SUMMARY OF PRESENTATIONS

1. Current Nuclear Power Outlook

Trends in the world's population and energy use during the past century show dramatic and relatively parallel increases. The demand for electricity is expected to increase more rapidly than the demand for other forms of energy and nearly double by 2020. This worldwide growing energy demand and the rising concern of climate change has led to the need for the production of significant amounts of safe and clean energy, which in turn favours the nuclear option.

The strategic importance of considerations such as security of energy supply, environment safety, instability of fossil fuel prices, and limited availability of energy resources, along with the concerns regarding global climate change have a great impact on the choice of future electricity production technologies. In this context, nuclear energy seems to be a reasonable option since it produces insignificant life cycle emissions, uranium resources are well distributed around the world and sufficient to support the projected demands and the fluctuations in the cost price of produced electricity are minor.

According to the latest projections of the International Atomic Energy Agency, which are based on the information provided by the Member States, nuclear power will continue to play a major role over the next several decades. Nuclear energy is one of the few large scale alternatives capable of supporting reductions in global greenhouse gas emissions while meeting growing energy demands.

There has been a two prong-approach to the expansion of nuclear power. On the one hand, countries with existing nuclear power programmes have made a effort towards making the most of their current nuclear assets by capitalizing in many years of operational excellence, as well as by extending and optimizing their operational life. On the other hand, and despite these life management efforts, there is a clear need to eventually replace current nuclear capacity and also to meet increased energy demand in an environmentally sound manner by building new nuclear power plants.

2. Nuclear Deployment Challenges and Solutions

Nuclear energy is a mature technology that is expected to play an expanded role in meeting the growing demand for electricity in a safe and economic manner without contributing to global climate change. Water Cooled Reactors will be the preferred nuclear technology for many newcomer countries, and it is expected that they will continue to be the cornerstone of the nuclear industry for the remainder of the 21st century and beyond.

Many Member States, especially developing countries, are interested in the deployment of new nuclear power plants, due to the limited availability of natural resources, relatively high population growth and high energy demand for economic development. Prior to the deployment or the expansion of a nuclear power programme, there are many challenges to be addressed related to infrastructure development, human resources, public acceptance, power grid stability, legal and regulatory aspects, financing and so on. The papers presented during the conference covered several of these issues, with particular emphasis on the challenges associated with nuclear project financing and human resources development.

Several countries presented the historical evolution of the development of their nuclear power programmes including best practices and lessons learned that could be effectively applied in other countries. These experiences are consistently gathered by the IAEA and appropriately incorporated in IAEA’s guidance documents and support programs for both newcomer countries and countries with existing nuclear programmes to ensure continuous improvement during the launching and expansion of nuclear power programmes.

3. Design and Construction of Advanced Water Cooled Reactors

To support the future role of Water Cooled Reactors substantial design and development programmes are underway in a number of Member States to incorporate additional technology improvements into advanced nuclear power plant designs. One of the key features of advanced nuclear reactor designs is their very high level of safety due to a reduction in the probability and consequences of accidents and to an increase in the operator time allowed to better assess and properly react to abnormal events. The need for additional efforts, however, was identified in several areas such as the development of advanced materials and reliable components able to support longer plant lifetimes and more demanding working conditions, the optimum balance in the use of active and passive safety systems, the effective use of alternative fuels and advanced fuel designs and the attainment of higher conversion rates in Water Cooled Reactors.

In addition to their improved safety, most advanced Water Cooled Reactor concepts have also achieved improved economics and performance by 1) decreasing construction costs through the optimization of conventional construction methods and the effective incorporation of recent advances in construction technologies; 2) shortening construction schedules by using prefabrication, modularization, very heavy lift cranes, etc, while increasing quality; 3) applying modern information technologies and 3D simulations during the design, construction, commissioning and operation of new nuclear plants, 4) improving plant availability by enhancing operability and maintainability; and 5) increasing design plant lifetimes up to 80 years .

The suppliers for most of the advanced Water Cooled Reactors currently available in the market presented their key technical features and specifications. Some of the design features available in many advanced reactor concepts include: a 60-year design life, four-train safety systems, more than 90% availability factors, full digital control systems, double containment with external impact protection, and corium retention and stabilization systems. Concerns associated with the harmonization of licensing requirements as a necessary step towards true design standardization were also discussed.

In response to doubts regarding the ability to deploy these Water Cooled Reactor concepts at large scale in the short term, each reactor designer explained that relationships with component supply vendors would be established in a timely fashion. These relationships would ensure that procurement can be managed within the constraints of the critical path. While vendors have been established for recent international nuclear construction projects, to deepen the connection between nuclear steam supply system (NSSS) vendors and component suppliers, and ensure that all necessary controls are in place when construction begins, the NSSS suppliers plan to establish the necessary relationships and work with the component supply vendors while completing detailed engineering.

4. Safety and Performance Achievement in Current Nuclear Power Plants

For Ageing and Plant Life Management (PLiM) programmes to achieve their full potential, it is required that they are based on the current state of science and technology and thus benefit from results based on experience, lessons-learned and advances in the understanding of materials and human behavior. Continuous research is essential to enable existing and future nuclear power plants to benefit from advances made in materials selection, treatment and component fabrication methods.

To ensure the safety and performance of existing nuclear power plants, most facilities have implemented plant life management programmes consistent with their strategic plan and their overall goals, objectives, and commitments. These plant life management programmes should be established as a set of plant-specific guidelines and generic requirements based on the periodic safety reviews issued by the IAEA or referring to commonly accepted regulatory practices such as generic aging lessons learned and standard review plans issued by the US NRC. An effective plan life management programme determines what systems need to be analyzed, what systems can be maintained, the priority order of the systems to be modernized, how the systems should be modernized, etc.

