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Nuclear Power Newsletter

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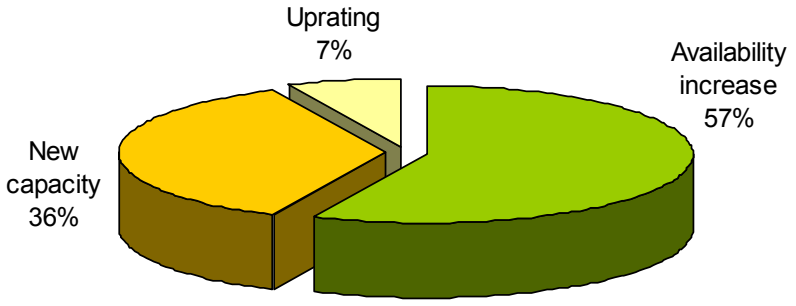
FACTORS CONTRIBUTING TO INCREASED NUCLEAR ELECTRICITY PRODUCTION: 1990-2004

Nuclear electricity production has grown almost continuously since the nuclear industry's inception. Part of this growth is due to building new nuclear power plants, part is due to uprating existing plants, and part is due to energy availability improvements at existing plants. Since the beginning of the 1990s, when new construction slowed, energy availability improvements and power uprates have become, at the global level, increasingly important factors in expanding nuclear electricity production.

The purpose of this report is to quantify the contributions of the three different factors to the growth in nuclear electricity production during the last fifteen years.

Fig.1: Contributions to nuclear production growth

1990-2004



From 1990 through 2004, global nuclear electricity production increased from 1901 to 2619 TWh, and available energy production grew from 2054 to 2679 TWh.[1]

[1] Available energy production is essentially the electricity that would be produced if plants were to always produce whenever they could, i.e. if there were always the necessary demand for electricity when plants are up and ready to produce it. Since most nuclear power plants supply baseload electricity, actual electricity production is usually very close to available energy production. But if nuclear plants are sometimes used for load following, as in France, or if there are grid limitations, actual production will be less than available production.

Installed nuclear capacity rose from 327.6 to 366.3 GW(e) due to both new construction and uprates at existing facilities, and the global average energy availability factor improved from 71.6 to 83.3%. The relative contributions of the three factors to the additional 625 TWh available in 2004 (compared to 1990) are shown in Fig. 1. Improved energy availability factors were the leading contributor, accounting for 57% of the increase. Next in importance was new construction (36%) and, finally, uprates (7%).

The results presented in Fig. 1 are based on the comprehensive worldwide data in the IAEA's Power Reactor Information System[2]. PRIS also includes data on trends in individual and average load factors (LF) for nuclear power plants. Load factors are easier to calculate and sometimes intuitively easier to work with than availability factors because LF is simply a plant's actual production divided by its 'reference energy generation', i.e. what it would produce if run full-time at its rated power level. But, because of this, load factors are affected by load following, grid restrictions or periods of operation above the reference level. To eliminate these influences, the results presented in Fig. 1 are based on the Energy Availability Factor (EAF), defined for each nuclear power plant as the plant's reference energy production minus energy losses due to plant unavailability, divided by its reference energy production. Comparable calculations based on load factors provide essentially the same conclusions – increased availability has been most important over the last 15 years, then new construction and then power uprates.

In Fig. 2 the red bars show the growth in global nuclear electricity production since 1990 (measured against the right scale). The green bars show the growth in available energy production, also measured against the right scale, while the orange bars show the growth in installed capacity measured against the left scale.

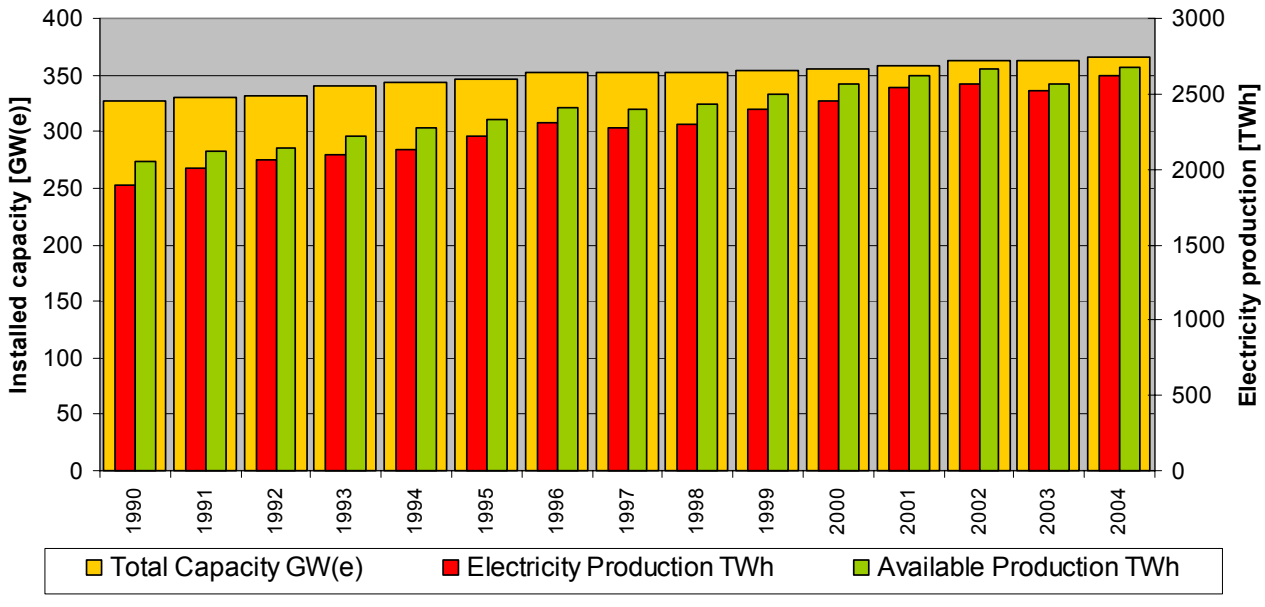
Further improvements in availability

The annual improvement in the global EAF from 1990 to 2004 averaged 0.9% per year. Currently, the global EAF average EAF is over 83% and more then half the world's units operate with an EAF over 86%. As EAFs improve and approach the ceiling of 100%, each incremental improvement becomes ever more difficult and expensive. But there is still plenty of room for improvement. Using the performance of the world's ten best performers over the last five years to define a practical limit yields a value slightly over 96%. If the worldwide EAF average energy availability factor reached this value, the result would be an additional 413 TWh of available electricity, i.e., 15% of the 2004 total.

