Grid-Appropriate Reactors

Licensing Issues from the Multinational Design Evaluation Program (MDEP) and Recent NRC Reviews of Small Reactor Designs

Global Nuclear Energy Partnership

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GAR Campaign

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SUMMARY

The Global Nuclear Energy Partnership (GNEP) seeks to create an international regime to support large-scale growth in the worldwide use of nuclear energy. Fully meeting the GNEP vision may require the deployment of hundreds of new reactors in dozens of countries, many of which currently do not use nuclear energy. Some of these needs will be met by large-scale Generation III and III+ reactors [>1000 MW(e)] and Generation IV reactors when they are available. However, many infrastructure-limited countries have small and immature electricity grids that make the currently available Generation III reactors unsuitable because they are too large, too expensive, and too complex. GNEP therefore seeks to develop and deploy new types of reactors that are "right sized" for the infrastructure-limited countries and based on technologies, designs, and policies focused on reducing proliferation risk.

The "Grid-Appropriate Reactors" (GAR) element of GNEP plans to develop and demonstrate appropriately sized reactor designs that can provide infrastructure-limited countries with safe, simple, and robust sources of energy to meet their expanding needs for electricity, potable water, and district heating at an affordable price while minimizing the risk of nuclear proliferation. Deployment of these reactors, combined with a policy of reliable fuel services, can provide an attractive energy solution to many countries without the need for them to develop the more proliferation-vulnerable parts of the nuclear fuel cycle. Although the primary mission of the GAR Campaign is focused on the needs of electricity generation in infrastructure-limited countries, similar interests exist domestically and in other established countries for regional needs and nonelectrical applications such as water desalination and process heat. One of the four major task areas in the GAR Campaign is "Regulation Development." Under this task area, the Department of Energy (DOE) sought to partner with the U.S. Nuclear Regulatory Commission (NRC) to support their efforts in advancing regulatory frameworks that will facilitate the licensing and regulation of GAR systems. One topic of particular interest to DOE was pursuing a collaborative relationship with the NRC on the Multinational Design Evaluation Program (MDEP). The MDEP was established in 2005 as a phased program to facilitate cooperation among nuclear regulatory authorities in several countries to address licensing issues on specific plant designs that are being supplied by one country for construction in another country. The ultimate goal of MDEP continues to be improved protection of the health and safety of the general public through the harmonization of the regulatory processes and requirements of countries that are using or are considering the use of nuclear power plants.

A project was authorized by the GAR Campaign in October 2007 to commence interactions with NRC on issues relevant to licensing grid-appropriate reactors that could be successfully resolved through MDEP. An information meeting on the GAR Campaign was conducted with NRC personnel in Rockville, Maryland, in November 2007. Subsequently, the interactions continued through informal exchanges on MDEP meeting plans/results and research of open media sources for articles and reports on MDEP activities. However, during this same time interval, results from the multinational cooperative effort showed that convergence of regulatory requirements was not feasible in the near term. As such, based on decisions made at the MDEP Policy Group meeting in March 2008, the phased program was restructured into a single program focused on harmonization of regulatory practices, especially in the areas of design reviews and inspections. While harmonization of regulatory requirements for advanced reactors is expected to be a logical outcome of this new program structure, results are not expected for several years. Consequently, with the new focus on work solely within the purview of the nuclear regulatory bodies, opportunities for collaborative efforts in this area did not materialize.

At the same time, the project began assimilating information on regulatory interactions that could affect the siting, construction, and operation of GARs. There continues to be significant interest in having designs of new, smaller reactors undergo an acceptance review by NRC because such a review (provided that it results in no adverse conclusions) would help those reactor vendors in marketing their designs to

potential customers in both domestic and international markets. In FY 2008, companies representing three different small–reactor concepts (the 4S Liquid Metal Reactor, the NuScale integral Pressurized Water Reactor, and the gas-cooled Pebble Bed Modular Reactor) conducted public meetings with NRC to discuss design features of their reactor systems. The vendors for all three reactor designs have announced their intentions to pursue an acceptance review by NRC through the submittal of a Design Certification or Combined License application. A number of licensing issues (technical and legal) were identified in the review meetings, and those issues will require the development of additional regulatory guidance, design information, and analysis results before any conclusions as to the acceptability of the reactor designs can be reached by NRC. In addition, the ultimate resolution of those issues has the potential to influence the designs of all grid-appropriate reactors currently being pursued by industry.

Even though the approach to establish a collaborative effort with NRC was not successful, DOE will need to remain aware of the activities and products of MDEP. For example, work is currently in progress under MDEP to identify similarities and differences in the technical requirements of design codes used in various countries. The results of this work could influence future acceptability reviews by nuclear regulatory bodies (including the NRC) of nonindigenous reactor designs. In addition, both the NRC and the International Atomic Energy Agency (IAEA) have published technical reports that could serve as the basis for establishing technology-neutral regulatory requirements for future reactor designs. It remains vital to the successful deployment of grid-appropriate reactor systems that the potential safety benefits offered by smaller reactors be fully realized without significant licensing delays or economic penalties being incurred through the application of regulations that are intended to address risks traditionally associated with large plants. As such, any new work authorized by DOE on this project should include not only following MDEP developments but also becoming involved in codes and standards activities for advanced reactors and any NRC rulemaking initiated to set requirements for technology-neutral reactor designs.

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ACRONYMS

ACR	Advanced CANDU Reactor
AECL	Atomic Energy of Canada Limited
ANS	American Nuclear Society
ANSI	American National Standards Institute
AOO	Anticipated Operational Occurrence
AP-1000	Advanced Passive 1000 MW(e) PWR
ASME	American Society of Mechanical Engineers
ASN	Nuclear Safety Authority (France)
CANDU	Canadian deuterium uranium
CFR	Code of Federal Regulations
COL	Combined License (NPP construction and operation)
CORDEL	Cooperation in Reactor Design Evaluation and Licensing (WNA working group)
CNRA	Committee on Nuclear Regulatory Activities (OECD/NEA)
DBA	Design Basis Accident
DBE	Design Basis Event
DBT	Design Basis Threat
DC	Design Certification
DID	Defense-in-Depth
DOE	U.S. Department of Energy
ENEF	European Nuclear Energy Forum
EPR	Evolutionary (European) Pressurized Reactor
EU	European Union
GAR	Grid-Appropriate Reactors
GDC	General Design Criteria
GIF	Generation IV International Forum
GNEP	Global Nuclear Energy Partnership
HTGR	high-temperature gas-cooled reactor
I&C	Instrumentation and Control
IAEA	International Atomic Energy Agency
IRIS	Integral Reactor Innovative and Secure
ITAAC	Inspections, tests, analyses, and acceptance criteria
LBE	Licensing Basis Event
LMR	Liquid Metal Reactor
LOCA	Loss of Coolant Accident
LWR	Light Water Reactor

MASLWR	Multi-Application Small Light-Water Reactor
MDAP	Multinational Design Approval Program
MDEP	Multinational Design Evaluation Program
MW(e)	megawatt electric
NEA	Nuclear Energy Agency
NGNP	Next Generation Nuclear Plant
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC technical report designation
OECD	Organization for Economic Co-Operation and Development
PBMR	Pebble Bed Modular Reactor
PBMR (Pty) Ltd.	Pebble Bed Modular Reactor (Proprietary) Limited
PDC	Principal Design Criteria
PIRT	Phenomena Identification and Ranking Table
PRA	Probabilistic Risk Assessment
PRISM	Power Reactor Innovative Small Module; alternately, Power Reactor Inherently Safe Module
PSER	Preliminary Safety Evaluation Report
PWR	Pressurized Water Reactor
SoK	Status of Knowledge
SRP	Standard Review Plan
SSC	Structures, Systems and Components
STUK	Radiation and Nuclear Safety Authority (Finland)
V&V	Validation and Verification
VHTR	Very High-Temperature Gas-Cooled Reactor
WERNA	Western European Nuclear Regulators Association
WGRNR	Working Group on the Regulation of New Reactors
WNA	World Nuclear Association

GRID-APPROPRIATE REACTORS (GAR) CAMPAIGN

LICENSING ISSUES FROM THE MULTINATIONAL DESIGN EVALUATION PROGRAM (MDEP) AND RECENT NRC REVIEWS OF SMALL REACTOR DESIGNS

1. INTRODUCTION

The GNEP seeks to create an international regime to support large-scale growth in the worldwide use of nuclear energy. Fully meeting the GNEP vision may require the deployment of hundreds of new reactors in dozens of countries, many of which currently do not use nuclear energy. Some of these needs will be met by large-scale Generation III and III+ reactors [>1000 MW(e)] and Generation IV reactors when they are available. However, many infrastructure-limited countries have small and immature electricity grids that make the currently available Generation III reactors unsuitable because they are too large, too expensive, and too complex. GNEP therefore seeks to develop and deploy new types of reactors that are "right sized" for the infrastructure-limited countries and based on technologies, designs, and policies focused on reducing proliferation risk.

The "Grid-Appropriate Reactors" (GAR) element of GNEP plans to develop and demonstrate appropriately sized reactor designs that can provide infrastructure-limited countries with safe, simple, and robust sources of energy to meet their expanding needs for electricity, potable water, and district heating at an affordable price while minimizing the risk of nuclear proliferation. Deployment of these reactors, combined with a policy of reliable fuel services, can provide an attractive energy solution to many countries without the need for them to develop the more proliferation-vulnerable parts of the nuclear fuel cycle. Although the primary mission of the GAR Campaign is focused on the needs of electricity generation in infrastructure-limited countries, similar interests exist domestically and in other established countries for regional needs and non-electrical applications such as water desalination and process heat.

