Nuclear Power

Objective

To enhance the capability of interested Member States, in a rapidly changing market environment, to improve nuclear power plant operating performance, life cycle management including decommissioning, human performance, quality assurance and technical infrastructure, through good practices and innovative approaches consistent with global objectives on non-proliferation, nuclear safety and security; to enhance the capacity of Member States for the development of evolutionary and innovative nuclear system technology for electricity generation, actinide utilization and transmutation and for non-electric applications, consistent with sustainability goals; and to encourage the improvement of public understanding of nuclear power.

Establishing an Appropriate Infrastructure for Introducing Nuclear Power

In response to growing interest among Member States in the steps necessary to initiate a nuclear power programme, the Agency published a brochure — *Considerations to Launch a Nuclear Power Programme* — that summarized the infrastructure issues associated with the introduction of nuclear power. The brochure was followed by the publication of *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1), which provides a more detailed description of the infrastructure issues to be addressed during each of the three successive phases of the programme's development. Figure 1 lists 19 issues for which the publication describes milestones.

The Agency held a workshop in November in Vienna focusing on the importance of comprehensive infrastructure development to the overall success of a nuclear power programme and its particular impact on reducing investment risks, and on actions that might improve financing prospects. In addition, the Agency conducted several multidisciplinary missions to Member States planning the introduction of nuclear power. These missions have shown that an integrated approach and strong government commitment can help build confidence among the international community in emerging nuclear programmes and can also attract support from others. It is also clear that infrastructure planning must be carried out in the context of a national strategy, taking into account existing institutions, resources and stakeholders. In this regard, under its technical cooperation programme, the Agency provides assistance to Member States which have plans to introduce nuclear power in the preparation of their comprehensive work plans that address issues such as project management, energy planning, safety and legal frameworks, and site evaluation.

Nuclear Power Plant Operating Performance and Life Cycle Management

Three quarters of the world's nuclear power plants are more than 20 years old. Although the typical design life of a nuclear power plant is 30–40 years, it is possible to extend design lives to 60 years, and perhaps longer. Plant life management programmes help operators plan in advance for the challenges of modernization, refurbishment and maintenance. In addition to extending plant life, a number of operators are also uprating the power level at which plants are operated. In this regard, the Agency's second international symposium on 'Nuclear Plant Life Management', held in Shanghai in October, served to exchange information between experts from different countries and organizations dealing with operations and nuclear power plant components. The participants emphasized that the effects of extended operations and power upratings on power plant systems, structures and components must be continually reanalysed for safety and for system optimization. Other issues highlighted were the importance of easy access for inspections, and the need for designs that facilitate easy inspections and component replacement.

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Modernization of instrumentation and control (I&C) systems is a major issue for nuclear power plants worldwide. The introduction of digital technologies brings new challenges both in licensing and operation. The Agency held technical meetings on integrating hybrid analogue–digital control rooms, potential common cause failure in digital I&C systems, digital I&C system licensing and I&C

