	1	1.5
Sweden	7.6	6.7	6.9	5.1	6	8	8.8	8.2	1	2.6	3.1	4.3	—	6.71
USA	4.6	3.8	2.8	2.9	3.5	5	4.8	4	2.7	2.7	2.2	2.5	2	

Source: Refs [II–2, II–3].

TABLE II–III. COMPARISON OF OECD AND IMF GDP DEFLATORS

	Differences between the two statistics sources[a]												
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Belgium	–0.1	–0.1	0.2	0.1	–0.3	–0.1	0.2	–0.8	–0.1	–0.1	0.4	—	—
Canada	0	0	0	–0.1	0.1	0	0	0	0	0.1	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0.1	–0.2	–0.1	–0.2	–0.1	0.1	0
Sweden	0	0.1	0	0.3	–0.5	0	–0.1	0.6	–0.1	0	0.7	0.6	—
USA	0.8	0.4	0.2	–0.2	–0.2	0.8	0.5	0	–0.1	0.1	-0.2	0	–0.3

[a] IMF value from Ref. [II–2], OECD value from Ref. [II–1].

TABLE II–IV. ADDITIONAL EXCHANGE RATES ACCORDING TO THE OECD
(national currency units per US $)

	1994	1995	1996
Belgium	33.46	—	31
Canada	—	—	1.36
Finland	—	—	4.6
France	—	—	5.12
Germany	1.62	1.43	1.5
Italy	—	—	15.43
Japan	—	—	108.8
Netherlands	—	1.6	1.686
Spain	—	—	126.7
Sweden	7.7	—	6.71
UK	—	—	0.641
USA	—	—	1

Source: Ref. [II–1].

TABLE II–V. GDP PPP INDICES (CURRENT INTERNATIONAL DOLLARS)

	1990	1991	1992	1993	1994	1995	1996	1997
Argentina	2.11×10^{11}	2.41×10^{11}	2.75×10^{11}	2.97×10^{11}	3.27×10^{11}	3.22×10^{11}	3.41×10^{11}	3.67×10^{11}
Armenia	1.95×10^{10}	1.60×10^{10}	7.84×10^{9}	6.84×10^{9}	7.41×10^{9}	8.14×10^{9}	8.70×10^{9}	8.94×10^{9}
Belgium	1.81×10^{11}	1.89×10^{11}	2.01×10^{11}	2.02×10^{11}	2.11×10^{11}	2.22×10^{11}	2.27×10^{11}	2.32×10^{11}
Brazil	7.42×10^{11}	7.68×10^{11}	8.20×10^{11}	8.55×10^{11}	9.17×10^{11}	9.84×10^{11}	1.03×10^{12}	1.06×10^{12}
Bulgaria	3.92×10^{10}	3.69×10^{10}	3.58×10^{10}	3.60×10^{10}	3.74×10^{10}	3.96×10^{10}	3.59×10^{10}	3.33×10^{10}
Canada	5.19×10^{11}	5.23×10^{11}	5.51×10^{11}	5.78×10^{11}	6.13×10^{11}	6.43×10^{11}	6.58×10^{11}	6.81×10^{11}
China	1.58×10^{12}	1.77×10^{12}	2.11×10^{12}	2.45×10^{12}	2.81×10^{12}	3.20×10^{12}	3.54×10^{12}	3.84×10^{12}
Czech Republic	1.03×10^{11}	9.06×10^{10}	8.86×10^{10}	8.97×10^{10}	9.40×10^{10}	1.03×10^{11}	1.08×10^{11}	1.08×10^{11}
Finland	8.44×10^{10}	8.07×10^{10}	8.13×10^{10}	8.22×10^{10}	8.76×10^{10}	9.46×10^{10}	9.86×10^{10}	1.04×10^{11}
France	1.02×10^{12}	1.05×10^{12}	1.11×10^{12}	1.12×10^{12}	1.18×10^{12}	1.24×10^{12}	1.27×10^{12}	1.29×10^{12}
Hungary	6.71×10^{10}	6.08×10^{10}	6.16×10^{10}	6.26×10^{10}	6.57×10^{10}	6.85×10^{10}	7.02×10^{10}	7.31×10^{10}
India	9.52×10^{11}	9.83×10^{11}	1.08×10^{12}	1.16×10^{12}	1.28×10^{12}	1.41×10^{12}	1.53×10^{12}	1.61×10^{12}
Iran, Islamic Rep.	2.26×10^{11}	2.60×10^{11}	2.86×10^{11}	3.05×10^{11}	3.10×10^{11}	3.22×10^{11}	—	—
Italy	9.34×10^{11}	9.71×10^{11}	1.02×10^{12}	1.03×10^{12}	1.07×10^{12}	1.14×10^{12}	1.16×10^{12}	1.17×10^{12}
Japan	2.31×10^{12}	2.47×10^{12}	2.60×10^{12}	2.67×10^{12}	2.74×10^{12}	2.86×10^{12}	3.00×10^{12}	3.04×10^{12}
Kazakhstan	8.04×10^{10}	7.70×10^{10}	7.00×10^{10}	6.49×10^{10}	5.79×10^{10}	5.47×10^{10}	5.55×10^{10}	5.62×10^{10}
Korea, Rep.	3.35×10^{11}	3.76×10^{11}	4.12×10^{11}	4.46×10^{11}	4.94×10^{11}	5.52×10^{11}	5.96×10^{11}	6.25×10^{11}
Lithuania	2.10×10^{10}	2.04×10^{10}	1.68×10^{10}	1.44×10^{10}	1.32×10^{10}	1.41×10^{10}	1.49×10^{10}	1.57×10^{10}
Mexico	5.61×10^{11}	6.02×10^{11}	6.51×10^{11}	6.79×10^{11}	7.23×10^{11}	6.98×10^{11}	7.41×10^{11}	7.90×10^{11}
Netherlands	2.40×10^{11}	2.53×10^{11}	2.69×10^{11}	2.77×10^{11}	2.92×10^{11}	3.07×10^{11}	3.20×10^{11}	3.30×10^{11}
Pakistan	1.31×10^{11}	1.42×10^{11}	1.60×10^{11}	1.67×10^{11}	1.77×10^{11}	1.91×10^{11}	2.02×10^{11}	2.00×10^{11}
Romania	9.63×10^{10}	8.63×10^{10}	8.23×10^{10}	8.53×10^{10}	9.05×10^{10}	9.95×10^{10}	1.04×10^{11}	9.71×10^{10}
Russian Federation	9.24×10^{11}	9.00×10^{11}	8.32×10^{11}	7.62×10^{11}	6.73×10^{11}	6.62×10^{11}	6.44×10^{11}	6.44×10^{11}

TABLE II–V. (cont.)

Slovak Republic	3.76×10^{10}	3.30×10^{10}	3.22×10^{10}	3.17×10^{10}	3.39×10^{10}	3.73×10^{10}	4.01×10^{10}	4.26×10^{10}
Slovenia	—	—	1.80×10^{10}	1.89×10^{10}	2.03×10^{10}	2.18×10^{10}	2.27×10^{10}	2.34×10^{10}
South Africa	2.35×10^{11}	2.39×10^{11}	2.43×10^{11}	2.52×10^{11}	2.67×10^{11}	2.83×10^{11}	2.97×10^{11}	3.00×10^{11}
Spain	4.79×10^{11}	5.04×10^{11}	5.30×10^{11}	5.35×10^{11}	5.58×10^{11}	5.90×10^{11}	6.09×10^{11}	6.26×10^{11}
Sweden	1.44×10^{11}	1.47×10^{11}	1.51×10^{11}	1.51×10^{11}	1.59×10^{11}	1.70×10^{11}	1.74×10^{11}	1.75×10^{11}
Switzerland	1.52×10^{11}	1.55×10^{11}	1.62×10^{11}	1.65×10^{11}	1.69×10^{11}	1.75×10^{11}	1.77×10^{11}	1.79×10^{11}
Ukraine	2.19×10^{11}	2.06×10^{11}	2.04×10^{11}	1.79×10^{11}	1.41×10^{11}	1.27×10^{11}	1.15×10^{11}	1.11×10^{11}
UK	9.30×10^{11}	9.37×10^{11}	9.74×10^{11}	1.02×10^{12}	1.08×10^{12}	1.14×10^{12}	1.18×10^{12}	1.22×10^{12}
USA	5.62×10^{12}	5.72×10^{12}	6.15×10^{12}	6.44×10^{12}	6.81×10^{12}	7.18×10^{12}	7.51×10^{12}	7.77×10^{12}

Source: Ref. [II–4]

REFERENCES TO ANNEX II

[II–1] ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, OECD Economic Outlook, OECD, Paris (1997).

[II–2] INTERNATIONAL MONETARY FUND, International Financial Statistics Yearbook, IMF, Washington, DC (1997).