The main factors contributing to improvements in reactor availability are:

- The elimination of unplanned energy losses through effective failure prevention (root cause analyses), on-line preventive maintenance, timely indications of equipment degradation, and the implementation of concurrent design improvements.

Fig. 2: Trend of installed capacity and available production



[2] http://www.iaea.org/programmes/a2/

- The reduction of planned energy outages through fuel cycle extensions, effective management of refueling and maintenance outages, and risk oriented maintenance.
- The continuing exchange and dissemination of operating experiences.
- Additional consolidation in the nuclear industry such that more plants are operated by those who do it best.

Prospects for power uprates

Based on PRIS data, total uprates between 1990 and 2004 workout out to 5.9 GW(e). This increase, however, is a global aggregate that hides important regional differences. In particular, power uprates have proved most significant in countries where the construction of new units has stagnated for a long time.

There are three main ways to increase a unit's rated power: (1) implementing enhanced techniques for parameter measurement and reactor power calculations (this uprate is usually less than 2%), (2) utilising design capacity margins, so called "stretch power uprates", which involve changes in instrumentation setpoints and the installation of more efficient equipment but do not involve major plant modifications (the usual uprate is up to 7%), and (3) extended uprates that require significant modifications to the main plant equipment and can increase reference unit power by up to 20%.

For the immediate future, taking into account the increasing cost and difficulty of continuing availability improvements, and the processes underway for extending operating plant licences, it is likely that power uprates will contribute more than they have in the recent past to future increases in total nuclear power production. Contact: J.Mandula@iaea.org.

Message from the Director

Welcome to the 3rd Newsletter from Nuclear Power Division for 2005

I have noticed that this year staff from the Division have visited 32 different Member States in support of Technical Cooperation or Regular Budget projects. Of these 32 Member States, 10 were Member States which currently do not operate nuclear power plants, which is an indication of the increasing international interest in Nuclear Energy as a source for electricity or for desalinated water supplies. We expect that this involvement, in particular to assist developing countries, will continue and we look forward to supporting this growing interest in nuclear power with due care to safety, security and non-proliferation.

Our cover story provides an indication of the tremendous success of the operation of nuclear plants over the last ten or so years. Improved availability from existing plants has become the leading factor in the growth of electricity production from nuclear power. In several Member States power upgrades have also provided a significant increase in the available electricity supply. For the coming several years the extension of operating licenses and the demonstration of the safe and reliable operation will provide the major global impact upon the nuclear supplied electricity. Beyond that, the expectation is that a considerable growth in new plants built will drive the further expansion of electricity production as some countries expand their nuclear capacity (Examples are the reported ambitious plans by China to expand 6 fold and by India 10 fold both by 2020) and other countries decide to adopt nuclear power. I would like to encourage you to pay attention to the PRIS (Power Reactor Information System) because the above information was compiled by use of the PRIS information accessible on the public domain information.

Now as we look ahead at our activities, I think our Division needs to address, on one hand, what actions to be taken in support of the potentially emerging "Nuclear Renaissance" (as was indicated by the Paris Ministerial Conference and other information coming from various sources). On the other hand, we need to define clearly what we provide in response to the Member State's requests for timely professional support. I also feel we need to establish a well structured document system by bringing in structure and hierarchy to the various technical documents which our Division produces. I will continue to inform you by the use of this Newsletter, of the evolution of such activities. A.Omoto@iaea.org.

Nuclear Power Plant Operating Performance and Life Cycle Management

Continuous Process Improvement of NPP Operation

The **20th Meeting of the IAEA Technical Working Group on Nuclear Power Plant Control and Instrumentation** (TWG-NPPCI) was held on 23-25 May 2005 in Vienna. The objective of the meeting was to discuss current issues of instrumentation and control (I&C), to evaluate on-going programmes, to address new emerging challenges, and to make recommendations for future IAEA I&C programmes. Country reports on the national experience of Member States were also presented. Representatives from 24 Member States of the TWG and three international organizations attended the meeting.

The Technical Meeting on **On-line Condition Monitoring of Equipment and Processes in NPPs**

Using Advanced Diagnostic Systems was held on 27-30 June 2005 in Knoxville, Tennessee, USA. 84 experts from 19 countries attended the meeting, and 34 papers were presented. The program included a technical tour to the Oak Ridge National Laboratory (ORNL) and the Spallation Neutron Source (SNS) facility. The meeting was also used to initiate a TECDOC on the subject and to produce its outline. Contact: O.Glockler@iaea.org.

A consultancy meeting on Strategies to **Optimise Operation and Maintenance Costs** was held on 19-21 July in IAEA Headquarters to review the first second draft of the report on Strategies to optimize operation and maintenance costs, to provide comments and suggestions and also to provide additional information, particularly examples on developing and implementing such methodologies. The overall consensus of the participants was that the document meets the objectives set out in the Terms of Reference and once the document has been completed with all additional information and revised to address all comments, it should be published by the IAEA as soon as possible. The participants endorsed the recommendations made in the TM held in December 2004 on the same subject. Contact: M.Condu@iaea.org.