The overarching GNEP objectives and the supporting role of grid-appropriate reactors give rise to a number of specific requirements that must be addressed. Those requirements include the following:

- developing reactor technologies that radically improve the safety, security, and proliferation resistance of new reactor designs while maintaining economic competitiveness;
- developing and licensing reactor designs that are appropriately sized and featured for smaller countries with limited infrastructure and financial resources;
- accelerating the near-term deployment of light-water, grid-appropriate reactors within 20 years, as well as the development of next-generation designs to support future deployments within 50 years;
- developing, in conjunction with the Generation IV program, the research and development infrastructure needed to support education and training of personnel on advanced reactor designs domestically and internationally; and
- supporting the development of reactor designs suitably matched to nonelectrical applications such as water desalination and process heat.

Satisfying the requirements described above holds many challenges for designs of grid-appropriate reactors that are considered mature and consistent with existing regulatory infrastructures as well as those innovative reactor designs that are emerging for consideration. Current light-water reactor (LWR) grid-appropriate reactor designs incorporate engineering innovations to achieve greater levels of safety and security while maintaining competitive economics. However, confirmation of the added value of the engineering innovations is needed to achieve acceptance from the appropriate regulatory bodies. The "next-generation" designs are expected to offer further enhancements in plant performance and will build on the successful resolution by near-term grid-appropriate reactor designs of critical infrastructure issues. However, the deployment of next-generation grid-appropriate reactors will require the successful resolution of many technology challenges as part of the regulatory acceptance process.

The GAR Campaign is organized into four major task areas: Management and Integration, Reactor Development, Infrastructure Development, and Regulation Development. The organization and relationships of these task areas are diagrammed in Figure 1.

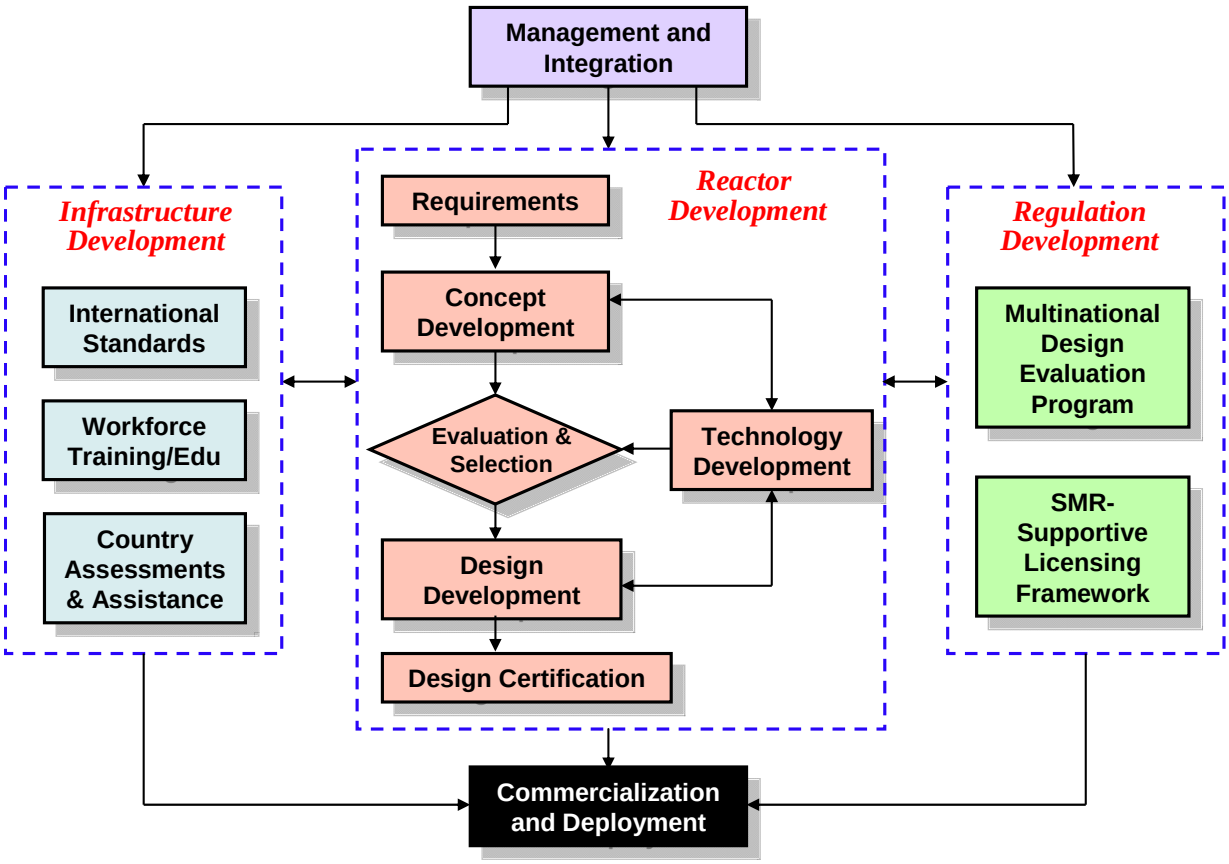

Figure 1. Diagram of major task areas for Grid-Appropriate Reactors Campaign.

The "Regulation Development" task area was defined in recognition of the importance associated with understanding the technical and legal requirements that could be used to evaluate grid-appropriate reactor designs for acceptability. For example, any reactor design that receives approval from the NRC as part of a Design Certification (DC) or Combined License (COL) application review is considered to have a competitive advantage in the world nuclear market. However, with many of the grid-appropriate reactor designs having fundamental design attributes or evolutionary features that have not been evaluated as part

of any recent licensing activity, it was concluded that efforts should be expended to better understand the type and nature of nuclear regulatory requirements that could eventually be applied to licensing (both within the United States and abroad) of grid-appropriate reactors.

Increased emphasis is being placed across the nuclear power sector for a greater degree of cooperation between industry and the regulatory bodies to reduce the time required to receive regulatory approval for new nuclear power plants.

- In an attempt to provide more certainty in the licensing process for new nuclear power plants in the United States, the NRC created a "one-step" licensing process through the publication of Part 52, "Early Site Permits; Standard Design Certifications and Combined Licenses for Nuclear Power Plants," to Title 10 of the Code of Federal Regulations (CFR). However, as reported in the *Wall Street Journal* on October 15, 2007, the NRC licensing system is still viewed by utilities and vendors involved with applications for new nuclear generating capacity as being too slow to support the projected demands for electricity.

- In discussions at the World Energy Congress on November 13, 2007, Anne Lauvergeon, the chair of AREVA, commented that "the licensing process is long," and she called for international coordination in the licensing of new nuclear projects to help speed approvals for construction and operation of the projects.

- As reported in the *National Post* on January 28, 2008, Brad Wall, the premier of Saskatchewan, advanced his views that the nuclear project approval process in Canada was too long, and a "new national approach" to licensing nuclear reactors was needed. In the same article, Wall also cited an interest in the potential use of "small, non-AECL (Atomic Energy of Canada, Ltd.) reactors" for applications such as providing electricity and heat for oil sands projects.

Attention is also being given to increasing collaborative efforts within the industrial and regulatory communities to gain an understanding as to where nuclear safety standards, regulations, and processes can be made more uniform to permit more timely acceptance and deployment of standardized nuclear power plant designs.

- The Organization for Economic Co-Operation and Development's Nuclear Energy Agency (OECD/NEA) notes in its 2006–2009 Operating Plan (NEA/CNRA/R(2006)2) an activity directed as "Harmonising Nuclear Safety Requirements for Selected Design Features of New NPP (nuclear power plant) Types that are Considered for Construction in Near Term." This activity is addressed by the Committee on Nuclear Regulatory Activities (CNRA).

- The World Nuclear Association (WNA) issued a discussion paper (January 2008) entitled "Benefits Gained through International Harmonisation of Nuclear Safety Standards for Reactor Designs." The publication describes the WNA's views as to how harmonization of international nuclear safety standards benefits the nuclear industry and identifies a special working group (Cooperation in Reactor Design Evaluation and Licensing, CORDEL) that was established for "stimulating a dialogue between the nuclear industry and nuclear regulators (national and international) on the benefits of achieving a convergence of safety standards globally."

- A working paper (May 6, 2008) presented to the European Nuclear Energy Forum (ENEF) Subgroup on Harmonisation cites an activity by the Western European Nuclear Regulators Association (WERNA) that is aimed at "harmonizing nuclear regulatory systems in the EU (European Union) countries with nuclear programs and Switzerland by 2010."

Under the Regulation Development task area of the GAR Campaign, DOE sought to partner with the NRC to support their efforts in advancing regulatory frameworks that would facilitate the licensing and regulation of grid-appropriate reactor systems. One topic of particular interest to DOE was pursuing a collaborative relationship with the NRC on the Multinational Design Evaluation Program (MDEP). The MDEP (also referred to at an early stage as the Multinational Design Approval Program, MDAP) was established in 2005 as a phased program to facilitate cooperation among nuclear regulatory authorities in several countries to address licensing issues on specific plant designs that are being supplied by one country for construction in another country. MDEP/MDAP participation is also mentioned in the above cited publications related to harmonization of international nuclear safety standards. Further, DOE's involvement and cooperation (under the Generation IV International Forum, GIF) with NRC on MDAP/MDEP was encouraged in a December 6, 2005, letter from Senator Pete Domenici to NRC Chairman Nils Diaz.

To facilitate progress in this task area, a project was authorized by the GAR Campaign in October 2007 to commence interactions with NRC on issues relevant to licensing grid-appropriate reactors. The initial set of tasks defined included

1. interacting with NRC personnel involved in the MDEP to discuss issues relevant to grid-appropriate reactor licensing that could be successfully resolved through MDEP,

2. representing DOE interests in meetings (national and international) involving discussions and activities of MDEP working groups, and

3. maintaining awareness of regulatory developments that could impact the siting, construction, and operation of grid-appropriate reactors.