Based on the best practices, nuclear power plants should be improved continuously rather than through one-time major investments. A strong safety culture and a proactive attitude are key assets for a successful PLiM implementation. The latest safety requirements and the current licensing basis should be considered for continuous operation.

Continued training, education and knowledge management are essential to ensure the continuous improvement in safe and reliable operation of nuclear power plants. As nuclear power plant personnel retire, succession planning for recruitment of new personnel is a vital management task. Attracting and retaining talented and highly motivated young professionals through mentoring and other recruitment methods is essential. Furthermore, such personnel must be empowered with adequate knowledge and be able to recognize career growth possibilities as an incentive to remain in the nuclear industry.

5. Advanced Technology Applications

The experience gained during many years of successful operation of conventional Water Cooled Reactors constitutes an excellent source of knowledge that has been used to design the evolutionary Water Cooled Reactor concepts currently on the market, through optimization and incorporation of small or moderate modifications. However, innovative designs incorporate radical conceptual changes that would normally require a prototype or demonstration plant before commercialization.

One of such designs is the supercritical water cooled reactor (SCWR), currently under consideration by the Generation-IV International Forum (GIF). The high international interest in the SCWR arises from the high thermal efficiencies (44-45%) and improved economic competitiveness promised by this concept, utilizing and building on the recent developments of highly efficient fossil power plants. But there are still some challenges such as; the selection of corrosion resistant materials for the core components, and the specification of suitable water chemistry conditions. In addition, research and development is needed in some areas such as thermal-hydraulics and safety system design to extend the range of existing data to supercritical conditions. Several papers discussed the various efforts and SCWR reactor concepts currently being explored in many countries. Other revolutionary ideas, such as the High Pressure Boiling Water Reactor, the use of nanofluids as coolants in nuclear safety systems and a roadmap for the utilization of existing Pressurized Water Reactors in a sustainable Thorium-Uranium breeding cycle were also presented.

Several small and medium size Water Cooled Reactor designs were presented, such as the Argentinian CAREM, the Brazilian FBNR (Fixed Bed Nuclear Reactor), the VK-300 from Russian Federation, and the International Reactor Innovative and Secure (IRIS), which is an international project led by Westinghouse. Many of these concepts take advantage of passive safety systems thus resulting in more simplified reactor designs while maintaining the same or higher levels of safety. These small and medium size reactors can also be coupled with non-electrical applications such as desalination or cogeneration facilities. In addition, other advanced applications that take advantage of water cooled reactors for hydrogen production, oil sands development or other innovative cogeneration applications were introduced during the conference.

6. Safety Assessment of Nuclear Power Plants

Given the importance of safety for the operation of existing and future Water Cooled Reactors, the conference included a special technical session on Safety Assessment. It was recognized that an accident anywhere is an accident everywhere, and as a consequence it is in every Member State's interest to participate in international nuclear safety instruments and conventions, and in international arrangements for the establishment of networks to share knowledge and to collaborate on safety matters. For newcomer countries, the need to establish an adequate legal and regulatory framework as well as a strong and independent regulatory authority was emphasized.

The main purpose of the nuclear safety analysis is to guarantee protection against any harm due to nuclear plant operation to the people and the environment. The nuclear safety analysis determines the structures, systems and components needed to minimize radiological risks that are to be established and maintained for operation under normal and abnormal conditions. The safety assessment and improvements are primarily driven by the evolution of technology, feedback from operating experience, new research findings and evolving regulatory requirements. One of the key features of advanced Water Cooled Reactor designs is their improved safety due to a reduction in the probability and consequences of accidents and to an increase in the operator time allowed to better assess and properly react to abnormal events.

It can be concluded that, safety analysis as a knowledge framework will continue to be important in supporting nuclear operations, not only for existing reactors, but also for advanced Water Cooled Reactors. In order to face the more demanding analytical needs of the next generation of reactors, more detailed codes, models and methods will be necessary, although still based on, or not very different from the current state of the art technology for nuclear engineering.

7. Instrumentation & Control (I&C)

Various subjects were addressed during the technical session and panel discussion on Instrumentation and Control. As the technologies develop and mature, the modernization of I&C systems has been pursued at all levels of the nuclear industry. Advanced monitoring and diagnostic technologies play an important role in PLiM programmes and safety and security of nuclear power plants. It has been recognized that the effort needed to maintain or increase the reliability and useful life of existing I&C systems may be greater in the long run than that of modernizing I&C systems or replacing them completely with new digital systems.

First of all, digital I&C systems have been developed and are in the process of being adopted in existing nuclear plants. Advanced reactor designs already include digital I&C systems. Prototype testing of digital I&C systems for new nuclear power plants and licensing of digital I&C systems used in nuclear safety system is ongoing. Possible common-cause failures in digital I&C systems for safety and wireless communication in diagnostics and monitoring applications were also addressed.

Utilities have used power uprates as a way to generate more electricity from their nuclear plants. New I&C systems were developed to support power uprates and the license of new I&C systems should be renewed. Modernization issues such as the I&C standards were discussed and Field-Programmable Gate Arrays (FPGA) technology and its applications in safety systems were introduced.

Additionally, as the lifetime of current nuclear power plants is extended and long term operation is pursued, issues on I&C cable integrity and qualification of equipment become an issue and were addressed during the conference. New sensing technologies have been developed to support increased monitoring and diagnostics in ageing nuclear power plants. Other interesting subjects such as on-line monitoring for fault detection in instrument channels and processes and reactor noise analysis used for diagnostics were also covered.