Integrated NPP Life Cycle Management

The first Research Co-ordination Meeting for the Coordinated Research Project (CRP) on **Master Curve Approach to Monitor Fracture Toughness of RPVs in Nuclear Power Plants** was held on 11-13 May at KFKI Atomic Energy Research Institute in Budapest, Hungary. A new CRP is a follow-on to previous successful CRPs on resolving technical issues associated with application of the Master Curve (MC) approach to RPV integrity assessment. New CRP topic areas to be investigated were discussed and defined for measuring dynamic fracture toughness on specimens as follows; 1) Constraint/geometry effects; 2) Role of MC shape in evaluation, and 3) Evaluation and use of MC data generated under dynamic loading conditions including development of standardized test methods.

The consultancy meeting to **develop guidance document for principles and guidelines on plant life management for long term operation of Light Water Reactors** was held from 23 to 24 May 2005 at Paks nuclear power plant in Hungary. The purpose of this consultancy was to finalize the extended technical documents. The final version of documents was sent to publication committee for pressing. This document provides utilities, operators and regulators with a comprehensive state of the science and technology overview of the main issues concerning safe, long term operation, ageing management and the basic economical aspects concerning PLiM. Contact: K.S.Kang@iaea.org

On June 7-9, 2005, the Technical Meeting on **preparation of a TECDOC on Strategies and Tools for Predictive Maintenance** was held at the VIC. There were 10 experts from 6 Member States and one international organization (EU JRC) attending the meeting. The 6 presentations on NPP maintenance related work were delivered and the whole text of the 105-page document was reviewed, discussed, and revised section by section. Five cases of best industrial practice (from EdF, AECL, EU, KPEC and DNMC, respectively) were added to the document as Appendices. The final title of TECDOC is *Implementation Strategies and Tools for Condition Based Maintenance*. More text changes will be introduced based on the feedback from the participants. The next draft is scheduled to be finished in October 2005. Contact: H.cheng@iaea.org.

Improving Quality Management System, Technical Infrastructure and Human Performance

Quality Management System

A consultancy meeting on **general safety requirements – resolution of the Member States' comments on draft safety requirement** *DS338* was held on 19-21 July in IAEA Headquarters to review and resolve the comments submitted to the Agency on DS338 by the Member States; and finalize the 8th draft of DS338 for submission to the Safety Standard Committees (NUSSC, RASSC, TRANSSC and WASSC) and CSS (Commission of Safety Standards) for final approval. Based on entire review of all the comments of the Member States, the Consultancy Meeting concluded that: Draft 7a for DS 338 was complete and that it addresses the comments of the Member States; and Appendix I can be issued by the Agency as a Safety Guide that would be responsive to the advice from the Member States.

A consultancy meeting on **the second review of the Safety Guide on Management Systems for Nuclear Facilities, DS349** was held on 7-9 June in IAEA Headquarters to review the second draft and produce the third draft of the new Safety Guide on Management Systems for nuclear installations; and identify any additional information as necessary in order to improve the version of DS349. As results of the review, a number of actions were established and the responsible persons assigned these actions, which should be completed by the agreed timescales in order to enable the next draft of DS349 to be produced. Contact: C.R.Clark@iaea.org, P.Vincze@iaea.org.

Strengthening National and Regional Nuclear Power Infrastructures

1. Technical Issues that Influence the Socio-economic and Environmental Implications of Decisions on Operation

The first draft of a guidance document, directed to provide to the management of nuclear utilities with information relevant for negotiating regulatory, financial and strategic planning in case of the early closure or continued NPP operation, was reviewed at a Consultants' Meeting held in Vienna from 4 to 6 July 2005. Recommendations for revising and completing the document were provided. The draft will be complemented with a simplified modelling with techniques for evaluating issues including profitability/net present value of alternatives, replacement energy costs when applicable, employment effects and environmental costs. The final draft ready for publication is planned by the end 2005.

2. Nuclear Power Infrastructure

The preparation of the first draft of a technical document directed to provide guidance on the potential for **sharing of nuclear power infrastructure** among countries adopting or extending nuclear power programme, was initiated. This guidance will cover the subject areas where sharing of infrastructure could be possible during stages of nuclear power project life cycle. The guidance will be consistent and developed in parallel with the document on guidance on **minimum infrastructure** necessary to enable Member States to adopt nuclear power, currently under development. The final drafts for both documents are planned to be ready by the end 2005. Contact: N.Pieroni@iaea.org

A Technical Meeting on **infrastructure needed for nuclear power implementation**, scheduled in Vienna, 05-09 December 2005, is under preparation. The meeting will review and finalize three guidance documents currently in development, which cover the following areas: 1) Human resources management and training/education programmes for the next generation of NPPs; 2) Minimum infrastructure necessary to enable Member States to adopt nuclear power, and 3) Potential for sharing of nuclear power infrastructures. About 50 specialists from more than 30 Member States are expected to take part in the meeting. Contacts: T.Mazour@iaea.org; N.Pieroni@iaea.org.

3. Delayed Nuclear Power Plants

Following requests from Member States and a need to support delayed NPP projects, a review is being performed as to future work on this subject. The preparation of an IAEA Regional Workshop on **Problems and Solutions in Managing Delayed Nuclear Power Plants Projects**, scheduled 7-11 November 2005 in Constanta Mamaia, Romania, was initiated. This activity is performed under the TC programme RER/4/027 directed to strengthening capabilities for NPP performance and service life, including engineering aspects. The Workshop's technical programme includes topics related with strategies for restarting of delayed NPP projects, concepts for financing, impacts regarding erection and commissioning activities, as well as status of delayed NPP projects. Envisaged participants are senior managers or his/her designated representatives, directly responsible for the

delayed NPP activities in nuclear utilities, design, technical support or regulatory organizations. At the present time **TECDOC-1110 on management of delayed NPPs** is available to Member States. Contacts: A.Cardoso@iaea.org; N.Pieroni@iaea.org.