FY 2008 activities on the above defined tasks are discussed in more detail in Sections 2 and 3 of this report.

2. LICENSING ISSUES FROM THE MULTINATIONAL DESIGN EVALUATION PROGRAM (MDEP)

As mentioned in Section 1 of this report, the MDEP was established in 2005 as a phased program to facilitate cooperation among nuclear regulatory authorities in several countries to address licensing issues on specific plant designs that are being supplied by one country for construction in another country. In a memorandum to his fellow NRC Commissioners dated July 22, 2005, Nils Diaz (then NRC Chairman) outlined his vision of a multistage, multinational reactor design approval program. The program concept emerged from earlier bilateral cooperative efforts with other regulators. Referred to as the Multinational Design Approval Program (MDAP), Diaz envisioned a "multinational safety-focused design approval program (that) would ensure the effectiveness and efficiency of nuclear power design reviews and associated programs, and would provide a practical forum for multinational cooperation and ultimate convergence on safety standards and their implementation." Other touted benefits of this program included "improved clarity and transparency of nuclear safety regulation across international borders, better communication, more standardization in reactor designs and in regulatory programs, better safety, security, and preparedness coordination among user countries, and improved public confidence."

On September 8, 2005, the Commission approved the proposal to move forward with implementation of Stage 1 of MDAP [review of a light-water reactor (LWR) design being considered by the United States and other countries] and, using the information gained in Stage 1, develop a proposal for implementation of Stage 2. That same month, the three-staged MDAP was outlined in a presentation given by Chairman Diaz. The MDAP stages discussed in the presentation were identified as follows:

- Transition and Formation—using the NRC technical review portion of the Design Certification process for existing/pending applications together with the expertise of outside regulators to expedite and improve the safety review of applications

- Consolidation and Initial Implementation—effort directed at standardization and multinational acceptance of approved reactor designs

- Implementation and Expansion—supporting approved designs, established safety review procedures, and multinational acceptance of Generation IV reactors

Even with the emphasis on coordination of activities, Chairman Diaz clearly stated that significant responsibilities in the nuclear licensing process would remain within the sole purview of the national regulatory bodies. These responsibilities include

- reactor siting approval;

- environmental assessment requirements;

- legal issues (i.e., ownership, financing, liability, etc.);

- acceptance criteria for construction, inspections, tests and analyses; and

- compliance with country-specific regulatory requirements.

In February 2006, at an international meeting of nuclear regulatory bodies in Moscow, the MDAP was discussed and program refinements were made. Chairman Diaz outlined the updated program in a

March 28, 2006, white paper on MDAP. Stage 1 was in process with the Evolutionary Power Reactor (EPR) selected for cooperative reviews between the NRC, the Nuclear Safety Authority (ASN, the nuclear regulator in France) and the Radiation and Nuclear Safety Authority (STUK, the nuclear regulator in Finland). The EPR was selected because the reactor was (a) being constructed in Finland, (b) being proposed for construction in France, and (c) undergoing preapplication reviews in the United States, in anticipation of a follow-on DC application. In Stage 2, regulatory working groups would be established, and those working groups would review applicable IAEA safety standards for completeness and identify a strategy for integrating the applicable IAEA standards into a group of modules that would constitute the core for a multinational design certification process. The Organization for Economic Co-Operation and Development/Nuclear Energy Agency (OECD/NEA) was proposed to serve as a secretariat for Stage 2 of MDAP since they already provided the same service for the GIF. Stage 3 of MDAP would use the products of the Stage 2 effort to aid in the review the GIF advanced reactor designs.

Implementation of Stage 1 continued through 2006. NEA issued a press communiqué notice on November 9, 2006, identifying its role as Technical Secretariat for facilitating Stage 2 of MDEP. The communiqué cited a main objective in Stage 2 of "(identifying) common regulatory practices and regulations that enhance the safety of new nuclear reactor designs" and identified the formation of two pilot projects to (1) "investigate the licensing basis for new nuclear reactor designs, the scope of design safety reviews and overall safety goals" and (2) "examine regulatory oversight of components manufactured for nuclear reactors." The pilot projects were tasked to complete their work in 1 year followed by a 3-month period for assessment of the results.

On December 5, 2006, the NRC held a public meeting in Rockville, Maryland, to "present NRC staff activities on the Multinational Design Evaluation Program including Stage 1 efforts associated with the EPR design and Stage 2 efforts associated with the multinational initiative to attempt to harmonize regulatory approaches to licensing new reactors." At this meeting, it was noted that Stage 2 of MDEP would have, as an initial phase, a 1-year pilot project to "assess the similarities and differences in the regulatory requirements (including safety goals) and regulatory practices in several areas" (Emergency Core Cooling System Performance, Severe Accidents, Digital Instrumentation and Control). Additional areas of convergence/cooperation would be pursued based on recommendations developed from the pilot project. It should also be noted that even with the Stage 2 pilot projects in process, collaborative activities between NRC, ASN, and STUK on the EPR design as defined in Stage 1 continued.

Work on the MDEP Stage 2 pilot projects continued in 2007. Chairman Klein acknowledged some of the challenges being encountered by NRC in reaching consensus with other regulators on terminology and acceptance standards when, in an NEA forum on June 12, 2007, he observed that "while different nations may have different ideas about what constitutes 'adequate protection,' I believe it would be an understatement to say that we should all agree on a standard set of metrics—in the sense of consistent definitions of terms." However, except for one trip report and a few meeting presentations, there was little information made public by NRC about their MDEP work during this period.

Based on a September 2007 presentation by NRC at the Global 2007 meeting, DOE concluded that they should pursue a closer working relationship with NRC on MDEP to better understand the regulatory issues being discussed that applied to advanced reactors, such as the longer-term small reactor designs under the GAR Campaign. A project was authorized by the campaign in October 2007 to commence interactions with NRC on issues relevant to licensing grid-appropriate reactors that could be successfully resolved through MDEP. Subsequently, an information meeting on the GAR Campaign was conducted with NRC personnel in Rockville, Maryland, in November 2007. In this meeting (two separate sessions held), expectations that the GAR Campaign would be engaged in the MDEP discussions were communicated to NRC. Following the November 2007 meeting, interactions with NRC personnel involved in MDEP took place though informal information exchanges on MDEP meeting plans/results.

From surveys of information in open media sources, it was known that some meetings of the pilot project working groups were taking place. However, there was insufficient information about the nature and scope of the meetings to support a participation request by the GAR Campaign. In addition, a representative of NEA confirmed that any participation in MDEP meetings by organizations outside the involved regulatory agencies would have to be approved by that country's regulatory body (i.e., participation by U.S. entities would require approval by NRC).

However, while these initial campaign interactions with NRC were in progress, results from the MDEP pilot projects were showing that convergence by the participating regulatory bodies on common areas of regulatory requirements was not likely in the near term. The results of NRC's efforts were discussed in SECY-07-0207, dated November 29, 2007. In this letter (approved by the Commission on January 3, 2008), the NRC staff recommended to the Commissioners that the MDEP be restructured from a multiphase activity to a single program focused on harmonization of regulatory practices among the participating regulatory bodies. The previous target outcome (i.e., harmonized safety standards for advanced reactors) would now be assumed to be a logical outcome of the regulatory interactions under MDEP. At the MDEP Policy Group meeting in March 2008, this new program structure was formally approved. A press communiqué from NEA dated March 7, 2008, described the restructured program and provided an organization structure chart (Figure 2).

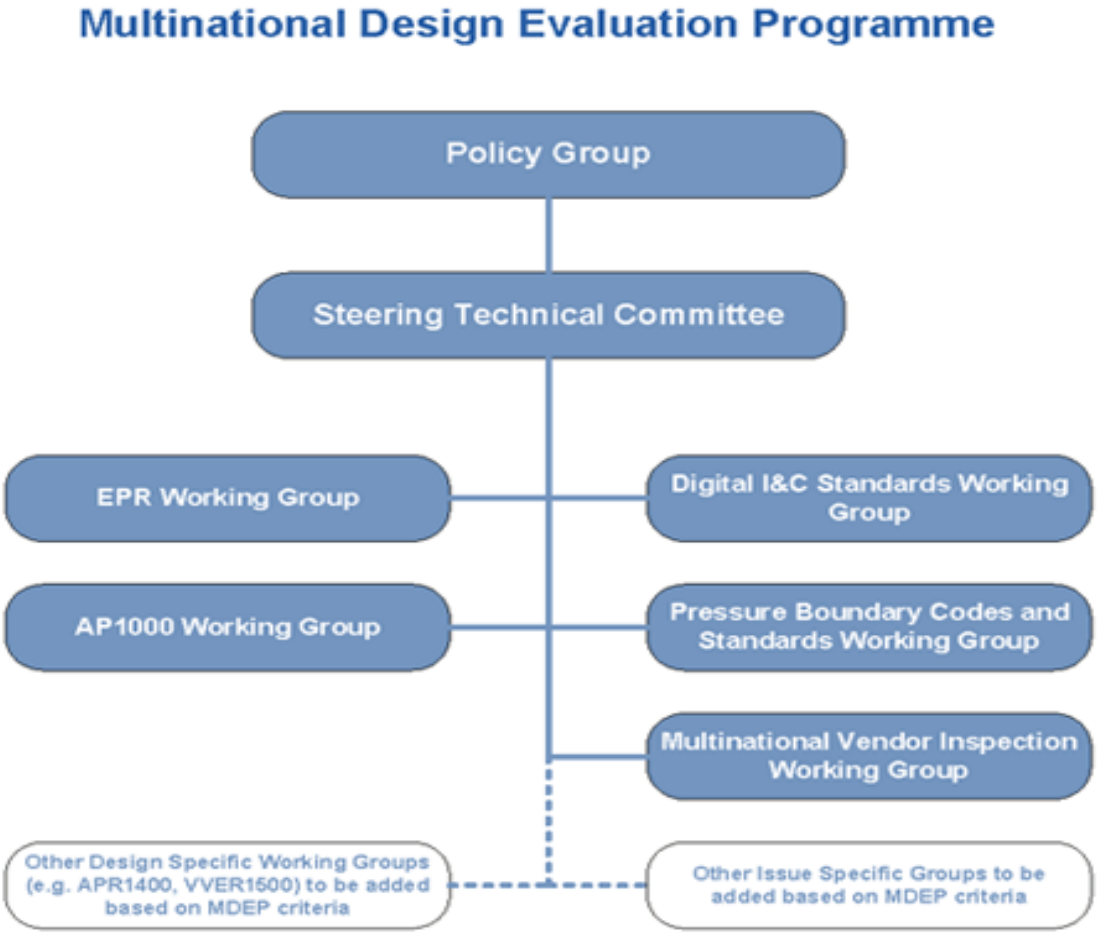

Figure 2. Multinational Design Evaluation Program (new program structure—March 2008).