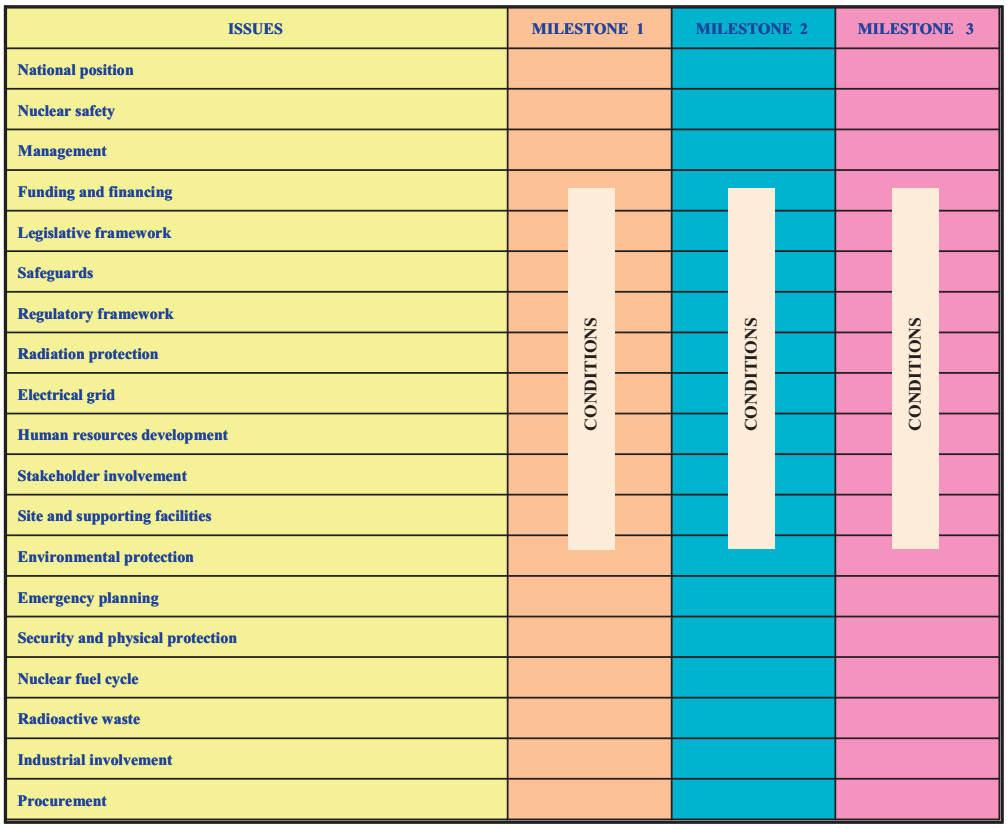

FIG. 1. A diagram from IAEA Nuclear Energy Series No. NG-G-3.1 on the issues and milestones to be considered for the introduction of nuclear power.

modernization for power uprates. Three reports were completed on the role of I&C in power uprating and on-line monitoring for improved performance and component diagnostics. The technical meetings raised awareness of the potential benefits and challenges of using digital I&C systems in functions critical to plant safety, since they significantly improve automation, human–system interfaces, on-line monitoring, nuclear safety, and power production. However, this is a relatively new technology in nuclear power plants, and its application in functions that are critical to plant safety requires significant verification, validation, testing and licensing. The reports detail the benefits of on-line monitoring and offer recommendations on how to take full advantage of these benefits. They also detail, for power uprates, the potentially adverse impacts (e.g. accelerated fatigue, ageing or corrosion effects, or excessive vibration) that need to be analysed in advance and carefully monitored during implementation.

Optimization of nuclear power plant maintenance can lead to improvements in safety, reliability and cost. The results of a CRP involving 13 organizations operating WWER-4400/1000 nuclear power plants were published in *Strategy for Assessment of WWER Steam Generator Tube Integrity* (IAEA-TECDOC-1577). While maintaining high safety levels, the strategy is designed to reduce shutdowns and the number of tubes requiring plugging, improve understanding of tube integrity and speed information sharing. Another maintenance optimization report published in 2007, *Implementation Strategies and Tools for Condition Base Maintenance at Nuclear Power Plants* (IAEA-TECDOC-1551), describes strategies to optimize the scheduling and performance of plant maintenance based on continual monitoring of plant conditions.

The Agency helped enhance equipment reliability in Mexico's Laguna Verde nuclear power plant through a technical cooperation project on modernization of the plant's preventive maintenance programme. As a result of implementing new methods of analysis and preventive maintenance techniques, the plant has seen improvements in safety, reliability and operational costs.

Improving Organizational Performance

A technical meeting was held in March to discuss the new Agency safety standards on management systems and the practical application of integrated management systems. The meeting identified

areas in which the Agency is expected to provide additional support to Member States on how to implement the new set of relevant safety standards. A joint IAEA–FORATOM workshop was organized in November to promote these new standards and to provide information on the transition from a traditional quality assurance approach to an integrated management system.

Technology Development

The Agency's role in technology development is to provide an international forum for the exchange of ideas and information, and to provide training and facilitate technology transfer. These activities are undertaken through technical working groups (TWGs) and CRPs.