Effective Training to Achieve Excellence in Human Performance

A technical meeting to review and further develop a technical document on **Authorization of nuclear power plant control room personnel: methods and practices with emphasis on the use of simulators** was held from 13-16 June 2005 at the IAEA Headquarters. Eighteen Member States provided comprehensive responses to the IAEA questionnaire before the meeting. During the meeting, the representatives from fifteen Member States actively exchanged their experience through presentations and working level discussions. Draft technical document was reviewed and mutually agreed. In addition to the summarized practices of authorization, reflected in the main body of document, about 45 actual documents (regulations, procedures, guidelines, job aids) will be included on the accompanying CD-ROM. This would be a good source for the use by the Member States' interested regulatory bodies and operating organizations. From the IAEA side, it is a joint effort and good example of cooperation between two divisions, Nuclear Power and Nuclear Installation Safety.

A number of activities has been conducted in the field of **Assistance to Operation Organizations in New Training Activities for NPP Decommissioning** (a workshop at the Ignalina NPP, Lithuania, for the Ignalina and Chernobyl nuclear power plants' personnel, a consultants' meeting at the IAEA to further develop a new technical document in the field of training for

decommissioning, the finalization of training materials for Kozloduy NPP). The specialists from Bulgaria, Lithuania, Slovakia, Spain, Russia, the UK, Ukraine and the USA contributed by their expertise. Activities were performed in cooperation between the NENP, the NEFW, NSRW and Technical Cooperation Department. Contacts: A.Kazennov@iaea.org; T.Mazour@iaea.org.

Technology Developments and Applications for Advanced Reactors

International Collaboration for the Development of Innovative Nuclear Technology

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) has produced first versions of chapters of a manual, which will provide detailed guidance how to apply the INPRO methodology in a quantitative manner. Two examples are presented from different areas of the manual.

The first example deals with the INPRO area of economics. The first step of an economic assessment is the definition of a scenario within a country (or region, or globally). The scenario is used to forecast the growth of total energy demand based on factors such as population growth, increase in living standard, growth of GDP and industrialization, etc. All energy sources available in the area to satisfy the energy demand have to be considered. The result of the first step is the definition of an energy supply plan including the technology options that could be used to meet the demand, such as fossil, hydro and nuclear. For the nuclear option different designs, e.g. LWR, HWR, FBR, GCR, etc need to be taken into consideration.

The next step is the determination of the economic indicators for each of the energy supply options. Such indicators include the levelized discounted cost of energy, the internal rate of return, the investment required to construct the plant. The acceptance limits, which will be established based upon national or regional conditions, are derived from the requirements that an Innovative Nuclear System (INS) must be competitive with the alternatives and thus has to supply power at a competitive cost and represent an attractive investment opportunity.

The final outcome of the economic assessment is comparison of the nuclear option with the available alternatives, including the identification of areas where economic improvements are needed to enhance the competitiveness of the INS.

The figure shows one result from an example economic assessment, for a particular Member State with a plentiful supply of natural gas (NG). The ratio (Nuc/Gas) of the cost of electricity produced by a reference INS and that of electricity from a NG-fired plant is shown as a function of time for a scenario in which the domestic price of gas will increase, driven by the attractiveness of exporting gas for sale on the world market. In this specific scenario in the year 2000, the INS is not competitive with the NG alternative, but it is becoming economically competitive (for two example NG pricing profiles, high and low) by about 2020.

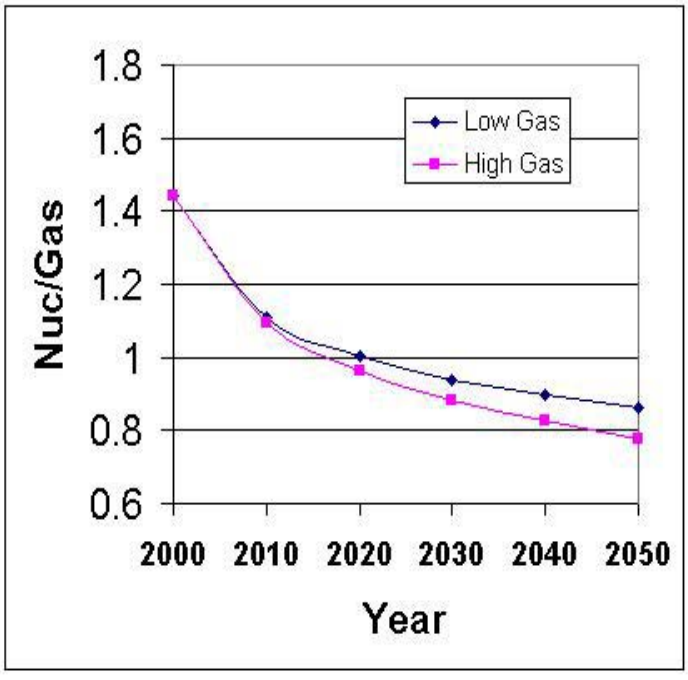
The second example from the INPRO manual deals with the area of safety. In this area the first one of the four Basic Principles reads as follows:

Installations of an Innovative Nuclear Energy System (INS) shall incorporate enhanced defence-in-depth (DID) as a part of their fundamental safety approach and ensure that the levels of protection in DID shall be more independent from each other than in existing installations.