The restructured MDEP now features the following two types of working groups.

- Reactor working groups— As discussed in both the March 7, 2008, NEA press communiqué and the March 17, 2008, edition of "Inside NRC," working groups for two reactor designs, the EPR and the AP-1000 [Advanced Passive 1000 MW(e) pressurized water reactor], had been formed. The EPR working group represented a continuation of cooperative efforts from the initial MDEP activities. The AP-1000 working group is a new group, and it is expected that meetings of this group will begin before the end of 2008. According to the rules of participation in the restructured MDEP, a minimum of three countries with active regulatory reviews on a specific reactor design is required before a MDEP working group for that design will be established.

- Technical working groups—While the reactor working groups are considered to be design-specific activities, the technical working groups are viewed as issue-specific initiatives that cut across all reactor designs. Since the March 2008 announcement of the new MDEP structure, a fourth technical working group on Component Manufacturing Oversight has been established.

With the exception of selected technical presentations and occasional references to MDEP in speeches and correspondence, very little information about the meeting schedules, agenda topics, technical or policy deliberations, and decisions made by the MDEP Policy Committee, Steering Technical Committee and working groups has been made public. The NEA Web site identifies areas where the correspondence for these committees can be posted; however, those sites are not available to the general public. One outside organization that is actively assisting NRC in a significant capacity with MDEP is the American Society of Mechanical Engineers (ASME). In several presentations and statements made in public meetings, ASME has been identified as participating in (1) a comparative review (together with representatives of similar code bodies from other countries) of pressure boundary code requirements to identify similarities and differences in technical requirements and (2) reviews of standards applied to reactor component manufacturing oversight. It is unknown when and if the results of the code reviews being performed by ASME will be made available for use by others in the nuclear industry.

To explore the possibility of additional cooperation with NRC on MDEP activities, an informal status meeting was held with involved NRC staff on May 7, 2008. At this meeting, the GAR Campaign was advised that, with the new MDEP focus on harmonization of regulatory interactions, there would be no opportunities for collaboration with DOE in the foreseeable future. In addition, the information prepared for or by the MDEP working groups would be made available only to the participating regulatory bodies. Further, should DOE want to bring a technical or policy issue to the MDEP participants for consideration, NRC would decide if direct DOE participation in the MDEP meetings was necessary.

During the May 7, 2008, meeting, it was noted that a final report on the MDEP pilot project had been prepared. This report (dated May 2008) was made publicly available by NEA on July 25, 2008. The report confirmed the conclusions reached and program redirection discussed above. In addition, the report identified the following activities to be pursued by the participating regulatory bodies under the restructured MDEP:

- Share information and cooperate on specific reactor design evaluations under current reviews

- Undertake a multinational vendor inspection cooperation programme

- Converge on codes and standards for pressure boundary components by completing an evaluation of their similarities and differences

- Evaluate the similarities and differences in other codes and standards, beginning with a comparison of the digital instrumentation and control standards

- Complete the evaluation of the similarities and differences in the overall scope of the regulatory review and analysis for severe accidents and develop a draft reference scope of review

- Compare how top level safety goals are derived, expressed, achievement is judged among the participating countries, and determine the extent to which they can be considered equivalent

- Compare the approaches used for taking account of operating experience in regulatory reviews for new reactors

- Develop a programme to collect, share, and use construction experience feedback in regulatory reviews

- Develop a legal framework and the necessary agreements that will support the free exchange of information, including the results of independent analysis and research, among MDEP participants

- Establish a "library" to collect and share regulatory documents of common interest describing design requirements and guidance, review process and inspection programme of new reactors. Complement this regulatory library with a list of technical reviews already performed and available for free exchange of information on request

The full text of the MDEP pilot project report is included in Appendix A of this report.

Recently, NRC's collaboration activities with other regulatory bodies on new reactor licensing expanded with the formation (under the OECD/NEA CNRA) of a Working Group on Regulation of New Reactors (WGRNR). As discussed on the NEA Web site, this working group "will examine the regulatory issues of the siting, licensing and regulatory oversight of Generation III+ and Generation IV nuclear reactors. The WGRNR will focus in particular on construction inspection issues and share this experience with the other groups working under the aegis of the CNRA. The WGRNR will also co-ordinate the activities of the CNRA and the Multinational Design Evaluation Programme (MDEP) in order to ensure that the MDEP's efforts take full advantage of the work already being done by the CNRA." Similar to MDEP, it is expected that the products of this new collaborative effort will be made available by NEA (subject to the approval of the participating organizations).

The ultimate goal of MDEP continues to be improved protection of the health and safety of the general public through the harmonization of the regulatory processes and requirements of countries that are using or are considering the use of nuclear power plants. While harmonization of regulatory requirements for advanced reactors is expected to be a logical outcome of the new MDEP structure, results are not expected for several years. Consequently, with the new focus on work solely within the purview of the nuclear regulatory bodies, opportunities for collaborative efforts with DOE through the GAR Campaign did not materialize.

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3. LICENSING ISSUES FROM SMALL REACTOR REVIEWS

As mentioned in Section 1 of this report, while efforts continued to establish a collaborative relationship with NRC on MDEP, the project began assimilating information on regulatory interactions that could affect the siting, construction, and operation of GARs. There continues to be significant interest in having designs of new, smaller reactors undergo an acceptance review by NRC because such a review (provided that it results in no adverse conclusions) would help those reactor vendors in marketing their designs to potential customers in both domestic and international markets.

In FY 2008, companies representing three different small–reactor concepts (the 4S Liquid Metal Reactor, LMR; the NuScale integral Pressurized Water Reactor, PWR; and the gas-cooled Pebble Bed Modular Reactor, PBMR) conducted public meetings with NRC to discuss design features of their reactor systems. The vendors for all three reactor designs have announced their intentions to pursue an acceptance review by NRC through the submittal of a Design Certification or Combined License application. A number of licensing issues (technical and legal) were identified in the review meetings, and those issues will require the development of additional regulatory guidance, design information and analysis results before any conclusions as to the acceptability of the reactor designs can be reached by NRC. In addition, the ultimate resolution of those issues has the potential to influence the designs of all grid-appropriate reactors currently being pursued by industry.

A summary of the public meetings held on grid-appropriate reactors in FY 2008 and the licensing issues raised in the meetings is provided in Sections 3.1 through 3.3 of this report. Additional regulatory considerations related to grid-appropriate reactor licensing are discussed in Section 3.4 of this report.

3.1 SUPER SAFE, SMALL, AND SIMPLE (4S) REACTOR

The 4S is a small molten sodium-cooled reactor designed by Toshiba. The nominal size (power) of the reactor is 10 MW(e), but smaller and larger versions of the reactor design exist. The 4S is specifically designed for use in remote locations and to operate for decades without refueling, hence, the reference to the 4S reactor as a “nuclear battery.” The use of molten sodium as a coolant has been employed in a number of earlier fast-breeder-reactor designs. The reactor fuel is a uranium alloy (17–19 percent enrichment), but other fuel designs, such as uranium-plutonium alloys, can be used. The city of Galena, Alaska, has expressed interest to use a 4S reactor (instead of diesel generators) for supplying electricity to their city. However, the NRC has indicated that they are not familiar with the plant design, and as such, the process of reviewing the reactor design for acceptability could be both time and resource intensive.

At the request of Toshiba (and Westinghouse, now a member of the design team), NRC conducted four public meetings in FY 2008 on the 4S design. The meetings were held on October 23, 2007; February 21, 2008; May 21, 2008; and August 8, 2008. The meetings served to familiarize the NRC with aspects of the 4S design in preparation for submittal of a Design Approval application to NRC in 2009 and, following receipt of approval, submittal of a COL application to NRC in the 2011–2012 time period.

The October 23, 2007, meeting was introductory in nature with Toshiba and Westinghouse providing a high-level overview of their organization, the 4S design parameters, and a proposed schedule for technical submittals and follow-on meetings. Highlights and regulatory issues from the other meetings are discussed below.