[II–3] INTERNATIONAL MONETARY FUND, World Economic Outlook, IMF, Washington, DC (1997).

[II–4] INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT (WORLD BANK), World Development Indicators 1999, CD-ROM, IBRD, Washington, DC (1999).

Annex III

DEFINITIONS AND TERMINOLOGY FOR NEPIS

III–1. OBJECTIVE

The purpose of NEPIS data collection is to gather information on O&M costs on a unit and plant basis. The benefits of collecting O&M costs are compelling. It will allow management to identify more clearly where and how costs are being incurred, and use its judgement to determine whether adjustments would improve the competitiveness of a unit.

III–2. GENERAL INSTRUCTIONS

The NEPIS database is based on the EUCG functional O&M database; although their account numbers were kept, their definitions were adapted for international use.

The general instructions given for the NEPIS database are given below.

(1) This data collection focuses on O&M costs.
(2) Certain nuclear unit costs should not be included in this database. They should not be reported in any sections of the survey. These costs include depreciation, interest, taxes (except payroll) and regulatory body civil penalties.
(3) Definitions of accounting are provided in Sections III–4.1 and III–5.3. Annex IV completes this information.
(4) Dissimilar units (e.g. significant vintage or design differences) at the same site should be reported separately. Exceptions should be discussed and agreed with the IAEA/EUCG Task Force involved in this project. Common site or unit costs should be allocated to individual units when they are reported separately.
(5) All cost information provided should be on a total plant basis. Separate spreadsheets must be completed for reporting each end of cycle refuelling outage on a unit specific basis.
(6) Complete the information for each plant contained in your database for the reporting year. Costs common to multiple plants should be prorated.
(7) Costs should be reported in the national currency. The methodology for cost data conversion to US dollars will be, for example, that the average of the 1997 exchange rate will be used for the conversion of national costs at 1 January 1997 into US dollars as at 1 January 1997. The use of the annual average is intended to minimize the possible effect of short term currency fluctuations.

This is known to be less accurate than the use of relevant purchasing parities but is considered justified at this stage in view of its simplicity and transparency. It is well understood that the described approach has weaknesses, in particular in respect of using such country aggregated parameters as average exchange rates. It is therefore intended to consider, at a later stage and following experience and users' suggestions, a more rigorous approach with the use of producer price indices and purchasing power ratios. However, for the initial development of the database the described simplified approach is considered to be the most appropriate.

(8) The database will convert by default to US dollars. Nevertheless, other conversion methods will be made available. Conversion methods are discussed separately.

(9) Costs should be reported for four categories: 'labour', 'materials', 'outside services' (external services, contractors and outsourced services) and 'others'. Totals will be calculated in the spreadsheet automatically.

(10) In all cases the data should be consistent with the best available internal corporate records. Data provided in this survey should reconcile with other published data.

(11) The NEPIS database is intended to provide actual data on an annual basis. Historical records will be retained.

(12) The reporting period should follow the calendar year from 1 January to 31 December. If data are provided for a different period, for instance when commercial operations or decommissioning took place in the reporting year, please specify this in the relevant fields (accounts 1100, 1101 and 1102).

(13) If your plant is scheduled to go into commercial operation in a future year, please submit your initial 12 month O&M budget and label it as 'budget information'. If your plant went operational during the reporting year, please submit your actual costs and indicate the number of units and unit months of commercial operation.

(14) A comment area is provided for each line of information you complete. Up to 50 characters of comments can be entered.

(15) Use your professional judgement to categorize your costs into these standard definitions.

(16) Year to year consistency of data is a long term objective of this data collection.

III–3. DATA QUALITY ASSURANCE

A data review and verification team made up of IAEA Secretariat and EUCG Nuclear Committee (IAEA/EUCG Task Force) members will validate submittals prior to data publication. In order to facilitate this process, a self-validation feature will be included in the database update program. This feature will automate many of the verifications made by the review team. As you review your submittal, consider the following:

- Unusual accounting adjustments, such as amortization, large credits or changes in accounting practices;
- Reasonableness of costs;
- Comparison to prior year's data submittals;
- Inclusion/exclusion of refuelling outage costs;
- Review the submittal for missing or incomplete data.

III–4. GENERAL PLANT AND UNIT DATA

III-4.1. General

The plant and unit categories contain basic plant and unit[1] information and should be completed using the most current information available. All the definitions and terminology used should be in accordance with the IAEA PRIS database, the source of this information. See Annex V for the definitions and terminology used by the IAEA PRIS database.

A0001. Organizational structure: provide the utility/plant organizational structure (schematic) for the current year (one page only).

III-4.2. Plant specifications: A1000 to A1415

This section describes the account number, account names and definitions needed for each plant specification.

A1000. Operator [name]: the full name of the operating company.

A1010. Plant name [name]: the full name of the generating plant.

A1015. Ownership [%]: your ownership share of the plant reported as a percentage. Note that all data submitted for jointly owned plants are to be 100% totals.

A1020. Contact person [name, address, phone, fax, email]: the name of the respondent, including telephone number and mailing address. This should be the person to contact if there are questions about the plant data.

[1] 'Unit' is a single operating reactor at a site. 'Plant' is designated as multiple units of identical design at one location.

A1100. Reporting start date [mm/dd/yyyy]: the reported start date, as mm/dd/yyyy. Use this field to report differences between the fiscal and calendar year, or for a plant/unit that starts commercial operation or decommissioning during the year.

A1105. Reporting end date [mm/dd/yyyy]: the reported end date, as mm/dd/yyyy. Use this field to report differences between the fiscal and calendar year, or for a plant/unit that starts commercial operation or decommissioning during the year.

A1110. Actual/budget [A/B]: the data provided should be reporting year actual. If actual data cannot be provided, please submit budget data and mark it as budget (B).

A1120. Currency used [name]: note the national currency used when reporting cost data (for example Swiss franc, Spanish peseta, Indian rupee, etc.).

A1200. Operating crews [number]: the number of control room operating shift crews currently in use at the nuclear power plant.

A1205. Do you pay overtime to salaried staff?: indicate yes or no.

A1210. Paid base overtime [%]: paid overtime person-hours divided by paid straight time person-hours for all utility works. Comment on different reporting methods. (Can include unplanned outage overtime.)

A1215. Paid refuelling outage overtime/paid overhaul (on-line refuelling) outage overtime [%]: paid overtime person-hours divided by paid straight time person-hours during a major outage period for all utility works.

A1218. Standard work week [person-hours]: report the number of straight time person-hours (for example 38 hours, 44 hours, etc.).

A1219. Overtime [hours]: at what hour in the week do you begin to pay overtime? Report when you begin to pay overtime, for example after 8 hours or after 44 hours, etc.

A1220. Paid absence [%]: the paid absence rate expressed as a percentage of hours worked. It may include sick leave, accidents, vacations and holidays in accordance with national or local legislation.

A1230. Benefits [%]: the total payroll benefits expressed as a percentage of base payroll dollars, including paid absence. Benefits as defined here include such items as social security taxes, unemployment insurance, medical benefits, housing, schooling, etc. The total payroll benefits used to calculate this percentage should be also reported in the account 2502 section. Refer to the account 2502 section for a more complete definition. Identify the benefits included in the account.

A1315. Union percentage [%]: the approximate percentage of the total work-force who are members of a recognized union.

A1320. Multiple unit operating licence [yes/no]: a response is required for multiple units only. Are your operators licensed to operate all units at the site?

A1410. Inventory [value in national currency]: provide the total value of material and supplies in the general inventory at the year end.

A1415. Inventory pool [yes/no]: do you utilize the services of an inventory pool?

A1420. Inventory consumption [%]: the portion of the inventory consumed divided by the total inventory at the end of the year (A1410).

III-4.3. Unit specifications: A1600 to A2015

The terminology and definitions used in this section follow the IAEA PRIS database: see Annex V.

A1600. Unit's name [name]: the name of the unit(s) reported in the O&M costs report.

A1606. Ref-unit code [code]: the same as reported to the IAEA PRIS. This field is provided by the database itself.

A1610. Commercial date [mm/dd/yyyy]: the commercial operation date for each unit. The commercial operation date is the date when the unit is handed over by the contractors to the owner and declared officially to be in commercial operation.

A1620. Reactor type [code]: select the appropriate reactor type from the following:

- AGR: advanced, gas cooled, graphite moderated reactor.
- BWR: boiling light water cooled and moderated reactor.
- FBR: fast breeder reactor.
- GCR: gas cooled, graphite moderated reactor.
- HTGR: high temperature, gas cooled, graphite moderated reactor.
- HWGCR: heavy water moderated, gas cooled reactor.
- HWLWR: heavy water moderated, boiling light water cooled reactor.
- LWGR: light water cooled, graphite moderated reactor.
- PHWR: pressurized heavy water moderated and cooled reactor.
- PWR: pressurized light water moderated and cooled reactor.
- SGHWR: steam generating heavy water reactor.
- WWER: water cooled, water moderated power reactor.