The majority of currently operating nuclear power plants are water cooled, and it is anticipated that the near term growth of nuclear power will be based on water cooled reactor technology. The Agency's TWGs on LWRs and HWRs recommended additional work on simulators, and noted progress towards the planning, licensing and construction of evolutionary designs with passive safety features. Innovative systems are under development in several countries. The TWGs also recommended:

— Compilation of information on construction technologies for water cooled reactors;
— Updating of the Agency's status report on advanced LWR designs;
— Preparation of a report on the status of the supply chain for HWRs addressing resources, fuel fabrication, and the supply of heavy water and major equipment.

Following a recommendation of the Technical Working Group on Gas Cooled Reactors, the Agency organized a meeting in Vienna in December to review cost analysis software developed through the Generation IV International Forum (GIF). The meeting concluded that GIF's 'G4Econs' code was the most appropriate software for analysing both electricity generation costs and process heat production costs for HTGRs. As a result, the Agency will: provide training to allow users to perform calculations on a national or regional basis, provide a forum to review the results of those calculations and provide feedback on the lessons learned to the code originators.

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The development of the technical rationale for a nuclear power programme, including the level of local industrial participation, fuel cycle policy and site selection, is an important factor in the decision to set up such a programme. The Agency held a workshop on nuclear power plant technology assessment to discuss assessment approaches and economic evaluation methods, and to share experiences and lessons learned in technology selection.

In cooperation with the Japan Atomic Energy Agency and OECD/NEA, the Agency organized an international conference on 'Non-electric Applications of Nuclear Power: Seawater Desalination, Hydrogen Production, District Heating and Other Industrial Applications', which was held in April in Oarai, Japan. The conference reviewed case studies on applications of nuclear heat for desalination, hydrogen production and enhanced use of fossil fuel resources (e.g. coal liquefaction or enhanced oil recovery from tar sands). In addition, two technical documents on desalination case studies were published.

The Agency carries out studies on small and medium size reactors appropriate for smaller grids, including those in developing countries. A new report entitled *Status of Small Reactor Designs without On-site Refuelling: 2007* summarizes the common design objectives and considerations for reactors that have very long lifetime cores. The report provides information on important development trends and objectives for small reactors, on the state of the art concerning their design and technology development, on their design status, and on possible applications.

Owing to its potential in both closing the fuel cycle and making more efficient use of resources, fast reactor technology and fuel cycles continue to be of great interest. The Agency published a technical report entitled *Liquid Metal Cooled Reactors: Experience in Design and Operation* (IAEA-TECDOC-1569) to preserve the knowledge gained over the past five decades in the development, design, operation and decommissioning of these reactors. With regard to fast reactor fuel cycles, the Agency concluded a CRP on advanced reactor technology options for the effective incineration of radioactive waste, in which the transient behaviour of various transmutation systems was studied. The CRP completed benchmarking exercises focusing

on eight innovative transmutation systems with different critical and subcritical concepts, including critical fast reactors, accelerator driven systems and fusion/fission hybrid systems. The CRP included analyses of neutronics and transient behaviour in systems to incinerate minor actinides.

International Project on Innovative Nuclear Reactors and Fuel Cycles

At the end of 2007, the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) had 28 members, and two additional countries had announced their intention to join. Seven volumes of the INPRO *Methodology Manual* were published, providing recommendations on the application of the methodology in such areas as economics, the environment, infrastructure, waste management and proliferation resistance. The methodology is being used in assessments in a number of Member States and by the European Commission. A joint assessment of a closed fuel cycle with fast reactors is being conducted by various Member States. The July 2007 meeting of the INPRO Steering Committee approved 14 collaborative projects on nuclear power for small countries, nuclear fuel cycle issues, environmental impacts, safety issues, proliferation resistance, non-stationary nuclear power plants and the architecture of future innovative nuclear systems.

A workshop held in November in Vienna reviewed common user expectations for nuclear power plants among interested developing countries. It discussed future activities in line with the INPRO objective to be a forum for joint deliberations by technology holders and users. The workshop report addressed the technical and economic characteristics of nuclear plants to be deployed by developing countries, and of associated activities such as fuel cycle options, services and support.