February 21, 2008

This meeting focused on 4S system design features and a description of the long-life metallic fuel design parameters. Because of the unique features of the 4S design (such as its advertised 30-year operating cycle without refueling), the NRC staff asked questions on a number of topics, including the following:

- Performance of the annular reflectors
- Qualification of the electromagnetic pump (including the plant's ability to reach natural circulation conditions without a flywheel to provide inertia during plant coast down)
- Steam generator design (not similar to designs used on earlier sodium-cooled reactors)
- Confinement design/performance (including security/operational safety during midcycle removal of fixed absorber)
- Extent of safety instrumentation used
- Potential for sodium leaks inside containment
- Qualification of metallic fuel for 30-year life (including supporting calculations and test results)
- Use of grid spacers in metallic fuel
- Resolution of open issues with use of HT9 cladding [cited in the Power Reactor Innovative Small Module (PRISM) Preliminary Safety Evaluation Report (PSER), NUREG-1368]

Each of these topics, without the receipt of additional information (design specifications, calculations, confirmatory testing, etc.) represent areas where significant resources may be needed to resolve NRC questions about the acceptability of the 4S design.

Subsequent to the meeting, Toshiba and Westinghouse submitted descriptions of the plant design and metallic fuel to NRC on May 20, 2008, and June 30, 2008, respectively.

May 21, 2008

This meeting focused on the safety basis and regulatory conformance of the 4S design. Toshiba and Westinghouse described their efforts to review the current General Design Criteria (GDC), Appendix A of Title 10 of the Code of Federal Regulations (CFR), the Standard Review Plan (SRP, NUREG-0800), the "General Safety Design Criteria for a Liquid Metal Reactor Nuclear Power Plant" (ANSI/ANS-54.1), and the PSER for the Clinch River Breeder Reactor (NUREG-0968) and PRISM (NUREG-1368) and, from this review, prepare a separate set of Principal Design Criteria (PDC) for the 4S reactor. Using their PDC, Toshiba and Westinghouse then provided an overview as to how the 4S design satisfies the PDC. The Toshiba/Westinghouse presentation further included an overview of their analysis of selected NRC Regulatory Guides against the 4S design, the process for selecting design basis accidents, and safety enhancements made to the 4S design based on previous experience with passive plant features.

August 8, 2008

In this meeting, Toshiba and Westinghouse focused on (1) the results of a Phenomena Identification and Ranking Table (PIRT) exercise performed for the 4S reactor and (2) conformance of the 4S design with the recently released "Regulation of Advanced Nuclear Power Plants; Draft Statement of Policy" (published in the Federal Register on May 9, 2008). The PIRT exercise concluded that there were no instances where the Status of Knowledge (SoK) for all identified phenomena was completely unknown (i.e., no new theoretical evaluations and supporting tests are required). Phenomena where the SoK was partially known (i.e., testing possible based on results of theoretical evaluations) included the following:

- Flow distribution of the intra- and inter-assembly
- Maldistribution of the core flow; redistribution of the mass flow in all core assemblies
- Natural circulation (in core/fuel assembly)
- Natural circulation (in reactor internal structure)
- Natural circulation head and pressure loss (Primary Heat Transfer System)
- Radial heat transfer between subassemblies
- Coolant mixing in upper plenum including thermal stratification
- Thermal radiation between the reactor vessel wall and the guard vessel wall
- Thermal radiation between the guard vessel wall and the collector wall
- Thermal radiation between the collector wall and concrete wall
- Asymmetric airflow in the Reactor Vessel Auxiliary Cooling System
- Pressure loss in core region
- Reactivity insertion rate and delay of scram reactivity insertion
- Eutectic reaction between fuel and cladding
- Pressure loss of airflow path in the Reactor Vessel Auxiliary Cooling System
- Reactivity insertion by cavity failure

There were additional issues raised by NRC during this presentation.

- The staff noted that additional PIRT exercises may be needed to address the effects of phenomena on plant features (i.e., selection of materials).
- The staff indicated that they will need additional information to justify the absence in the 4S design of the type of in-core instrumentation typically used in LWRs to monitor core performance (power shapes and distribution).

Again, each of the topics listed above represents potential challenges in the NRC's review of the acceptability of the 4S design.

In addition to the reactor and fuel design descriptions noted earlier in this section of the report, Toshiba and Westinghouse plan to submit the following additional technical reports to NRC to conclude the familiarization phase of the 4S review.

- Safety design and safety analyses (principal design criteria, evaluation criteria, analysis methodologies, and safety analysis results)— October 2008
- PIRT and test program— November 2008
- Seismic isolation design and responses to NRC questions— December 2008

3.2 NUSCALE

The NuScale reactor is based on the Multi-Application Small Light-Water Reactor (MASLWR) that was designed at Oregon State University with DOE funding under the Nuclear Energy Research Initiative. The reactor is rated at 45 MW(e) and is intended to be a modular system (i.e., the overall facility will consist of multiple reactor modules). With its relatively small size (length – 65 feet; weight – 300 metric tons), it is expected that the containment vessel can be fabricated in the United States and shipped (rail, truck, or barge) to the plant site. Like most of the new small-reactor designs, the NuScale reactor is cooled by natural circulation, thus eliminating the need for many active components (pumps, valves, etc.) to safely operate the plant. Also, because it is a PWR, the NuScale reactor can undergo a licensing acceptance review using current NRC regulatory requirements.

The NuScale team met with the NRC on July 24, 2008. This forum permitted the NuScale team to familiarize NRC personnel in attendance with the NuScale design together with NuScale Power's organization and their intentions for further interactions with the NRC. The team indicated their plans to prepare and submit a DC application to NRC in 2010. In response to questions from the NRC meeting participants, NuScale further commented that (a) they did not intend to apply for a Manufacturing License under 10 CFR Part 52 for fabrication of the reactors modules and (b) they considered a scenario where different organizations own different reactor modules at the same plant to be unlikely.

Even with the use of reactor technology that is consistent with the current NRC licensing framework, this introductory meeting served to raise a number of technical and legal issues that will require additional consideration and/or analysis to support an eventual licensing review, including the following:

- Application of SRP chapters that do not address multiple module operations
- Safety aspects of "on-line refueling" (i.e., one module in refueling mode while other NuScale modules are at power)
- Staffing and operational planning for multimodule digital I&C main control room (NuScale design currently assumes one main control room for up to three reactor modules)

- Use of probabilistic risk assessment (PRA) for multimodule operations (i.e., addressing common mode failures, defining accident sequences, confirming performance of passive features, and addressing the quality and applicability of data used in the analysis)

- Treatment of postulated severe accidents (conformance with Commission policy statements and need for combustible gas control)

- Dose calculations and emergency planning (source term guidance, off-site doses for emergency planning, Level II multimodule PRA results)

- Codes and standards (safety analysis assumptions, extent of experimental programs, applicability of existing benchmarks for large LWRs, validation and verification plans, and results from PIRT exercises)

- Certification of multiple modules— The NuScale team wants a single COL from NRC for a multimodule plant. However, as each reactor module is brought into service, NuScale would like a 40-year operating period assigned to individual modules.

- Payment of COL fees under 10 CFR Part 171— The NuScale team only want to pay one COL fee to NRC for the entire multimodule facility (not individual fees per reactor module).

In their presentation, NuScale identified a series of reports that will be submitted over the next 9–12 months to present additional information on the issues identified above as part of NRC's familiarization review.

- Plant design description— 1st quarter FY 2009

- Codes and methods— 1st quarter FY 2009

- On-line refueling— 2nd quarter FY 2009

- Multimodule I&C and operations staffing— 2nd quarter FY 2009

- Multimodule PRA— 3rd quarter FY 2009

- Severe accidents— 3rd quarter FY 2009

- Dose calculations and emergency planning – 3rd quarter FY 2009

3.3 PEBBLE BED MODULAR REACTOR (PBMR)

The PBMR is a high-temperature gas-cooled reactor (HTGR) that will use coated particles of enriched uranium as fuel and helium as a coolant. The reactor is rated at about 165 MW(e). South Africa (Eskom) is proceeding with plans to build a prototype PBMR with a target criticality date of 2013. Smaller versions of the PBMR have been built and are in operation in China and Japan. A preapplication review of the PBMR by NRC is proceeding but at a slow pace. There are plans for submittal of a Design Certification application on the PBMR to NRC in 2010. The PBMR design is considered to be a possible candidate for DOE's Next Generation Nuclear Plant (NGNP) to be constructed in Idaho. However, the

NRC has stated in recent public meetings that it could take them until 2013 to be prepared to conduct an independent review of a PBMR application.

The NRC held a public meeting with representatives of Pebble Bed Modular Reactor (Proprietary) Limited [PBMR (Pty) Ltd.] on May 8, 2008. However, the meeting turned out to be more of an informal question-and-answer session with NRC about their interactions with international vendors and use of international standards. NRC was quick to confirm that their review of any PBMR application would be conducted against the standards in NRC's regulatory documents and not against the national standards of the applicant.

The current PBMR preapplication review activities at NRC are focused on a series of white papers being prepared and submitted by PBMR (Pty) Ltd. on a number of technical and regulatory issues related to PBMR design requirements and licensabililty of multi-module operation scenarios. The set of white paper topics include the following:

- Licensing Approach
    - Use of PRA
    - Selection of licensing basis events (LBEs)
    - Classification of Structures, Systems, and Components (SSC)
    - Defense-in-depth (DID) approach

- Fuel
    - Fuel performance envelope and test program
    - Radionuclide release from fuel

- Codes and Standards
    - Metallics
    - Ceramics
    - Reliability Integrity Management Program
    - Electrical I&C systems

- Validation and Verification (V&V) of Codes
    - Evaluation model development and assessment
    - PIRT comparisons and application to PBMR design
    - PBMR test program
    - System response modeling
    - Fuel response modeling
    - Source terms and release modeling

- Specification for Design Certification Application
    - Single vs multimodule certification

- Physical Security Protection by Design

Again, each of the topics listed above represent potential challenges in the NRC's review of the acceptability of the PBMR design.