A1630. NSSS supplier [name]: the NSSS supplier for each unit.

A1640. Maximum reference capacity [net MW(e)]: the net generation capacity for each unit. See Annex V.

A1645. Design electrical capacity [net MW(e)]: the net generation capacity for each unit. See Annex V.

A1650. Net generation [MW(h)]: the actual net generation per unit in MW(h) for the entire reporting year.

A1656. Annual unit capability factor [%]: this is defined as the ratio of the available energy generation (net) over a given time period to the reference energy generation (net) over the same period, expressed as a percentage. Both of these energy generation terms are determined relative to reference ambient conditions.

UCF (%) = (REG – PEL – UEL)/REG × 100

where

REG is the reference energy generation (net) (MW(e)·h),
PEL is the total planned energy losses (MW(e)·h),
UEL is the total unplanned energy losses (MW(e)·h).

The total planned and unplanned energy losses is the sum of the losses from all planned and unplanned events, respectively. These data will be extracted from the IAEA PRIS.

A1671. Annual energy availability factor [%]: this is defined as the ratio of the available energy generation (net) over a given time period to the reference energy generation (net) over the same period, expressed as a percentage.

EAF (%) = (REG – PEL – UEL – OEL)/REG × 100

where

REG is the reference energy generation (net) (MW(e)·h),
PEL is the total planned energy losses (MW(e)·h),
UEL is the total unplanned energy losses (MW(e)·h),
OEL is the total external energy losses (MW(e)·h).

The total planned and unplanned energy losses and energy loss due to causes external to the plant for the period is the sum of the losses from all planned, unplanned and external events, respectively. These data will be extracted from the IAEA PRIS.

A1681. Unplanned outage rate [%]: the total unplanned outage hours divided by the sum of [(total unit service hours + unplanned outage hours)], stated as a percentage for each unit.

A1690. Unplanned loss capability factor (ULCF) [%]: this is the energy that was not produced during the period because of unplanned shutdowns, outage extensions or unplanned load reductions owing to causes under the plant's management's control. Causes of energy losses are considered to be unplanned if they are not scheduled at least four weeks in advance.

UCLF (%) = (UEL/REG) × 100

where

REG is the reference energy generation (net) (MW(e)·h),
UEL is the total unplanned energy losses (MW(e)·h).

These data will be extracted from the IAEA PRIS.

A1700. End of cycle refuelling outage start date [mm/dd/yyyy]: the refuelling outage start date.

A1710. End of cycle refuelling outage end date [mm/dd/yyyy]: the refuelling outage return to service date. Enter as: mm/dd/yyyy. Note: even if your outage end date goes into the next year, use 12/31/yyyy as the end of cycle date.

A1715. Refuelling or annual maintenance outage duration: note that this field will be autocalculated based on accounts A1700 and A1710.

A1720. Incremental refuelling or annual maintenance outage cost [national currency]: the incremental O&M outage costs of the most recently completed refuelling outage (even if it spans more than one year). See the refuelling outage cost definitions, Section III–6. Note: refer to account A1710 for the refuelling outage end date.

A1750. Operating cycle (12, 18, 24, etc.) [number]: the duration, in months, of the operating cycle, that is the time between two refuelling/overhaul outages (12, 18, 24, etc., months). Note that you can enter any required number.

A1800. Original capital cost [national currency × 1000]: the original capital cost of the facility when first put into commercial operation, excluding the interest during construction. If the plant is sold and revalued, please state the revalued cost. (Multiples of 1000.)

A1810. Current annual investment/capital [national currency × 1000]: all costs associated with any improvements and modifications made during the reporting period (i.e. the additional capital investment made during the current reporting period, excluding interest). These costs include any designs, installations, removals or salvages that occurred during the reporting period. Other miscellaneous investment/capital additions, such as for facilities, computer equipment, moveable equipment or vehicles, should also be included. These costs should be fully burdened with indirect costs. Exclude interest during construction. (Multiples of 1000.)

A1820. Total investment/capital additions [national currency × 1000]: the capital improvements and modifications made since the unit was placed in commercial operation, excluding interest during construction and retirements. Note that this amount should equal the sum of the value reported last year for account A1820 and the current year value shown in account A1810. (Multiples of 1000.)

A1900. Nuclear fuel cost (total) [national currency × 1000]: the total of accounts A1901, A1902 and A1903. These are the total costs associated with the fuel in the reactor that is burned up during the reporting period, separated into three categories: A1901, A1902 and A1903. This cost is based upon the amortized costs associated with the purchasing of uranium, and the costs of conversion, enrichment and fabrication services along with storage and shipment costs, and inventory (including interest) charges less any expected salvage value. Also included should be payments for decommissioning and decontamination charges, as well as current and prior spent nuclear fuel disposal costs (both the principal and interest). You may enter this value and not the specific values in accounts A1901, A1902 and A1903. (Multiples of 1000.)

A1901. Direct fuel costs [national currency × 1000]: the direct amortized cost of the fuel load, including the purchase of uranium, its conversion, enrichment, fabrication services, design analysis, shipping and storage charges (for CANDUs include the costs associated with heavy water replenishment). (Multiples of 1000.)

A1902. Fuel financing costs [national currency × 1000]: the indirect financing cost of the fuel load, the lease financing charges and the carrying costs. (Multiples of 1000.)

A1903. Fuel regulated and other costs [national currency × 1000]: the regulated and other amortized costs of the fuel load, including decommissioning and decontamination charges, current and prior spent fuel disposal costs, and amortization of the final core cost. (Multiples of 1000.)

A1904. Design effective full power days [dd]: design effective full power days for the current fuel load.

A1920. Operating life [yyyy]: the number of years the plant is licensed for or, if more appropriate, the designed lifetime.

A1925. Most recent full cycle start date [mm/dd/yyyy]: using the last fully completed cycle, the beginning of that cycles' power production or the end of the last refuelling outage.

A1930. Most recent full cycle end date [mm/dd/yyyy]: using the last fully completed cycle, the end of that cycle's power production or start date of the next refuelling outage.

A1935. Most recent full cycle unit capability factor [%]: the capability factor for the entire cycle (the time period between the finish and start of the last refuelling outage).

A2000. Annual decommissioning funding [national currency × 1000]: provide the amount of your unit's annual contribution or accrual to provide for the cost of decommissioning, if applicable. State in current year money and do not include annual interest earned. Note: to report total unit contributions will require input from your co-owners (if it is a jointly owned project). It is important that this information be obtained, because for comparability a 100% number is required.

A2010. Decommissioning cost estimate [national currency × 1000]: provide the estimated total cost for decommissioning. Specify the type of decommissioning in the comments (for example prompt removal/dismantling the unit). This should be the total estimated cost, not the amount accrued in the fund. This should be in the currency of the year that the most recent formal cost estimate was made; do not escalate to current year money. This should be the total cost estimate for a unit, not a utility's share or a jurisdiction's portion — add a field or comment.

A2011. Year of cost estimate [yyyy]: provide the year that the decommissioning cost estimate was made. This is the year of the currency reported above in account A2010.

A2015. Nuclear insurance premiums [national currency × 1000]: provide the total nuclear insurance premiums (for nuclear liability, property and any extra expense premiums) for the reporting year. Please provide this amount per plant, using any appropriate means of unitizing plant or station premiums. Barring any better basis for such allocation, consider dividing the station premium by the number of units at the station. Do not include refunds or recoveries.

A2110. Low and medium radioactive waste distance from plant [km]: indicate if radioactive waste is stored at the plant or transported elsewhere. If it is transported, indicate the distance from the plant to the storage facilities in kilometres.

A2120. High radioactive waste distance from plant [km]: indicate if radioactive waste is stored at the plant or transported elsewhere. If it is transported, indicate the distance from the plant to the storage facilities in kilometres.

III–5. O&M COST DEFINITIONS

III-5.1. Overview

- The data provided should reflect the full direct costs for operating and maintaining the nuclear plant given in account 2000 of the annual spreadsheet. This should include all the costs from the senior nuclear corporate officer down, plus other identifiable direct costs.
- The plant indirect costs should be reported in accounts 2500 to 2503, separate from the functional breakdown of direct costs (accounts 1099 to 2000). These costs should reflect the share of payroll taxes and benefits and the corporate administrative and general costs applicable to the nuclear plant. Costs that would be applicable if the plant was considered a business unit should be included.
- All costs should be submitted in multiples of thousands of the national currency.
- All data reported in this section should be reported on a plant basis. However, as previously noted, separate data should be submitted for dissimilar units at a single site.