The following is an example of an INPRO User Requirement that relates to DID Level 5:

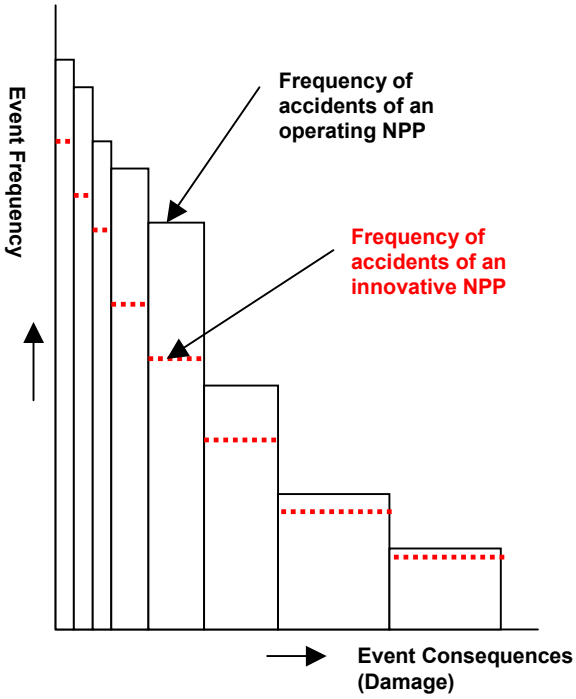
A major release of radioactivity from an installation of an INS should be prevented for all practical purposes, so that INS installations would not need relocation or evacuation measures outside the plant site, apart from those generic emergency measures developed for any industrial facility used for similar purpose.

This is an issue of PSA where the frequency of a major release of radioactivity to the environment is the product of the frequency of major releases into the containment multiplied by the frequency of containment failure. These



numbers will vary for various NPP designs. While in LWR plants similar emphasis is placed on both components, in HTR plants, more emphasis is placed on preventing a release to the containment and less on containment performance.

It is provisionally proposed that the acceptance criteria



INS: Safety Improvements due to Risk Reduction

for INS reactor plant is that the frequency of a major release from the site would not exceed 10^{-6} per annum, or it is practically excluded by design. The overall objective is to ensure that INSs have improvements in release frequencies over the whole range of potential consequences (see figure below).

This example shows the important role of PSA concerning the quantification of Acceptance Limits in the framework of an INS safety assessment. In a similar way, all fourteen URs and associated Indicators and Acceptance Limits have been treated in the Manual.

Moreover, a carefully performed PSA and design review should also demonstrate that, for an INS, the levels of DID are more independent from each other than for existing plants. However, in comparison with existing reactor plants, the input data set for a PSA of an INS is necessarily more uncertain due to less or no plant operating experience, which can lead to some assessment problems.

The INPRO Manual Chapter will provide, inter alia, quantitative information for selected reactor designs that may be useful in the performance of an INS assessment. Contact: F.Depisch@iaea.org.

Small and Medium sized Reactors

A technical meeting to **review passive safety design options for small and medium sized reactors (SMRs)** was held on 13-17 June 2005 June in Vienna, in cooperation with NSNI, to foster international information ex-change on the state of the art of inherent and passive safety features and passive systems in small and medium sized reactors (SMRs). The meeting produced an insight on potential benefits resulting from the implementation of inherent and passive safety features and passive safety systems in innovative SMRs, and outline potential benefits and issues, such as validation of passive system reliability. Questionnaires for systematic analysis of the role and implications of passive safety design options in SMRs have been developed at the meeting and would be sent out to designers to proceed with the preparation of a relevant report.

As a follow-up, a technical meeting on **review of experience and options of validation, testing and demonstration of passive systems for SMRs in under preparation**, to be held on 17-21 October 2005 in Vienna. Letters re-questing for nominations of experts have been sent out to Member States.

The first research coordination meeting for a coordinated research project on **small reactors without on-site refuelling** will be convened on 21-25 November 2005 in Vienna, to discuss first year reports of 17 participating re-search institutions from 11 Member States and to elaborate plans for future activities.

A draft TECDOC on **Protection against external events for NPPs with evolutionary and innovative reactors** has been prepared and submitted for a pre-publication review. Contact: V.Kuznetsov@iaea.org.

Technology Advances in Water Cooled Reactors for Improvement in Economics and Safety

Activities address a broad range of proven means and new approaches for **improving economics of advanced LWRs and HWRs.**

1. Activities on proven means for Improving Economics of Advanced LWRs and HWRs:

Efficient operation / reducing outages: Preparations continued for the final RCM for the CRP on **Inter-comparison of Techniques for Pressure Tube Inspection and Diagnostics** (17-21 October, 2005, at AECL). The objective of the meeting, hosted by the Canadian Government at AECL's Chalk River Laboratories, will be to review and revise the initial draft of the TECDOC reporting CRP results. Collaborative activities have focussed on round robin comparisons of both proven and developmental diagnostic techniques, and their associated methodologies, to detect and characterize flaws in HWR pressure tubes. Flaw characterization conducted by participants is now complete.

2. Activities on new approaches for Improving Economics of Advanced LWRs and HWRs:

An important new approach incorporated into several advanced LWR and HWR designs involves use of passive systems. This approach promises to provide improved economics and a very high level of safety through design simplification. Considering the weak driving forces of passive systems based on natural circulation, careful design and analysis methods must be employed to assure that the systems perform their intended function.

To foster international collaboration on the enabling technology of passive systems that utilize natural circulation, a CRP on **Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Utilize Natural Circulation** was started in 2004. The scope includes natural circulation for removal of core power under normal operation (start-up, nominal and shutdown) and accident conditions, and to provide cooling of the containment. Building on the shared expertise within the CRP, a TECDOC is in publication describing the present state of knowledge on natural circulation in water-cooled NPPs and passive system reliability. It presents extensive information on phenomena, models, predictive tools and experiments that currently support design and analyses of natural circulation systems, and highlights areas where additional research is needed. It will serve to guide the planning and conduct of the CRP thereby focusing activities on advancing the state of knowledge. With the benefit of the results of the CRP, this document will be updated in the future to produce a document on the State-of-the-Art of Natural Circulation in Water-Cooled NPPs.