3.4 OTHER NON-LWR LICENSING REVIEWS

In addition to the GAR-sized reactor reviews discussed in Sections 3.1, 3.2, and 3.3 of this report, the NRC continues to interact with other designers of small reactors. In particular, the Integral Reactor Innovative and Secure (IRIS) design has been undergoing a preapplication review with the NRC with the expectation of receiving a Design Certification from NRC by 2012. The preapplication review has been deferred for the near-term; however, the IRIS designers are attempting to restart the review with the NRC. Also, organizations sponsoring the "Hyperion" reactor (a small, modular uranium hydride-fueled reactor) met informally with the NRC on February 19, 2008. No other public meetings on that reactor concept have been announced.

The most recent preapplication safety assessment report completed by the NRC for a non-LWR plant involved the Advanced CANDU Reactor (ACR) 700. The ACR-700, a light-water-cooled, heavy-water-moderated evolution of the CANDU series of reactors, was being considered by a domestic U.S. licensee. As such, Atomic Energy of Canada Limited (AECL) requested the NRC in 2002 to perform a preapplication review of the ACR-700 design. The review focused on selected topical areas of the plant design, such as

- Class 1 pressure boundary design,
- design basis accidents and acceptance criteria,
- computer codes and validation adequacy,
- severe accident definition and adequacy of supporting research and development,
- design philosophy and safety-related systems,
- Canadian design codes and standards,
- distributed control systems and safety critical software,
- on-power refueling,
- confirmation of negative void reactivity,
- preparation of standard design certification docketing,
- ACR probabilistic risk assessment methodology, and
- ACR technology base.

The NRC's preapplication safety assessment report was published in October 2004. A cursory review of the report indicates that there were many technical issues on which NRC was going to require additional information and technical justifications from AECL before the preapplication review could be completed. Example topics include the following:

- definition of Class 1 pressure boundary components (a more complex issue for reactor designs with on-line refueling);

- conformance with U.S. standards (vs Canadian standards);
- definition of design basis events, DBEs [i.e., anticipated operational occurrences (AOOs), design basis accidents (DBAs), and severe accidents];
- reactor control systems/functions for normal operations and upset conditions;
- qualification of the ACR fuel design;
- application of risk assessment methodologies and conformance with NRC policy on risk objectives for advanced reactors; and
- identification of needed exemptions from NRC regulations.

The following statements made by NRC in the "Introduction and Summary" section of the report could apply to any non-LWR supplier (especially a vendor outside the United States) attempting to have the NRC complete a preapplication review for their reactor design:

> *(The) staff concludes that the applicant will need to pursue a number of technical issues in more detail to reach satisfactory conclusions for design certification. The policy, regulatory and technical issues involved are complex. The staff expects the review and evaluation of the ACR-700 design will be more challenging, will involve expenditures of more resources, and may take longer to review than a typical light-water design.*

Recently, DOE and NRC jointly issued to Congress a *Next Generation Nuclear Plant Licensing Strategy* report to Congress. The report (August 2008) was required by the Energy Policy Act of 2005 to provide insight on the licensing process to be applied to the NGNP (assumed to be a Very High-Temperature Gas-Cooled Reactor, VHTR) and identify challenges associated with having the plant constructed and in operation by 2021. The report provides a good outline (relevant excerpts provided below) for a non-LWR vendor to consider following in mapping out a strategy to pursue some degree of regulatory approval (i.e., Design Approval, Design Certification, or Combined License) from the NRC for their design.

> *The technical approach to establishing the NGNP licensing basis and requirements is expected to include the following:*
>
> - *establishment of licensing-basis event categories (i.e., abnormal occurrences, design-basis accidents, and beyond-design-basis accidents) based on the expected probability of event occurrence; within each category, selection of licensing basis events using deterministic engineering judgment complemented by insights from the NGNP PRA.*
> - *selection of the safety-significant systems, structures, and components (SSCs) relied on to prevent or mitigate the safety-significant licensing-basis events using deterministic judgment, complemented by insights from the NGNP PRA.*
> - *establishment of conservative design and acceptance criteria for core and safety-significant SSCs, consistent with the applicable LWR requirements and recognizing the design and technology aspects unique to the NGNP.*

- *verification of adequate safety margins to the integrity and performance of core and safety-significant SSCs using a conservative analysis or a best-estimate analysis with consideration of uncertainties.*

- *establishment of special treatment requirements to ensure the required performance capability and reliability of the safety-significant SSCs using deterministic engineering judgment, complemented by insights and information from the plant PRA.*

- *use of consequence acceptance limits for onsite or offsite releases for licensing-basis events that are consistent with current dose limits for LWRs in 10 CFR Part 20, "Standards for Protection Against Radiation," and 10 CFR 50.34, "Contents of Construction Permit and Operating License Applications; Technical Information"; also, assessment of radiological consequences for licensing-basis events on the basis of event-specific mechanistic source terms.*

- *consideration of containment functional performance requirements as a radionuclide barrier in the context of design and performance of such NGNP features as the core, fuel, and cooling systems.*

- *establishment of defense-in-depth (DID) requirements using deterministic engineering judgment, complemented by risk insights, as appropriate.*

To successfully implement the above technical licensing requirements, NRC expects that it will be necessary to resolve the following NRC licensing technical policy/programmatic issues and obtain Commission decisions on these matters:

- *requirements and criteria for functional performance of the NGNP containment as a radiological barrier.*

- *allowable dose consequences for the licensing-basis event categories.*

- *approach for using the PRA to select licensing-basis events; establish special treatment requirements and establish DID requirements.*

- *acceptable basis for event-specific mechanistic source term calculation, including the siting source term.*

The NGNP applicant is expected to meet the following technical and programmatic requirements:

- *implementation of an acceptable fuel qualification test program to demonstrate the high levels of safety performance and reliability of the NGNP reactor fuel as a barrier to fission product release.*

- *fabrication quality control for fuel to ensure the requisite high level of in-reactor fuel safety performance over the lifetime of the NGNP fuel supply.*

- *use of verified and validated evaluation models, analytical tools, and methods used for the NGNP accident analysis, thermal-fluid and neutronic analysis, and*

confirmation of the acceptability of the models; also, adequate understanding and applicable data for significant radionuclide transport mechanisms for all sources and barriers and pathways to the environment, including containment design features.

- *establishment of performance and reliability of the safety-significant NGNP reactor core ceramic structures using acceptable engineering codes and standards, including materials property requirements under irradiation and accident conditions.*

- *sufficient provisions, including in-service inspections, post-irradiation examinations, and testing, to adequately inspect, examine, and test the SSCs of the NGNP reactor and plant that are determined to be safety significant; also, instrumentation to accurately and reliably monitor the safety-significant parameters and conditions of the NGNP reactor and plant.*

- *an adequate startup test and commissioning program to validate the data and assumptions used in the design of the SSCs, to demonstrate their proper functioning, and to validate the design and safety analysis methods and calculations.*

NGNP design and licensing activities may also be guided by an emerging national standard (ANSI/ANS-53.1-200X, "Nuclear Safety Criteria and Safety Design Process for Modular Helium-Cooled Reactor Plants"). The draft standard "provides a process that can be used to:

- develop MHR (modular helium-cooled reactor) top level nuclear regulatory safety criteria,

- identify safety functions, top level design criteria, licensing basis events, design basis accidents, and methods for performing safety analyses,

- determine safety classifications of systems, structures and components (SSCs), and

- identify safety related SSCs special treatment requirements and defense in depth provisions."

At the request of the Commission, the NRC staff, in a July 3, 2008, memorandum, provided recommendations on establishing criteria for funding the staff's reviews of grid-appropriate reactors. In this memorandum, the staff recommended that the current criteria for acceptance reviews of COL applications for large LWRs be applied to grid-appropriate reactors. The staff also commented on the following matters.

- For LWR designs, it was noted that many of the Commission's regulations, regulatory guides and other review guidance will likely be applicable. However, the staff may have to consider whether the reactor application adequately addresses specific technical areas where the design appears to significantly deviate from the existing NRC regulatory framework. In such cases, the staff will have to "develop the requisite technical knowledge and review guidance for areas where grid-appropriate LWR designs significantly deviate from large LWR technology."

- For non-LWR designs, a determination must be made as to whether the application "addresses all pertinent licensing matters for those designs, including key technical areas that significantly deviate from LWR-specific regulations and regulatory guidance." Further, any gaps in regulations

> or regulatory guidance for addressing unique plant design features must be identified and resolved. To address these issues, NRC would need to develop "staff expertise, guidance for conducting the review, analytical tools, and the safety bases against which to judge the application" in advance of a non-LWR application being received. Plant design issues requiring attention in this development effort include "power generation systems; fuel design, performance, and qualification; balance-of-plant design; security and safeguards; spent fuel; environmental matters; and inspection and startup testing." However, the guidance memorandum notes that such an approach could result in "extended schedules for acceptance of the application as well as review of the design."

The NRC continues to receive requests from vendors of grid-appropriate reactors for the allocation of resources to hold meetings and perform licensing reviews of documents for their reactor designs. However, because of the large number of COL applications currently under review or expected to be received by NRC, staff resources to support such requests have been limited. This information was conveyed to the Oregon congressional delegation on July 16, 2008, in response to their request that NRC "give all new reactor design certification applicants equal access to a timely review of their applications." Subsequently, in a September 16, 2008, letter, the NRC advised NuScale Power that "the staff's current plans for FYs 2009 and 2010 are to limit interactions with the designers of grid-appropriate reactors to occasional meeting and other nonresource-intensive activities."