— All data in this section should include all costs related to normal operations, maintenance and outage periods.
— All labour costs submitted should include paid absence but exclude benefits.
— The full direct cost to operate and maintain the plant should be broken down in accounts 1099 to 1399. They are automatically totalled in account 2000.
— Capital expenditures during the year should be reported separately in account 3000. The total capital in account 3000 should match the total of the unit capital costs reported in account A1810 in the plant spreadsheet.

III–5.2. Resource definitions

— Labour: this includes all direct utility payroll costs, both on- and off-site, plus shift and overtime premium pay (including paid absence but excluding other benefits).
— Materials and equipment: this includes all materials used and consumed during plant operations, maintenance, testing and monitoring. Include consumed operational spares (i.e. the cost of replacing spare parts) and other miscellaneous equipment. Also include fuels, oils, chemicals and gases, resins, general office supplies, as well as other miscellaneous materials and consumables. Include purchasing and material handling overheads if, and only if, they are not already accounted for in account 1340.
— Outside services: this includes the costs of services performed by outside firms. General categories include, but are not limited to, craft support, data processing, technical or engineering services, security and management consultancy.
— Other: this includes all other costs not provided for in the labour and materials, equipment, and outside services categories. It specifically includes travel, staff development, regulatory fees, utilities and internal company services such as computer equipment, microfilming and duplicating.

III–5.3. Account definitions: 1099 to 3004

This section describes the account ID, organization, function and definition of each account ID for all the accounts.

The following definitions provide the basis for categorizing the cost data. The cost data should reflect the total O&M direct costs for labour, materials, equipment and the outside services/functions shown below.

Capital additions costs should not be included in accounts 1099 to 2000. These costs should be reported in account 3000. Indirect costs should be reported in accounts 2500 to 2503.

III-5.4. Operations costs

1099. Operations (total) [national currency × 1000]: the activities associated with the operations function, which includes:

- — Control room licensed and unlicensed operators;
- — Equipment tagging processes;
- — Operations procedures;
- — Fuel handling personnel/management and supervision;
- — Control room technical shift advisers;
- — Process gases, fuels and resins;
- — Shift operating managers;
- — Off-site power costs (put in the account 1099 ‘other’ cost category).

III-5.5. Maintenance costs

1110. Preventive maintenance (mechanical and electrical) [national currency × 1000]: the activities associated with forestalling or preventing anticipated problems or the breakdown of a system, part, etc.; for example:

- — Maintenance procedures,
- — Recalibrations,
- — Work package planning and preparation,
- — Obtaining/preparing work permits for work packages,
- — Reviewing completed work packages,
- — Machine shop services,
- — Lubrication programmes,
- — Interval replacements of equipment components,
- — Tool room activities.

1115. Preventive maintenance (instrumentation and control) [national currency × 1000]: the activities associated with forestalling or preventing anticipated problems or the breakdown of a system, such as:

- — Support plant process instrumentation,
- — Support plant process computer systems,
- — Work package planning and preparation,
- — Obtaining/preparing work permits for work packages,
- — Reviewing completed work packages,
- — Lubrication programmes,

— Recalibrations,
— Interval replacements of equipment components.

1117. Preventive maintenance, subtotal (1110 + 1115) [national currency × 1000].

1120. Corrective maintenance (mechanical and electrical): the activities associated with the repair or replacement of plant systems, equipment, components, etc., that are found to have been defective, and repairing, altering, adjusting or bringing them into conformity or making them operable, including:

— Maintenance procedures,
— Recalibrations,
— Work package planning and preparation,
— Obtaining/preparing work permits for work packages,
— Reviewing completed work packages,
— Machine shop services,
— Tool room activities.

1125. Corrective maintenance (instrumentation and control): the activities associated with the repair or replacement of plant systems, equipment, components, etc., that are found to be defective, and repairing, altering, adjusting or bringing them into conformity or making them operable, including:

— Support plant process instrumentation,
— Support plant process computer systems,
— Work package planning and preparation,
— Obtaining/preparing work permits for work packages,
— Reviewing completed work packages.

1127. Corrective maintenance, subtotal (1120 + 1125).

1128. Preventive and corrective maintenance, subtotal (1117 + 1127) [calculated field].

1130. Surveillance testing (mechanical and electrical) [national currency × 1000]: the verification of safe operations and compliance with the regulatory requirements and commitments, such as diesel generator tests, safety systems tests, instrument calibrations, etc., and:

— Calibration and functional testing of equipment,
— Measurement and equipment testing programmes,
— Safety systems tests,
— Tool room activities.

1135. Surveillance testing (instrumentation and control): the verification of safe operations and compliance with the regulatory requirements and commitments, such as diesel generator tests, safety systems tests, instrument calibrations, etc., and:

— Instrument and control surveillance,
— Calibration and functional testing of equipment,
— Measurement and equipment testing programmes,
— Instrument and control procedures,
— Safety systems tests.

1137. Surveillance testing, subtotal (1130 + 1135).

1140. Non-capital modification: this includes all non-capital modification costs not included in accounts 1099 to 2000. Examples are: (1) in France any modification that improves efficiency is considered a capital investment, which should therefore not be included in O&M costs; (2) a change of steam generator is considered a capital modification, which should also not be included here.

1199. Total maintenance [calculated field]: the total maintenance cost as defined by the preceding functions (accounts 1128 + 1137 + 1140). This is a calculated field.

III–5.6. Support services

1210. Technical/engineering: this includes all the costs associated with the following technical/engineering activities: engineering support, contractor co-ordination, performance monitoring/analysis, code compliance, engineering required for plant modifications, base design database and design document maintenance, technical/engineering support for O&M, non-destructive examination and in-service inspection programmes, and systems engineering. It also includes general analysis engineering and estimating services, such as:

— Engineering support of licensing;
— Estimating services;
— Engineering analysis, operability and evaluations;
— Administrative controls for design control, configuration control and engineering evaluations;
— Preparing requests for the financial approval of new projects;
— Site environmental qualification programmes;
— Snubber surveillance programmes;
— Site fire protection engineering;

— Engineering resolutions of materials problems;
— Plant design documents;
— Engineering databases, software controls and personnel qualifications for computer programs;
— Points of contact for Institute of Nuclear Power Operations (INPO), WANO or other organizations' activities;
— Integrated containment leak rate test programmes;
— Support for maintenance and operations;
— Support for contractor co-ordination;
— Preparing and maintaining assigned plant procedures;
— Safety system unavailability monitoring and monthly plant operating reports;
— Trending of system and component performance;
— System reviews for root cause of failure determinations;
— Post-modifications retest, surveillance testing and special test preparations;
— Spare parts evaluations;
— Incident report responses;
— Predicting failures of rotating equipment;
— Predicting secondary system equipment thermal performance efficiency losses;
— Erosion/corrosion programmes;
— Repair and replacement programmes;
— Repair alteration programmes;
— Evaluation of site radiography;
— Evaluation of site ultrasonic examinations;
— Local leak rate testing;
— Preparing design packages for modifications and new designs;
— Revising drawings, manuals and computer databases to maintain plant configurations;
— General drafting support;
— Commercial grade material for nuclear safety related applications;
— Researching and responding to materials problems as identified by the regulatory body, supplies and industry;
— Seismic qualification programmes;
— Equipment lubrication programmes;
— Reliability centred maintenance reviews;
— Design basis documentation (DBD) (note that if DBDs are capitalized by the utility, they should be included in the capital portion of the database and not included here).

1212. Fuels management: nuclear fuel management (including core configuration and core performance and evaluation not included in the A1900 account).

— Reload core physics design activities;
— Core modelling and assessments;
— Providing support for reload licensing involving enrichment or configuration;
— Monitoring and evaluating fuel performance;
— Nuclear fuel procurement, market analysis and procurement;
— Fuel cost economic analysis and fuel budgeting;
— Fuel fabrication contract administration and fabrication audit support.

1214. Licensing: all the costs associated with licensing and with regulatory agencies. Note: any fees should be entered in the account 1214 'other' category and not in 'labour', 'materials' or 'outside services'.

— Final safety analysis report change notices and annual updates;
— Processing of operating licence amendment requests;
— Technical support for the NSSS owners' group;
— Co-ordination of responses to regulatory body bulletins and generic letters;
— Environmental technical specification issues;
— Incident programme reportability reviews;
— Licensee event reports and reports to regulating agencies;
— Co-ordination of support of regulatory body inspections and responding to their findings;
— Regulatory body annual fees;
— INPO/WANO dues.

1219. Technical/engineering services, subtotal [calculated field]: the total of accounts 1210, 1212 and 1214. This is a calculated field.