Natural circulation systems are a very key area for innovative reactor development, and therefore education of young scientists and engineers in natural circulation phenomena, modelling and experimental results is key to the future of innovative reactor development. Therefore, expertise from the CRP and material in the above mentioned TECDOC forms the basis for an intensive IAEA educational course for scientists and engineers involved in the design, testing and analysis of natural circulation systems. The Course is titled "Natural Circulation in Water-Cooled Reactors".

To contribute **to *Improvement of the technology base for eliminating over-design*** (i.e. for removing the need to incorporate considerable margins into the design simply for the purpose of allowing for limitations of calculational methodology and data uncertainties) a CRP on **Establishment of a Data Base of Thermo-Physical Properties for Materials of LWRs and HWRs** has recently been completed. A Consultancy meeting is being organized for August 2005 to complete the TECDOC presenting the data assessments and new measurements contributed by the participating organizations, and to establish the web-based data base which is being prepared by Hanyang University of the Republic of Korea under the financial support of the Korean government, within Hanyang University's role as "IAEA's Designated Centre for Nuclear Material Data Base Management".

A CRP on **Heat Transfer Behaviour and Thermo-hydraulics Code Testing for Super-Critical Water-cooled Reactors (SCWRs)** is being planned to begin in 2006. There is interest in both developing and industrialized countries in SCWRs, primarily because such systems would achieve higher thermal efficiencies (44-45%) than current evolutionary LWRs and HWRs (34-36%), and thereby have the promise of improved economic competitiveness. Coordination has been agreed with the OECD-NEA. The Specific Research Objectives are to (1) establish a base of accurate data for heat transfer to super-critical fluids; and (2) test computer methods for analyses of SCWR thermo-hydraulic behaviour, and to identify code development needs.

3. Other Activities – primarily for education

Preparations continued for the **Workshop on NPP Simulators for Education** (ICTP, Trieste, 31 October – 11 November 2005). This Workshop teaches the use of BWR, PWR, VVER and HWR simulators for university level education. Interest in this Workshop remains high. Many more application were received from Permanent Missions than the Workshop can accommodate. Applicants whom cannot be accommodated at this Workshop have been encouraged to apply for subsequent Workshops. Contact: J.Cleveland@iaea.org.

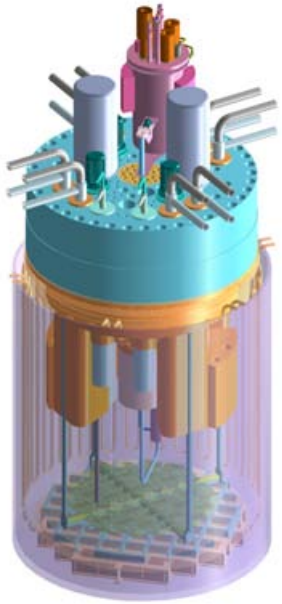
Technology Advances in Fast Reactors and Accelerator Driven Systems

Activities are conducted with the **advice and support of the Technical Working Group on Fast Reactors** (TWGFR), addressing all **technical aspects of FR and ADS research and development, design, deployment, operation, and decommissioning**. The following summarizes recent progress and plans:

The TWGFR Scientific Secretary was invited to present an **Overview of Global Development of Advanced Nuclear Power Plants** at the Symposium on "Future of Energy and the Nuclear Option", organized by the Italian Society for Energy (Milan, 18 May 2005).

The **38th Annual Meeting of the TWGFR**, co-hosted by the Instituto de Pesquisas Energéticas e Nucleares and by the Instituto de Engenharia Nuclear was held in São Paulo/Rio de Janeiro, Brazil, from 23 to 27 May 2005. Representatives of the TWGFR Member States reported on progress in fast neutron systems (critical and sub-critical) research and technology development. On-going TWGFR activities were reviewed on the basis of the TWGFR Scientific Secretary's report. Proposals for new activities were discussed and prioritized.

The Project organized a special session on **Accelerator Driven Systems** (one overview and six technical papers) at the **International Symposium on Utilization of Accelerators** (Dubrovnik, Croatia, 5 to 9 June 2005) convened by the Agency's Division of Physical and Chemical Sciences. As an example for ongoing research and technology development work in this area, the figure shows the general layout of the MYRRHA accelerator-driven multi-purpose fast neutron spectrum, lead-bismuth eutectic cooled facility under development at SCK•CEN, Mol, Belgium.



Experts from France, Russia, Sweden, the UK, and the USA participated in the **Consultancy on Potential of Fusion/Fission Sub-critical Neutron Systems for Energy Production and Transmutation** (Vienna, 15 to 17 June 2005). The Consultancy recommended enhanced coordinated research and technology development efforts for developing fusion blanket designs, mainly in the areas of nuclear data, forms and preparation of fuel, chemistry control, blanket designs, and system integration. The Consultancy recommended convening a follow-on workshop under IAEA aegis (Moscow, February/March 2006).

The TWGFR Scientific Secretary **delivered two lectures** (Status of ADS Technology, and Overview of Global Development and Applications of Advanced Reactors) to a class of students from developing countries at the Nuclear Training Centre of the Jožef Stefan Institute in Ljubljana, Slovenia (30 June to 1 July 2005).

The Project is continuing the activities required to achieve the goals of the Agency's 2004-2005 Project and Budget Plan. The most salient ones till the end of the year are: (i) proposal for activities to be implemented jointly with INIS/NKM within the framework of IAEA's **Project on Fast Reactor Data Retrieval and Knowledge Preservation**; (ii) paper for, and scientific committee member duties for **AccApp 2005** (Venice, 28 August to 1 September 2005); (iii) paper for GLOBAL 2005 (Japan, 3 to 7 October 2005); (iv) preparation of the joint **IAEA/ICTP Workshop** on ADS Technology and Applications (17 to 28 October 2005); (v) preparation of the kick-off **Research Coordination Meetings** of two new CRPs (**Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS)** and **Analyses of, and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems)**; (vi) **finalizing various publications**. Contact: A.Stanculescu@iaea.org. Visit: http://www.iaea.org/inis/aws/fnss/.