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4. SUMMARY AND PROPOSED PATH FORWARD

Worldwide interest in obtaining energy supplied by nuclear reactors continues to grow. Large [i.e., 1000+ MW(e)] base-load nuclear units are the current focus of the global nuclear "renaissance." However, logistical and economic matters, such as remote locations, low-capability or nonexistent electrical grid systems, multiple end-use needs for nuclear-generated electricity or process heat, and increasing fossil fuel costs, make the future deployment of large numbers of small reactors likely. Consequently, DOE will need to remain aware of and involved with activities where regulatory frameworks and technical requirements are being established to authorize the siting, construction, and operation of new nuclear power plants, including the evolutionary and revolutionary reactor designs that are appropriately sized for a specific area or application.

Even though the approach to establish a collaborative effort with NRC on MDEP was not successful, DOE will need to remain aware of the activities and products of the program. As discussed in Section 2 of this report, work is currently in progress under MDEP to identify similarities and differences in the technical requirements of design codes used in various countries. ASME is involved with this activity, and the results of this work could influence future acceptability reviews by nuclear regulatory bodies (including the NRC) of nonindigenous reactor designs.

In addition, both the NRC and the IAEA have published technical reports that could serve as the basis for establishing technology-neutral regulatory requirements for future reactor designs. The NRC's work in this area is described in NUREG-1860, *Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing*. In June 2007, the NRC decided to defer further efforts to develop this regulatory structure until the NGNP licensing strategy document had been published and an application for the PBMR had been received. Still, in September 2007, Chairman Klein offered NRC's body of work on technology-neutral regulation to the international nuclear community as a possible starting point for developing common regulatory requirements for Generation IV reactors. However, the IAEA has released its own report on this subject (IAEA-TECDOC-1570, *Proposal for a Technology-Neutral Safety Approach for New Reactor Designs*). It is anticipated that most of the discussions in this area will take place under MDEP. Again, DOE should continue to remain aware of developments as they become available.

A related topic to technology-neutral regulation is the need to ensure that any new standards or regulatory guidance for advanced reactors also be "size-neutral" as well. It remains vital to the successful deployment of grid-appropriate reactor systems that the potential safety benefits offered by smaller reactors be fully realized without significant licensing delays or economic penalties being incurred through the application of regulations that are intended to address risks traditionally associated with large plants. Example concerns identified in the licensing reviews of grid-appropriate reactors include

- application of large break loss-of-coolant accident (LOCA) assumptions,
- use of containment structures similar to large LWRs,
- source term assumptions,
- definition of emergency planning zones and emergency planning requirements,
- reactor staffing requirements, and
- safeguards and security requirements.

Accordingly, any new work authorized by DOE on this project should include not only following MDEP developments but also becoming involved in codes and standards activities for advanced reactors and any NRC rulemaking initiated to set requirements for technology-neutral reactor designs.

There is a broad range of technical and policy issues whose resolution (or lack thereof) will influence the deployment of innovative reactor designs. These issues include the following:

- Use of materials in high-temperature applications
    - Design data for high-temperature effects
    - Fatigue, creep, and creep-fatigue interaction
    - Materials degradation mechanisms and data
    - Effects of impurities in coolants
    - Aging behavior of alloys during exposure to elevated temperatures
    - Sensitization of austenitic alloys
    - Carburization, decarburization, and oxidation of metals
    - Effects of neutron dose
    - Methods and reliability of in-service inspection and online monitoring
    - Development and approval of code cases for acceptance of new materials/methods

- Qualification of long-life fuel designs

- Demonstration of performance of passive plant features

- Use of probabilistic risk assessment (multimodule and nontraditional applications)

- Control schemes and requirements (multimodule and nontraditional applications)

- Qualification of fabrication facilities for modular reactors

- Ability to obtain a license by testing (provision in 10 CFR Part 52)

- ITAACs (inspections, tests, analyses, and acceptance criteria) for multimodule and nontraditional applications

- Design basis threat (DBT) definitions and general security challenges under scenarios where a large number of small reactors have been sited and are in service

Proposals have been made for industry to consider forming technical working groups to begin developing industry positions on these topics to gain clarity on the expectations of the regulator and, in doing so, identify more realistic deployment strategies for small reactors. This is an area where DOE could provide assistance to the nuclear industry.

Finally, DOE should consider organizing and conducting a public workshop on licensing of grid-appropriate reactors. In this workshop, the reactor vendors would be invited to present their perspectives on grid-appropriate reactor regulatory issues together with proposed resolutions. The NRC and other involved regulatory bodies would be invited to give a status of their MDEP deliberations and expected results. At the same time, the involved standards bodies working on harmonization of international standards would be invited to provide an update on their work and expected outcomes.

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Appendix A

MULTINATIONAL DESIGN EVALUATION PROGRAM PILOT PROJECT REPORT

MAY 2008

(Report released by the Organization for Economic Co-Operation and Development / Nuclear Energy Agency, OECD/NEA, http://www.nea.fr/mdep/mdep_pilot_project_report.pdf)

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FORWARD

The Multinational Design Evaluation Programme (MDEP) is a multinational initiative to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who will be undertaking the review of new reactor power plant designs. MDEP is organised under the Nuclear Energy Agency, which performs the technical secretariat function for the programme.

Under MDEP, nuclear regulators are aiming to enhance safety worldwide through increased cooperation. The enhanced cooperation among regulators will improve the efficiency and the effectiveness of the design review process, aiming at increased convergence of regulatory practices. The participating countries retain their sovereign authority over all licensing and regulatory decisions at all times. The programme is directed by a Policy Group consisting of the heads of regulatory authorities of the participating countries. A Steering Technical Committee (STC), formed of senior level representatives of the ten participating regulatory authorities, was established to implement the activities. A one-year pilot project was initiated to identify areas of potential convergence of regulatory requirements and enhanced cooperation among regulators. This report discusses the conclusions of the MDEP pilot project and the resulting programme of work.

The Policy Group was chaired by Mr. Andre-Claude Lacoste (ASN, France) and member countries include Canada, China, Finland, France, Japan, Republic of Korea, Russian Federation, South Africa, United Kingdom, and the United States.

EXECUTIVE SUMMARY

The Multinational Design Evaluation Programme (MDEP) is a multinational initiative to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who will be tasked with the review of new reactor power plant designs. MDEP was originally envisioned as a three stage process: Stage 1 involved multilateral cooperation within existing regulatory frameworks; Stage 2 focused on enhanced multinational cooperation and convergence of codes, standards, and safety goals; and Stage 3 was envisioned as the implementation of Stage 2 products to facilitate licensing processes for new reactors, including those being developed by the Generation IV International Forum. A year-long pilot project was initiated to assess the feasibility of the Stage 2 goals. This report provides the findings of the pilot project and future actions for the programme including a restructuring of the stages into a single programme.

The pilot project consisted of two working groups to assess the feasibility of the programme. The first group was tasked with evaluating the similarities and differences in the licensing basis, scope of design review and safety goals of the participating countries. The second group was tasked with assessing the regulatory requirements and review associated with the manufacturing processes for components for use in nuclear power plants. The project was to assess both the regulatory requirements and programmes associated with licensing new nuclear plants. To facilitate completing this task within one year, the programme was focused on three selected areas, namely, Severe Accidents, Emergency Core Cooling System performance, and Digital Instrumentation and Control (I&C) Systems. The study of these selected areas provided insights into both these specific areas, and more broadly, the overall licensing basis, scope of design review, and use of safety goals in the participating countries. By considering a broad range of vendor, utility, and regulator activities for each of these three topics, a sufficiently broad understanding of the regulatory activities in each country was developed.

The pilot project demonstrated that there is a significant benefit in continuing a multilateral effort to cooperate on new reactor reviews. The pilot project also demonstrated that MDEP provides a reasonable tool for working together to identify areas for cooperation.

The results of the pilot project indicate that full convergence of regulatory requirements is not feasible in the short-term (i.e., for the reactor designs currently under review). However, participating countries should continue with cooperation initiatives, as increased cooperation is a prerequisite to convergence. Cooperation will allow a better understanding of each other's processes to encourage and facilitate eventual convergence. Increased understanding developed through cooperation will also allow increased use of the regulatory assessments carried out by other regulatory authorities, while ensuring that the ultimate decision making authority remains with each country's regulatory authority. In addition, there is benefit to formalising interactions and cooperative arrangements for specific reactor designs. The programme concluded that convergence should be pursued on specific reference regulatory practices which will help in further cooperation. Convergence on practices is considered more useful and feasible, as a first step, than convergence on regulations because regulatory practices are generally not written into law and are easier to change than the regulations themselves.

Opportunities for enhanced cooperation were identified in specific technical areas within existing regulatory frameworks. The programme also identified areas where enhanced cooperation will be facilitated by establishing reference regulatory practices. These opportunities will be pursued through the development and implementation of a revised Multinational Design Evaluation Programme. The new programme combines all stages of MDEP into a single programme. The focus of the new programme will be on enhanced cooperation on design evaluations and inspections. The specific recommendations developed from the pilot project constitute the foundation of the new programme, and successful implementation of the recommendations will result in tools that can be used to enhance the ability of regulatory authorities to cooperate in reactor design evaluations, vendor inspections, and construction oversight, leading to more efficient and more safety-focused regulatory decisions.

The revised programme will be implemented under the MDEP Policy Group and the Steering Technical Committee (STC), with NEA continuing to serve the Secretariat function. Two types of working groups will be formed under the STC:

- Design specific working groups to share information and cooperate on specific reactor design evaluations. A working group will be created for each new reactor design that is under review by multiple countries. Participants in these working groups will be the countries who are actively reviewing, or preparing to review, the specific reactor design. A working group will absorb the activities currently being undertaken by the US, Finland and France to share information on the EPR review as part of MDEP Stage 1.