1220. Nuclear training: all the costs associated with technical training (excluding the students' salaries, which are included with each function). Primarily development, instruction and evaluation for the following training activities: licensed and non-licensed operator training, health physics/chemistry, emergency preparedness, security, technical, maintenance and craft qualifications, general employee training and simulator support costs. The costs might include:

— Classroom training accredited by INPO or other organizations, such as:
  - Senior reactor operators' initial and re-qualification training,
  - Reactor operators' initial and re-qualification training,
  - Shift technical advisers' training,
  - Non-licensed operators' training,
  - Health physics technicians' training,
  - Chemistry/radioactive waste technicians' training,
  - Mechanical maintenance mechanics' training,

- Instrument/control technicians’ training,
- Technical staff and managers’ training (but not management training),
- Instructors’ training.

— Other classroom training programmes, such as:
  - General employee training,
  - Security training,
  - Emergency preparedness training,
  - Fitness for duty training,
  - Continued employee observation training,
  - Hazard aid/cardiopulmonary resuscitation training,
  - Radioactive chemical helper training,
  - Quality assurance engineers’ training,
  - Plant computer training.

— Training conducted by outside organizations, such as:
  - Maintenance contractors’ training,
  - Apprenticeship training,
  - Quality control inspectors’ training,
  - Management training,
  - Fire brigade training.

— Preparing and maintaining training department procedures.

— Operating and maintaining control room simulators:
  - Software support,
  - Repair and maintenance of the simulator,
  - Configuration control to assure certification.

— Process personnel for training and other requirements for unescorted access to plants.

— Training or qualification status.

1230. Security: this includes all the costs associated with plant security, including management/supervision, guards and other security functions. These costs might also include:

— Testing and operating the intrusion detection and assessment system,
— Performing background investigations,
— Administering contracts with security agencies,
— Security clearances for plant access.

1240. Radiation protection/health physics: this includes all the costs associated with the following: health physics activities, routine monitoring, exposure control and decontamination programmes, ‘as low as reasonably achievable’ programme implementation, instrument calibration and control. These costs might also include:

— Radiation exposure control programmes;
— Radiation work permits;
— Radiological surveys and postings;
— Temporary shielding;
— Instrument calibration control for radioactive materials and sources;
— Contamination control within controlled areas;
— Laboratory radioactivity counting and analytical equipment;
— Respiratory protection programmes;
— Calibrating, maintaining and operating portable radiation survey equipment, whole body contamination monitors, laundry and continuous air monitors;
— Radioactive effluent release monitoring and dose calibrations;
— Health physics procedure maintenance;
— Environmental monitoring programmes;
— Health physics records, access control and gamma spectroscopy computer systems;
— Hot particle programmes.

1245. Radioactive waste monitoring/decontamination: included in this category are radioactive waste disposal fees (excluding fuel), and:

— Gaseous radioactive waste systems;
— Operating evaporators and filters to process liquid radioactive waste;
— Sorting, compacting and packaging dry radioactive waste for off-site burial;
— Changing and packaging radioactive filters and resins for off-site burial;
— Discharging radioactive liquids that meet regulatory limits for off-site disposal;
— Decontaminating plant tools and equipment;
— Decontamination activities that launder and restock protective clothing inventories;
— Low level waste volume reduction;
— Radioactive waste disposal fees (excluding fuel);
— Shipping fees.

1249. Radiological waste/health physics, subtotal: the total of accounts 1240 and 1245. This is a calculated field.

1250. Quality assurance: all the costs associated with quality assurance programmes involved in operational quality assurance. These might include:

— Quality audits of plant activities and vendors,
— Operational quality assurance,
— Quality surveillance of plant activities,

— In-line reviews of documents and procedures,
— Maintenance programme manuals and quality assurance procedures,
— Management assessments for quality assurance issues,
— Providing for authorized nuclear inspection activities,
— Administering vendor verification programmes,
— Corrective action programmes (action assignments, tracking to closure and trending).

1252. Quality control: all the costs associated with quality control in plant inspection activities, including non-destructive examinations, receiving inspections and plant modification surveillance. These costs might also include:

— Visual inspections,
— Non-destructive examinations or tests,
— Technical specification surveillances on safety related systems (e.g. snubbers and fire barrier seals),
— Inspection of maintenance modification activities,
— Materials receipt inspections,
— Reviewing and reporting of nuclear reliability data systems,
— Non-compliance report processing,
— Reviewing and completing work requests and preventive maintenance,
— Task sheets,
— Performing material testing for commercial grade dedication programmes.

1254. Nuclear safety assessment: these activities might include:

— Reviewing and disseminating operating experiences;
— Independent safety engineering group activities;
— Human performance reviews;
— Significant event reduction programme co-ordinations and reviews;
— Safety analysis support of new core designs, plant occurrences or incidents and safety related set point changes;
— Independent plant evaluation studies;
— Plant risk and reliability studies.

Mention should be made in the comments field if it not possible to be specific about a particular number.

1259. QA/QC, subtotal [calculated field]: the total of accounts 1250, 1252 and 1254. This is a calculated field.

1270. Chemistry: all the costs associated with station chemistry programmes, routine chemistry monitoring, analysis and control, including:

— Analysing and maintaining all plant water and steam chemistry;
— Maintaining process and laboratory chemical instrumentation;
— Operating plant chemical addition equipment and making up demineralizers;
— Administering chemical control programmes;
— Routine chemistry monitoring, analysis and control;
— The cost of the chemicals.

1299. Support service costs, total [calculated field]: the total support services costs defined by the preceding functions (accounts 1219, 1220, 1230, 1249, 1259 and 1270). This is a calculated field.

III-5.7. Plant administration

1310. Plant administration management: all the costs for the plant administrative management, that is managers/superintendents and staff, human resources (including industrial safety), financial/budget (including contract administration), plant communications, performance evaluation and fire protection.

Note that managers' costs belong to the function that they manage (i.e. engineering, maintenance, quality assurance, etc., if that is their sole responsibility). This category is for those management positions that are not functionally addressed elsewhere in the database. The costs include all administrative management that provides support directly to or works at a nuclear power plant, and might include:

— Senior nuclear officers, general managers and plant managers.
— Administrative staff for senior nuclear officers.
— Plant personnel functions:
- Labour and employee relations,
- On-site recruitment services.

— Fitness for duty programmes (excluding training).
— Financial services:
- Budget preparation and overview,
- Work order programme support,
- Industrial safety programmes,
- Plant administrative services,
- Plant mail services,
- On-site medical services,
- Contract administration.

— Engineering and maintenance outside services.
— Direct material purchases.
— Plant communications.
— Performance evaluations.

— Fire protection.
— Visitors’ centres maintained by the plant administration.
— Community support maintained by the plant administration.

1312. Planning and scheduling: this includes:

— Developing and co-ordinating daily work scheduling;
— Preparing, scheduling and tracking of plant surveillance programmes and mode change letters;
— Long range work planning (not financial business).

1314. Outage support: the preparation, development and co-ordination of planned plant refuelling outages and scope of work activities. This includes the development and co-ordination of daily work schedules during outages. Note: this is not the incremental outage cost: see refuelling outage cost definitions, Section III–6

1319. Plant management, subtotal [calculated field]: the total of accounts 1310, 1312 and 1314. This is a calculated field.

1320. Records management: all the costs associated with the receipt, preparation, encoding, verification and filing of records and documents for plant design verifications, O&M manuals and general plant records. The costs might include:

— Maintaining controlled documents;
— Receiving, inspecting, filing, maintaining and retrieving plant records;
— Microfilming plant records and drawings;
— Providing reproduction services;
— Supplemental word processing support;
— Reproducing and distributing plant procedures and controlled documents;
— Maintaining plant libraries;
— Reproducing and distributing O&M manuals.

1325. Nuclear information services: all the costs associated with plant computer operations and support. The costs might include:

— Maintaining and operating a plant mainframe data centre, information systems network and help desk;
— Planning and implementing computer system hardware and software enhancements and growth management;
— Providing technical support for specialized application systems and software;
— Providing acquisition and technical support for PC based hardware and software systems;

— Providing technical support for data circuits and specialized information system hardware;
— Developing, implementing and maintaining in-house application programs and systems.

1330. Emergency planning: all the costs associated with emergency planning development, training, and conducting drills and providing interfaces with federal, state and local emergency organizations. Note: any fees associated with emergency planning should be entered in the account 1330 ‘other’ category and not in ‘labour’, ‘materials’ or ‘outside services’. The costs might include:

— Scenario development.
— Co-ordinating plant emergency planning affairs with those of state, county and local community organizations.
— Planning and conducting emergency planning drills and exercises.
— Providing emergency planning training for off-site organizations.
— Developing and maintaining emergency plans and procedures.
— Developing and maintaining emergency facilities (emergency operation facilities).
— Negotiating and administering fees and expenses paid to others for emergency planning activities.
— Co-ordination of the efforts associated with hazardous material emergencies.
— Maintaining programmes for the notification of plant personnel of staff emergency response positions.
— Maintaining a public alert system for notifying the general public of a radiological emergency.
— For US plants the expenses associated with Federal Emergency Management Agency fees, state and county assessments and activities. For other countries enter comparable expenses for similar activities.