Technology Advances for Gas Cooled Reactors

The IAEA Coordinated Research Project (CRP) on **core physics and thermal-hydraulic code benchmarks for High Temperature Gas Cooled Reactors (HTGRs)** has been extended until the end of 2006. Meanwhile, work continues on refining the current set of benchmarks and pro-posing additional ones by the various chief scientific investigators. Results will be analysed during the next Re-search Coordination Meeting (RCM), scheduled in Vienna (Sep. 5-9, 2005).

A set of benchmark cases on HTGR fuel performance under operational conditions, have been refined and sent out to all participants in the CRP on "**Advances in HTGR coated fuel particle technology**". Results will be discussed during the next RCM, scheduled in Vienna (Oct. 17-21, 2005).

The IAEA is cooperating with NEA on their third information exchange meeting on **nuclear hydrogen production**, scheduled at JAERI, Japan (Oct. 5-7, 2005). Contact: M.Methnani@iaea.org.

Support for Demonstration of Nuclear Seawater Desalination

Report on "**Plan for Producing Potable Water Economically Using Small and Medium-sized Nuclear Reactors**" was prepared for submission to the Board and the 49th General Conference. INDAG Newsletter # 5, highlighting the recent activities of the Agency and in the Member States, on nuclear desalination is under preparation. The nominations from the Member States for INDAG members for the third term (2005-08) were received and the members were designated by the Agency. The next INDAG meeting is planned for February 2006.

The results of the CRP on **Optimisation of the Coupling of Nuclear Reactors and Desalination Systems** were published in July 2005 as IAEA-TECDOC 1444. Progress reports in the framework of the CRP on "Economic research on, and assessment of, selected nuclear desalination projects and case studies" received from the CSIS were reviewed for inclusion in the proposed TEC-DOC. The beta version of DEEP 3.0 was prepared and sent to the CSIS for validation. The final version is scheduled to be released in September 2005.

The expert missions for the TC National Projects (2005-06 cycle) to Indonesia, Libya, Pakistan and UAE were completed and the detail work plan was prepared. Workshops on nuclear reactors and desalination systems and training to the engineers from these countries in the economic evaluation of nuclear desalination using DEEP and on the simulators for nuclear desalination plants are planned in the fourth quarter of 2005.

A Session on New Energy-Nuclear will be held at the IDA World Congress on Desalination and Water Reuse during September 11-16, 2005 in Singapore. A consultancy meeting on **Socio-economic and Environmental Aspects of Nuclear Desalination** is also planned on the sidelines of the Congress.

The Agency is a cosponsor of the **WSTA 7th Gulf Water Conference** to be held at Kuwait on November 19-23, 2005 with a keynote speaker on "Sea-water Desalination using Nuclear Energy.

The next Technical Meeting on **Integrated Nuclear Desalination Systems** is planned for December 2005 at Vienna. Issues related to the state-of-art of deployment of integrated nuclear desalination system including the techno-economic and socio-environmental aspects of nuclear desalination is to be discussed during the meeting.

The Agency has created a sub-programme for **non-electrical applications of nuclear power** including hydrogen production, for the 2006/2007 budget-cycle. An international conference on **Advances in nuclear power process heat applications** is also planned in 2007. Contact: B.Misra@iaea.org.

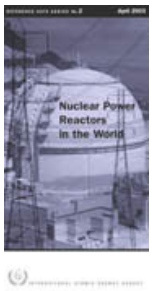
Recent Publications

Optimization of the Coupling of Nuclear Reactors and Desalination Systems

IAEA TECDOC Series No. 1444

In 1998, the IAEA initiated a Coordinated Research Programmed (CRP) on "Optimization of the Coupling of Nuclear Reactors and Desalination Systems" with participation of institutes from nine Member States in order to share relevant information, optimize resources and integrate related research and development in this area. All nuclear reactor types can provide the energy required by the various desalination processes. A total of nine nuclear reactors were examined for optimal coupling with desalination systems within this CRP. They are all of the water-cooled reactor type and are in various degrees of development. The commercial sea water desalination processes, which are proven and reliable for large scale production of desalted water are multi-stage flash (MSF) and multi-effect distillation (MED) for distillation processes and reverse osmosis (RO) for membrane processes and hybrid technologies such as MSF-RO and MED-RO. Different coupling options between the above nuclear and desalination technologies have been investigated within the CRP and were optimized with respect to safety, operational flexibility, reliability/availability and economics.