1340. Stores: all the costs associated with warehousing (for administering plant/utility inventories). Includes procurement associated costs when directly in support of the warehouse process. Also includes purchasing and material support costs that are not part of a materials or procurement overhead. The costs might include:

— Soliciting bids;
— Preparing procurement packages;
— Interfacing with suppliers and contractors;
— Expediting purchases;
— Receiving, storing, issuing and delivering materials and supplies;
— Creating and processing requisitions for stock;

— Maintaining storage areas and off-site shipping of non-radioactive hazardous materials that are returned to a storeroom;
— Administering purchases of materials and supplies;
— Resolving vendor claims.

Storeroom costs incurred during the reporting period are more appropriately accounted for in this category rather than as a material overhead. Note: if your company includes these storeroom costs as a part of the stores/material overheads, make sure these costs are not recorded twice in the survey. However, if there is a difference between reporting year storeroom costs and the amount of storeroom costs charged to issued material, enter the difference in this account. This can be a negative or a positive value.

Material costs should be reported under the appropriate function. Inventory costs are investments and should not be included here.

1350. Housekeeping: the costs expended on general plant cleanup. The costs might include:

— Providing plant helpers and supervisors for miscellaneous semi-skilled labour;
— Landscaping and snow removal;
— Vehicle maintenance personnel (if maintenance is carried out as a contract, this should be made clear);
— Rent and maintenance for off-site office or service buildings;
— Janitorial services;
— Sewage treatment;
— Removal of non-radioactive waste and rubbish from the site;
— Maintenance of non-power block buildings and grounds, including parking lots.

1360. Miscellaneous/other: this includes the costs of general clerical support when it is not identifiable with a specific function (i.e. word processing, duplicating, etc.) and other labour that cannot be categorized with a specific function. Note: clerical support for specific work functions are to be included with each function. Also included here are costs that cannot be categorized into any of the other plant administration categories.

1399. Plant administration, total [calculated field]: the total plant administration costs as defined by the preceding functions (accounts 1319, 1320, 1325, 1330, 1340, 1350 and 1360). This is a calculated field.

III-5.8. Direct and indirect costs

2000. Direct O&M, total [calculated field]: the total of accounts 1099, 1199, 1299 and 1399. This is a calculated field.

2500. Indirect costs, total [calculated field]: the total of accounts 2501, 2502 and 2503. This is a calculated field. For those units not providing total indirect costs (A&G), an approximation of 24% of the total O&M direct costs should be used. The approximation of 24% was obtained by averaging the ratio of 65 units of A&G to O&M for the past three years.

2501. Indirect costs, insurance portion: insurance, including liability, property, replacement power, etc. This number should match account A2015.

2502. Indirect costs, pension and benefits portion and payroll taxes: the cost of direct payments or company paid employee related insurance for any activity benefiting the employee. The costs include such items as:

— Accident or death benefits.
— Sick leave.
— Hospitalization.
— Medical insurance.
— Recreational allowances or facilities.
— Relocation expenses.
— Severance or retirement incentives.
— Performance incentives.
— Dependant care.
— Education reimbursement.
— Company supported or matched savings funds.
— Long term disability.
— Benefit related administrative expenses (e.g. employee housing, facilities, etc.).
— Payroll taxes: taxes based on the payroll to provide for unemployment insurance, social security and other benefits.

This number should also be reported in account A1230.

2503. Indirect costs, other: nuclear and corporate administrative and general expenses that are allocated to nuclear functions. These typically include:

— Corporate executive functions;
— Corporate procurement and contract administration;
— Human resources (personnel);
— Payroll, accounts payable and other corporate accounting;
— Computer operations not including account 1325 and nuclear information services;
— Community relations (not directly maintained by the plant's administration);
— Vehicle and equipment services;
— Legal services;
— Duplicating and printing services;

— Landlord costs (facilities management);
— Library and mail services;
— Fixed asset accounting.

3000. Total capital [national currency × 1000]: this includes the total capital expenditures for the current year broken down by labour, materials and equipment, outside services and other costs. The cost reported here must match the plant total for account A1810 and relate to cash expenditures, not to the ‘closed to plant’ or the used and useful concept.

III–6. REFUELLING/OVERHAUL OUTAGE COST DEFINITIONS

Unit refuelling outage cost data are organized in a similar format to the plant O&M data included in the functional cost section of the database. Except as noted, functional account numbers 1099 to 2000, their descriptions, resource categories and the account definitions used to categorize the unit refuelling/overhaul outage costs in this section are identical to those used in the plant O&M functional cost section and the ‘annual’ section of the electronic update spreadsheet. If the outage costs cannot be categorized within these detailed accounts, enter costs in the subtotal or total accounts where applicable.

III-6.1. Overview

The purpose of this section is to identify only the incremental or additional direct O&M costs incurred during the reporting period to perform a refuelling outage at a nuclear power unit. Although refuelling outage costs are included in the O&M functional cost accounts 1099 to 2000, incremental O&M costs attributed to unit refuelling outages are not specifically identified. Typically, incremental outage costs include the additional labour, materials and equipment, outside services and other costs incurred by a functional group to support a refuelling outage beyond that which would have been expended during the reporting period had the outage not occurred. For example, the additional or incremental overtime required by utility maintenance personnel to support a unit refuelling outage would be included as a labour cost in this section. The normal or base straight time labour cost of the same maintenance personnel would not be included. The additional or incremental outside service costs for contractors hired only to support the refuelling outage would be included as an outside services cost in this section.

— Costs and information included in this section are only those attributed to, or the result of, a unit specific refuelling outage.

— The refuelling/overhaul outage electronic spreadsheet should be used to input information for this section. Note that the unit number associated with the refuelling outage and the outage begin and end dates must be entered when adding a new outage to the database.
— Only the refuelling/overhaul outage costs incurred during the reporting period (through to 12/31/yy) should be included. If the refuelling outage extends into the following year the remaining outage costs should be included in the next year's submittal.
— The refuel outage start date, end date and duration should be identical to the dates and duration entered in the corresponding unit accounts A1700, A1710 and A1715, respectively.

Annex IV

GLOSSARY OF BUSINESS TERMS

A&G costs. Administrative and general costs: corporate overhead costs, covering items such as pensions, benefits, legal costs, human resources, tuition refunds, transportation and similar costs. A&G costs are often incurred at the corporate level and are not budgeted or assessed to specific business units.

above the line. The expenses borne by a rate payer.

accounting entity. The business unit for which financial statements are prepared. An accounting entity may be a complete business, such as a partnership or a corporation, or a smaller unit of a business, such as a subsidiary or division.

accounting equation. The equation reflected in the balance sheet:

Assets – liabilities = stockholders' equity

amortization. The assignment of the historical cost of an intangible asset to production periods an as expense.

asset. Something that is a store of future benefits.

asset allocation. The allocation of investment funds to different assets or groups of assets.

balance sheet. The financial statement of a firm that lists the assets and liabilities at a point in time.

basic income taxes. These consist of the annual income taxes levied upon a company by federal and state governments. Revenues received for the payment of operations and maintenance expenses are not subject to income tax since, in computing taxable income, they are recognized as deductions. Depreciation is also a recognized deduction. The portion of the return element attributable to interest on debt also is deductible. However, the portion of the return element attributable to earnings on preferred and common stock is not deductible and therefore is subject to income tax. Since the income tax element is a function of the return element it is a variable — being greatest initially and then declining over the years as the return element declines. The tax element, like the return element, is re-expressed in terms of an equivalent level annual amount.

below the line. The expenses borne by a stockholder.

benchmarking. The process of identifying best practices by comparing one's own performance to the best in the industry. Comparisons include process performance (cycle time and efficiency) and cost measures, as well as other indirect measures of performance. Benchmarking strives to improve one's own practices by implementing change, to be more like those of top performers.

book depreciation. The amount of money that must be set aside annually to recover a capital cost over the anticipated life of a facility. There are several methods of depreciation; emphasis will be upon the 'straight line' method. Using the straight line system of depreciation, this component is constant each year.

break even point. The point at which one is no longer losing money or gaining money.

budget. A formal plan for the approval and co-ordination of resources.

busbar costs. The total costs associated with supplying electricity at a generating station. Components include O&M costs, fuel expenses, capital carrying costs, decommissioning costs and A&G costs. These costs are usually expressed in cents/kW·h.

business improvement. The processes incorporated into a business in order to improve the results and efficiencies of business operations.

business literacy. The understanding and awareness of business/financial terminology and the application of this understanding to daily processes.

business plan. A document linking overall company strategic goals and objectives to everyday work processes, including major steps on how to achieve them.

business review meeting. A gathering of management personnel for the purpose of reviewing financial and/or operational business results.

capacity. The load for which a generating unit, generating station or other electrical apparatus is rated either by the user or by the manufacturer. The ratio of the actual output divided by the ideal output is called the capacity factor. Primary capacity factors are maximum dependable capacities, based on a reference test of the unit, and design engineering references, based on a nominal plant design rating.

capital. The costs associated with an investment in a facility; usually financed and can be depreciated. Capital return on an investment and depreciation are amortized over the life of the investment as an expense.

capital budgeting. The plan for the co-ordination of resources and expenditures that will determine which projects a firm should undertake.

carrying costs. The annual cost to maintain inventory or service the original cost of a capital investment.

cash flow. The difference between cash receipts and cash disbursements over a specified period of time.

cash flow statement. A financial statement consisting of cash receipts and disbursements, with a summary of the organization's net cash position. It reveals the sources and uses of a company's cash.

common capital stock or common stock. Shares of stock issued and stated at par value, the stated value or the cash value of the consideration received for such no par stock, none of which is limited nor preferred to the distribution of earnings or assets.

competitive business intelligence. The review and analysis of publicly available information that, when assessed and disseminated to management, may create value for the business.

competitive drivers. The factors that may impact, either directly or indirectly, on a strategy or business plan. These could include such items as changes in the law, innovation, the entrance of new competitors and mergers or acquisitions within the industry.

consolidated financial statement. The combined balance sheets, income statements and statements of cash flows of a parent company and its subsidiaries.

complete market. The market in which investors can buy or sell combinations of securities and/or commodities that pay off in all desired states, in all desired circumstances.

common dividends. A payment to common stockholders.

cost of capital (net). The return asked by investors for the use of their money, expressed as a percentage of capital funds.

cost–benefit analysis. A financial model used to determine if a project will be profitable by comparing the estimated project cost with the estimated project benefit.

cost management. Controlling and being acutely aware of the expenses incurred in and/or required to operate a business.

current asset. An asset whose useful life is less than one year, such as cash, securities and accounts receivable.

current period. The present accounting period.

decision support. The determination of whether a project or expenditure is a profitable endeavour to pursue. The process of providing a risk based analysis where several options may exist.

decommissioning. The costs presently being accrued for the end of life decommissioning of units.

deferred charges. An expense that has been incurred but whose payment, for whatever reason, has been put off until some time in the future.

depreciation. To lower the estimated value of something over a period of time.

depreciation expense. The cost of plant (less net salvage) recovered over the life of the plant through a reduction of income. This expense reflects the 'using up' of plant, owing to wear and tear or obsolescence, in the generation of income.

direct labour. The employees directly involved in the making of a product or in the rendering of a service. The payroll falls into the category of direct costs.

disbursement. A cash amount paid out by a company.

earnings per share. The net income available to shareholders divided by the number of shares of stock outstanding.

equity. The difference between the value of a company's assets and the amount of its liabilities.

expected rate of return. The rate of return expected on an asset.

expense. The consumption of assets for the purpose of generating revenue.

expenses. The costs of doing business.

financial risk. The risk posed by the heavy use of debt support by creditors.

financial reporting. The development and issuance of required fiscal reports to meet government and other standards.

fiscal period. A financial reporting period that may cover a year (fiscal year) or a quarter (fiscal quarter).

fiscal policy. Government spending and taxation policy.

fixed asset. An asset whose useful life is greater than one year, such as a manufacturing plant, an office building or heavy equipment.

fixed expenses. The expenses that do not vary with levels of production, such as plant costs or salaries.

generation, electric. The process of transforming other forms of energy into electric energy, or the amounts of electric energy so produced, generally expressed in megawatt-hours.

gross profit (margin). Sales less the cost of the sales.

historical cost. The total sum paid to purchase an asset and get it ready for use.

income from continuing operations. The after-tax income of the portion of a business that is continuing.

income risk. The risk of having insufficient income to carry on operations.

income (profit and loss) statement (P&L). A financial statement showing a company's net income — the profit after deducting all expenses — over a period. It provides investors and creditors with information that helps predict the amount, timing and uncertainty of future cash flows. Accurate predictions of future cash flows help investors assess the economic value of a company and creditors determine the probability of repayment of their claims against the company.

indirect cost (operating expense). A cost that cannot be directly attributed to production, such as selling expenses or A&G costs.

indirect personnel (labour). The employees who are necessary for running a business but who are not directly involved in production or a service. Indirect labour wages and salaries are indirect costs.

industry norms. For every industry there is a set of normal ratios that reflect the average value for a given type of business.

innovation. Process improvement using new ideas, concepts and technology.

interest. Regular payments (usually semiannually) remitted by bond issuers to bond holders for the use of borrowed money. Annual interest payments will be equal to the face value of a bond times its coupon value.

inventory. The goods owned by a corporation in the form of raw materials, work in progress or finished goods.

kilowatt-hour (kW·h). The basic unit of electric energy equal to one thousand watts of power supplied to or taken from an electric circuit steadily for one hour.

liabilities. A firm's obligations to pay its creditors at some time in the future.

line of sight. The ability to view how a company's corporate goals and objectives are being implemented throughout an organization.

load. The amount of energy delivered or required at any specified point or points on a system. Load originates primarily at the consuming equipment of the customers.

market price. The price at which a security or commodity is traded in the market. Electricity is traded at both the wholesale level and retail level as a commodity in a deregulated environment.

marketable security. A security or commodity that is easily traded, such as a stock or bond or megawatt-hour contract.

matching. The principle that helps accountants determine how to record fairly a production cost as an expense. The costs directly associated with producing a certain revenue should be expensed in the same period that the revenue is recorded. The costs that benefit more than one period should be expensed over the periods benefited.

materiality. The concept of relative importance. An item is material if it can influence a decision made by a user of financial statements. When an item is material it must be accounted for within the generally accepted accounting principles.

merger. A combination of two or more firms in which the assets and liabilities of the selling firm(s) are absorbed by the buying firm. Mergers are usually accomplished by either exchanging stock, by a cash purchase of assets or by the payment of debt, or by a combination of these methods.

net generation. Gross generation less power consumed for a station's use.

net assets. Assets minus liabilities. Net assets are equal to an owner's equity.

net fixed assets. Fixed assets less accumulative depreciation.

net income. The earnings or profits of an enterprise.

net loss. Negative cash flow of an enterprise.

net present value method. Annual revenue less all expenses including taxes but not book depreciation and return, discounted at an assumed rate of return (cost of money) to determine a present worth of incoming cash flow for comparison with the initial capital expenditure (an outgoing cash flow). Often used to determine a 'go or no go' decision for project implementation.

net salvage. The difference between the gross salvage value and the cost of removal resulting from the removal, abandonment or other disposition of retired plant. Positive net salvage results when the gross salvage value exceeds the removal costs. Negative net salvage results when the removal costs exceed the salvage value. Positive net salvage decreases the costs to be recovered through depreciation expenses and negative net salvage increases them.

nominal rate of return. The rate of return of an investment where the purchase price and payoffs are measured in units of currency.

non-current liability. Any debt of a business that is not expected to be paid for at least one year from the date of the balance sheet.

O&M. Operations and maintenance costs. Those expenses needed to operate and maintain a facility.

operating income. Sales less the cost of the sales (direct costs) and operating (indirect) expenses. It excludes peripheral income, such as interest on investments, and non-operating expenses, such as taxes.

operating revenues. Income received in transacting the normal course of business.

other direct costs. The costs, other than labour or materials, that are directly attributable to the making of a company's product, for example factory related expenses.

other indirect costs. Expenses that cannot be attributed to the making of a specific product. Examples are depreciation on a plant in which many products are made, utility and heating expenses, or delivery fleet lease payments and maintenance costs.

overhead. The costs associated with non-electricity producing operations.

owner's equity. The ownership interest in a business enterprise.

outage budget. The co-ordination of resources and expenditures solely related to an outage.

outage costs. The expenses solely related to a periodic refuelling outage.

parent company. The company that owns more than 50% of the voting stock of another company.

payback period. Annual revenue less all expenses including taxes (but not book depreciation or return) divided by the initial capital expenditure to determine the number of years required to equal or pay back the initial capital expenditure.

performance measurement. The process of measuring results against the desired state.

planning. Developing a road map that directs one's business strategy and how it is intended to achieve or realize that strategy.

present value. The discounted value of future cash flows.

pretax earnings. The earnings left after the addition of operating income to non-operating income (e.g. the interest earned on loads) and then deducting non-operating expenses, such as extraordinary costs, but not taxes.

price-earnings ratio. The market common stock price divided by the annual earnings per share of the common stock. The market price used may be a spot price, or an average of the closing or the high and low prices for a period, and the earnings are for the corresponding period.