Nuclear Power Reactors in the World



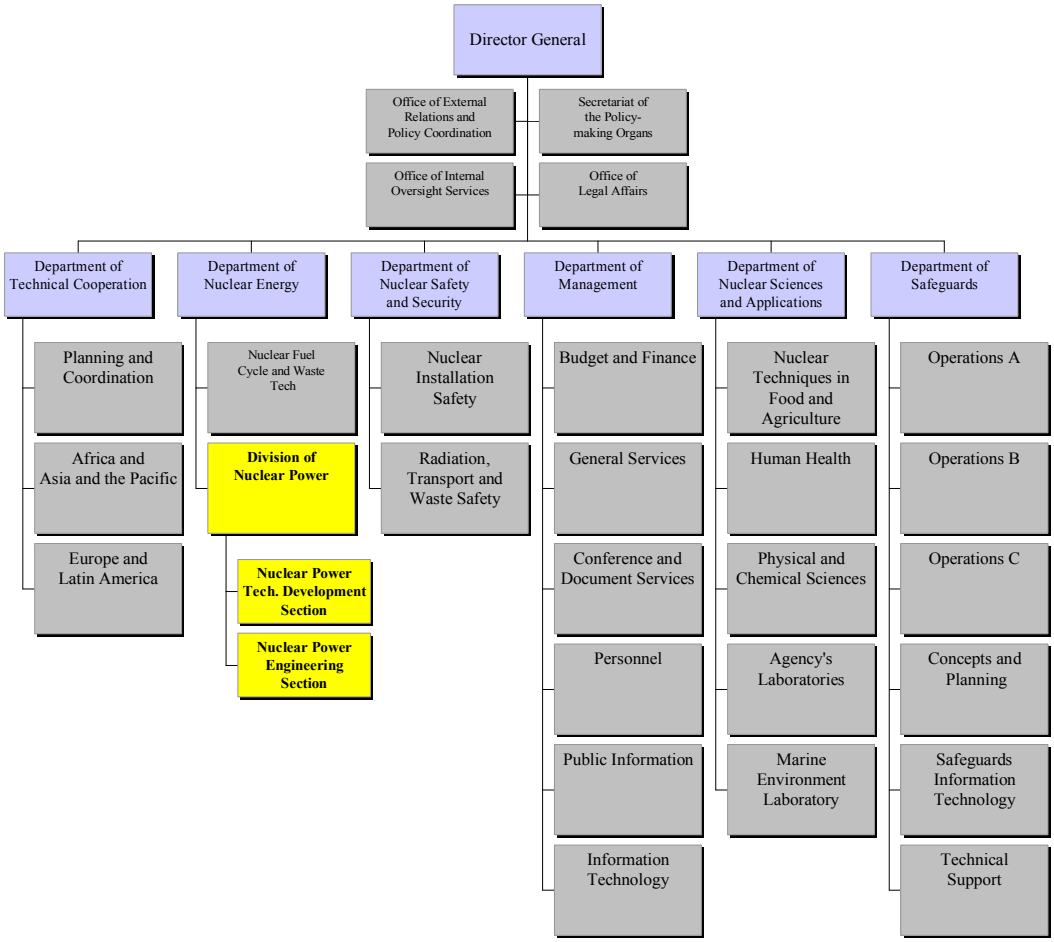
Reference Data Series No. 2

This is the twenty-fourth edition of Reference Data Series No. 2, which presents the most recent reactor data available to the IAEA. It contains summarized information as of the end of 2004 on: (1) power reactors operating or under construction, and shut down; and (2) performance data on reactors operating in the IAEA Member States, as reported to the IAEA. The information is collected by the Agency through designated national correspondents in the Member States. The replies are used to maintain the IAEA's Power Reactor Information System (PRIS).

IAEA-TRS-429	Guidelines for Application of the Master Curve Approach to Reactor Pressure Vessel Integrity in Nuclear Power Plants
IAEA-TRS-428	The Power Reactor Information System (PRIS) and its Extension to Non-electrical Applications, Decommissioning and Delayed Projects Information
IAEA-TECDOC-1435	Application of Surveillance Programmed Results to Reactor Pressure Vessel Integrity Assessment
IAEA-TECDOC-1434	Methodology for the assessment of innovative nuclear reactors and fuel cycles: report of Phase 1B (first part) of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO).
IAEA-TECDOC-1411	Use of Control Room Simulators for Training of NPP Personnel
IAEA-TECDOC-1406	Primary Coolant Pipe Rupture Event in Liquid Metal Cooled Reactors
IAEA-TECDOC-1405	Operational and Decommissioning Experience with Fast Reactors
IAEA-TECDOC-1402	Managing modernization of nuclear power plant instrumentation and control systems
IAEA-TECDOC-1400	Improvement of In-Service Inspection in Nuclear Power Plants
IAEA-TECDOC-1399	The Nuclear Power Industry's Ageing Workforce: Transfer of Knowledge to the Next Generation
IAEA-TECDOC-1395	Intercomparison and Validation of Computer Codes for Thermohydraulic Safety Analysis of Heavy Water Reactors
IAEA-TECDOC-1393	International Outage Coding System for Nuclear Power Plants
IAEA-TECDOC-1392	Development of Instructors for Nuclear Power Plant Personnel Training
IAEA-TECDOC-1391	Status of Advanced LWR Designs: 2004
IAEA-TECDOC-1390	Construction and Commissioning Experience of Evolutionary Water Cooled Nuclear Power Plants
IAEA-TECDOC-1389	Managing Modernization of Control Systems
Reference Data Series 2/23	Nuclear Power Reactors in the World, Reference Data Series No. 2
Book	Operating Experience in NPP in Member States in 2003
CD&Book	Country Nuclear Power Profiles 2003 Edition

Division of Nuclear Power WebSite Links

Division Introduction : NENP home: http://www.iaea.org/OurWork/ST/NE/NENP/index.html



Nuclear Power Engineering Section (NPES)

http://www.iaea.org/OurWork/ST/NE/NENP/NPES/index.html

- Main activities and result
  http://www.iaea.org/OurWork/ST/NE/NENP/NPES/Activity/index.html
- Publications and documents
  http://www.iaea.org/OurWork/ST/NE/NENP/NPES/publications.html
- Contact persons
  http://www.iaea.org/OurWork/ST/NE/NENP/NPES/staff.html
- Databases (PRIS, CNPP, ENTRAC), software (SAT) and downloads
  http://www.iaea.org/OurWork/ST/NE/NENP/NPES/Downloads/index.html

Nuclear Power Technology Development Section (NPTDS)

http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Projects/index.html

- Databases and software
  - ► Fast Reactors Database:
    http://www-frdb.iaea.org/index.html
  - ► ADS Database:
    http://www-adsdb.iaea.org/index.cfm
  - ► User friendly education with nuclear reactor simulators
    http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Projects/edu.html
- Active Coordinated Research Projects (CRPs)

http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/crps.html

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