prior period. A preceding accounting period.

production cost. The costs assigned directly to the production of electricity. The electric generation production cost equals the O&M cost plus the fuel expense. It is normally expressed in cents/kW·h.

ratio. A numerical relationship that compares one magnitude with another in the form of a multiple, such as 2:1. The multiple may also be expressed as a fraction (2/1), percentage (200%) or rate (2 per 1).

receipt. A cash amount received by a company.

retained earnings. The unit of currency amount of assets furnished by the earnings of a company that are not distributed as dividends.

return. This represents the money required annually to compensate security holders for the funds provided as invested capital for a plant's facilities. It consists of interest on debt, dividends on preferred stock and earnings on common equity. The return element is variable, being greatest initially and then declining over the years because a fixed cost of money, or rate of return, is applied annually to the net plant value (total plant value less accumulated depreciation). To adjust for the variability of this component, present worth techniques are employed to obtain an equivalent constant, annual return.

return on equity. The profit earned for each unit of currency of shareholders' equity.

return on investment. Annual revenue less all expenses including taxes and book depreciation but not return, divided by the investment required.

return on net assets. The profit earned on each unit of currency invested in assets.

revenue. The receipts from the sale of goods and services.

revenue recognition. Revenue is reported in the fiscal period in which a sale is made (or a service is provided) regardless of whether cash is collected from a customer or a customer still owes for the merchandise (or service).

return. The price change plus dividend or coupon income on an asset. Return equals unity plus the rate of return on the asset, that is a return of US $10 on a US $100 investment equals a rate of return of 10%.

self-assessment. A periodic review conducted by a site or company to compare the overall results with the expected results. Sources of information included in a self-assessment may be management comments, employee interviews, reviews of plant events and trends, external assessments of other companies, independent assessments and benchmarking. The goal of self-assessment is to evaluate the present direction of a business with regard to nuclear safety, shareholder value and corporate stewardship.

statement of cash flows. A statement that reports all the changes that have occurred in a balance sheet during a fiscal period that either provide or use cash.

station use (generating). The kilowatt-hours used internally at an electric generating station for purposes other than sale. Station use includes electric energy supplied from house generators, main generators, the transmission system and any other sources for this purpose. The quantity of energy used is the difference between the gross generation plus any supply from outside the station and the net output of the station.

statistical forecasting. Projecting a time series.

stock. A piece of paper that certifies the ownership of a fraction of a firm.

stranded investment. The net plant investment held by the owners of a facility at the time when de-regulation (restructuring) takes place. 'Stranded' implies an inability to recover the investment over the original amortization period.

strategy and planning. Strategy identifies the future business direction and goals. The key objectives in strategy are to employ company strengths to take advantage of business opportunities, while avoiding business threats created by company weaknesses. Planning refers to business planning or the objectives and methods anticipated to implement the strategy.

technical leverage. Using the relationship available among various information tools (i.e. intranets, Microsoft Access, etc.) to gain and/or communicate valuable insights into a business.

total sales. The total sales less allowances for returns and bad debt. Same as sales.

transaction cost. The cost associated with buying or selling assets.

trend. A long term movement, either upward or downward.

unit of measure. The currency used in financial statements. For US companies the unit of measure would be the dollar, unadjusted for inflation or deflation.

variable expenses. Expenses that fluctuate with the level of production.

watt. The electrical unit of power or rate of doing work. The rate of energy transfer equivalent to one ampere flowing under a pressure of one volt at unity power factor. It is analogous to horsepower or foot-pounds per minute of mechanical power. One horsepower is equivalent to approximately 746 watts. One thousand watts delivered for one hour equals one kilowatt-hour. Similarly, one million watts delivered for one hour equals one megawatt-hour.

working capital. The amount of cash or other liquid assets that a company must have on hand to meet the current costs of operations until such a time as it is reimbursed by its customers. Sometimes it is used in the narrow sense to mean the difference between current and accrued assets and current and accrued liabilities.

Annex V

IAEA POWER REACTOR INFORMATION SYSTEM DEFINITIONS

commercial operation. The date when a plant/unit is handed over by the contractors to the owner and declared officially to be in commercial operation.

energy availability factor. This is defined as the ratio of the available energy generation (net) over a given time period to the reference energy generation (net) over the same period, expressed as a percentage. Both of these energy generation terms are determined relative to reference ambient conditions.

energy generation (net). The electrical energy produced under reference ambient conditions during a given time period as measured at a unit's outlet terminals, that is after deducting the electrical energy taken by unit auxiliaries and the losses in transformers, which are considered integral parts of the unit.

external energy loss (energy loss owing to causes external to the plant). The energy that was not produced during a period owing to constraints external to a plant. These constraints are those considered to be beyond the control of a plant's management.

grid connection. The date when a plant/unit is first connected to an electrical grid for the supply of power.

load factor. This is defined as the ratio of the net energy generation during a given time period to the reference energy generation (net) during the same time period, expressed as a percentage. Both of these energy generation terms are determined relative to the reference ambient conditions.

operation factor. The ratio of the number of hours a unit or station is on-line to the total number of hours in a reference period, expressed as a percentage. It is a measure of the unit time availability and does not depend on the operating power level.

planned energy loss. The energy that was not produced during a period because of planned shutdowns or load reductions owing to causes under the plant's management's control. Energy losses are considered to be planned if they are scheduled at least four weeks in advance, generally at the time when an annual overhaul, refuelling or maintenance programme is established. Planned energy loss is expressed in units of megawatt-hours.

plant codification. Used in the IAEA's PRIS codification for reactors in operation and under construction.

reference energy generation (net) or maximum generating capacity. The energy that could be produced during a given time period if a unit was operated continuously at a reference unit power (net) under reference ambient conditions throughout the time period.

shutdown. The date when a plant/unit is officially declared to be shut down by the owner and taken out of operation permanently.

unplanned capacity loss factor. This is the ratio of the unplanned energy losses during a given period of time to the reference energy generation, expressed as a percentage.

unplanned energy loss. The energy that is not produced during a period because of unplanned shutdowns, outage extensions or load reductions owing to causes under a plant's management's control. Energy losses are considered to be unplanned if they are not scheduled at least four weeks in advance. Unplanned energy loss is expressed in units of megawatt-hours.

unit capability factor. The ratio of the available energy generation (net) over a given time period to the reference energy generation (net) over the same period, expressed as a percentage. Both of these energy generation terms are determined relative to reference ambient conditions.

CONTRIBUTORS TO DRAFTING AND REVIEW

Abraham, E.	Gerencia Centrales Nuclear, Mexico
Altshuller, M.	VNIIAES, Russian Federation
Bhasin, B.K.	Nuclear Power Corporation of India, Limited, India
Cadavid, M.	Ministry of Basic Industry, Cuba
Daguer Abraham, E.	Laguna Verde Nuclear Power Plant, Mexico
Danielsson, H.	Forsmarks Kraftgrupp, Sweden
De Mella, J.	Electric Utility Cost Group, United States of America
Gilbert, J.V.	Nuclear Energy Institute
Glorian, D.	Electricité de France, France
Han, T.-S.	KEPCO, Republic of Korea
Huddleston, J.	Southern Company Services, Inc., United States of America
Hwang, D.-C.	KEPCO, Republic of Korea
Ibañez, M.	Asociación Española de la Industria Eléctrica, Spain
Jin, H.	Ulchin Nuclear Power Plant, Republic of Korea
Jordanov, J.	National Electric Co., Bulgaria
Kang, H.-W.	KEPCO, Republic of Korea
Kiss Zoltanne, L.	Paks Nuclear Power Plant, Hungary
Lemaitre, J.-L.	Electricité de France, France
Mandula, J.	Dukovany Nuclear Power Plant, Czech Republic
Marlisa, R.	GKN, Netherlands

McKenzie, R.	AECL, Canada
Messer, C.	Programming Plus, United States of America
Pleskac, T.	Dukovany Nuclear Power Plant, Czech Republic
Richwine, R., Jr.	Southern Energy, Inc., United States of America
Russ Fernandes, S.	Electrobras Termonuclear S.A., Brazil
Sebastian, I.	Nuclear Power Corporation of India, Limited, India
Semenova, L.	National Nuclear Generating Co., Ukraine
Semmoloni, O.	Atucha Nuclear Power Plant, Argentina
Solomon, S.	Nuclear Energy Institute
Spiegelberg-Planer, R.	International Atomic Energy Agency
Thomas, S.	University of Sussex, United Kingdom
Turner, D.G.	CANDU Owners' Group, Canada

Advisory Group Meetings and Management Workshops

Vienna, Austria: 13–16 October 1997

Consultants Meetings

Vienna, Austria: 21–25 April 1997, 26–29 January 1998, 30 November–3 December 1998, 10–14 May 1999, 17–19 November 1999