- Issue-specific working groups to address regulatory process issues such as component manufacturing oversight and technical issues such as digital instrumentation and control standards.

The working groups identified above will be responsible for implementing the following activities. These activities were identified as actions that are both beneficial and achievable in the near term, and will result in improved international cooperation.

<u>MDEP activities</u>:

1. Share information and cooperate on specific reactor design evaluations under current reviews

2. Undertake a multinational vendor inspection cooperation programme

3. Converge on codes and standards for pressure boundary components by completing an evaluation of their similarities and differences

4. Evaluate the similarities and differences in other codes and standards, beginning with a comparison of the digital instrumentation and control standards.

5. Complete the evaluation of the similarities and differences in the overall scope of the regulatory review and analysis for severe accidents and develop a draft reference scope of review

6. Compare how top level safety goals are derived, expressed, achievement is judged among the participating countries, and determine the extent to which they can be considered equivalent.

7. Compare the approaches used for taking account of operating experience in regulatory reviews for new reactors.

8. Develop a programme to collect, share, and use construction experience feedback in regulatory reviews.

9. Develop a legal framework and the necessary agreements that will support the free exchange of information, including the results of independent analysis and research, among MDEP participants.

10, Establish a "library" to collect and share regulatory documents of common interest describing design requirements and guidance, review process and inspection programme of new reactors. Complement this regulatory library with a list of technical reviews already performed and available for free exchange of information on request

Background information and preliminary implementing strategies for each of these activities is included in the body of the report.

PART I BACKGROUND INFORMATION

1. Objectives

The main objective of MDEP, as set in the original Terms of Reference, was to establish reference regulatory practices and regulations to enhance the safety of new nuclear reactor designs. This goal is based on the concept that convergence of regulatory practices and regulations associated with the reactor design reviews would allow for enhanced cooperation among regulators, improving the effectiveness and efficiency of the regulatory design reviews, which are part of each country's licensing process. The establishment of reference regulatory practices and regulations would also: enable and encourage safer global standardised reactor designs; facilitate the design reviews of new reactors in many countries; and further public understanding and acceptance of safety goals on an international basis.

The expected results of MDEP, as set in the original Terms of Reference, were to:

- Increase knowledge transfer through the exchange of information on regulatory practices used by the participating countries in their design reviews, covering inter alia technical evaluations, codes, standards and safety goals, inspection practices, licensing requirements, safety research and operating experience.

- Identify similarities and differences in regulatory practices and obtain insights in order to better understand the technical basis for the differences.

- Seek for and achieve convergence on reference regulatory practices in order to facilitate more efficient and effective design reviews, if reasonably practicable.
- Implement the results on specific designs for new reactors.
- Further understanding of regulatory practices on an international basis.
- In completing its work, it is anticipated that the outcome will constitute a very useful input to upgrade the IAEA Safety Standards.

Ultimately, this is expected to lead to a convergence of codes, standards and safety goals in the participating countries. To this end, a pilot project, consisting of two working groups, was launched. The first working group investigated the licensing basis for new nuclear reactor designs, the scope of design safety reviews and overall safety goals. The second examined regulatory oversight of components manufactured for new nuclear reactors.

2. Organisation

MDEP is governed by a Policy Group (PG) and implemented by a Steering Technical Committee (STC), each consisting of representatives from each of the participating countries.

Participation in the Policy Group and STC is intended for interested countries that already have commitments for new build or firm plans to have commitments in the near future for new reactor design. Ten countries were members of MDEP, including seven NEA members (*): Canada*, China, Finland*, France*, Japan*, the Republic of Korea*, the Russian Federation, South Africa, the United Kingdom* and the United States*. In addition, the International Atomic Energy Agency (IAEA) takes part in the work of MDEP by contributing to the STC, working group and technical experts meetings. NEA performs the technical secretariat function.

The Policy Group consists of the heads of the participating regulatory authorities. The Policy Group approves the Terms of Reference, provides guidance to the STC, and monitors the progress of the programme.

The STC manages and approves the detailed programme of work, defines the topics and working methods, performs as a working group for broad scope topics to exchange information and produce reports, establishes technical expert groups, and reports to the PG.

A Component Manufacturing Oversight Working Group was formed for the Pilot Project and was given the task of assessing the regulatory requirements and review associated with the manufacture processes for components for use in nuclear power plants. The working group consulted with the MDEP STC as necessary (and provided progress reports) to facilitate the effort. The nuclear industry participated in the activities of the working group.

3. Conduct of Pilot Project

The Pilot Project consisted of two working groups to assess the feasibility of the programme. The first group was tasked with evaluating the similarities and differences in the licensing basis, scope of design review and safety goals of the participating countries. The second group was tasked with assessing the regulatory requirements and review associated with the manufacturing processes for components for use

in nuclear power plants. The project was to assess both the regulatory requirements and programmes associated with licensing new nuclear plants.

To facilitate completing the first task within one year, the Pilot Project focused its attention on: 1) the regulatory requirements; and 2) the regulatory programmes and practices in three selected technical areas, namely, Severe Accidents, ECCS Performance, and Digital Instrumentation and Control (I&C) Systems. The study of these selected areas was expected to provide insights into both these specific areas, and more broadly, the overall licensing basis, scope of design review, and use of safety goals in the participating countries. By considering a broad range of vendor, utility, and regulator activities for each of these three topics, a sufficiently broad understanding of the regulatory activities in each country was developed, to support findings and recommendations to the MDEP Policy Group.

The Pilot Project activities included a survey in which the same set of questions was asked in each technical area. The survey was answered by technical experts in each participating regulatory authority and relevant information was provided by the IAEA. The survey results were distributed to the MDEP participants and their national experts. The survey results identified that in some aspects there were sufficient similarities in the responses in each area to treat them as "generic" and a separate expert group was set up to evaluate these further. The areas covered by this group included overall safety requirements, quality assurance, role of external bodies in the reviews. The participants also determined that additional meetings of technical experts in the three specific areas were necessary to provide more complete information on the regulatory policies and practices in each country and to identify similarities and differences.

Each aspect of regulatory requirements and programmes was categorized depending on the level of similarity among the participating countries, as follows:

A) High degree of similarity — Significant opportunities for cooperation now and a high potential for convergence in the near-term.

B) Moderate degree of similarity — Moderate potential for cooperation and/or convergence in the near-term.

C) Low degree of similarity — Limited opportunity for cooperation in the near-term. Significant technical and programmatic obstacles to achieving convergence.

Qualitative cost/benefit factors were considered for each area. Factors that were included in judging the potential benefit or value of cooperation on an issue include the potential for knowledge transfer of technical information, the applicability of safety-related information, enhanced safety decision making, increased public confidence in safety decisions, and the potential for effectiveness and efficiency gains. Factors that were considered in judging the difficulty and the direct costs of increased cooperation include, the need for formal regulatory programme changes (e.g. changes in staff practice vs. changes in regulations vs. changes in national laws or decrees), regulatory complexity relative to an existing regulatory framework, resource investment required to achieve convergence and applicability of an approach or issue to a particular reactor design under consideration. The topic experts made a judgement about the potential benefits and difficulties or costs associated with cooperation and convergence.

The Working Group on Component Manufacturing Oversight (WGCMO) was given the task of assessing the regulatory requirements and review associated with the manufacturing processes for components for use in nuclear power plants. In addressing this subject, the working group focused on the highest safety class pressure boundary components (e.g.: pumps, valves, piping, and pressure vessels). In carrying out its work, the working group focused its review on the use of codes and standards, quality

assurance/management programmes, and inspection programmes by the manufacturer, designated third party inspection agency, the customer (i.e. licensee, applicant), and the regulatory authority.

To achieve its task the participants shared information on how their respective organisations performed regulatory oversight on the manufacturing of major components especially quality assurance programmes. This was followed by the issuance of a survey. Based on the results of this survey and group discussions, a supplementary group of questions was derived. The purpose of asking these supplementary questions was to identify points of convergence and divergence among regulatory practices in order to develop a potential path to reconciling the differences and leading to increased regulatory cooperation between regulators in the review and approval of the highest safety class pressure boundary components.

In addition to the survey and group discussions, the group communicated with and met with other interested and affected parties including vendors (AECL, Westinghouse, Areva and Doosan), and codes and standards organisations (ASME, AFCEN/RCCM, KEA/KEPIC and JSME). Additionally, members visited and communicated with manufacturers (Doosan, Japan Steel Works, Areva and Mitsubishi) producing high safety class pressure boundary components in order to better understand their respective Quality Assurance/Management programmes and how they meet various international standards imposed by different MDEP countries. The working group developed a final report addressing: areas of commonality and areas of differences; the nature, importance, and basis for the differences; potential areas for increased regulatory cooperation; and areas for potential programme modifications to minimise or eliminate those programme differences where appropriate.

The findings and recommendations of the technical experts and the working group were evaluated in the development of integrated recommendations to the MDEP Policy Group. The recommendations were chosen based on the likelihood of success, including the support of the participating regulatory authorities for each activity, as well as the resources required. The lower priority recommendations were not put forward, recognising the limited resources available. However, there is an understanding that the working groups may decide to pursue additional efforts, such as the lower priority recommendations, based on resources available and the success of the initial recommendations. The participating regulators focused on proposing results-oriented recommendations with clearly defined actions and goals. The feedback and lessons-learned from the MDEP Stage 1 on-going activities were considered in developing the recommendations. The recommendations were incorporated into a revised MDEP programme discussed in part III of this report.

PART II FINDINGS

This section provides a consolidated summary of the findings of the Pilot Project.

All regulatory programmes include the concepts that the health and safety of workers and the public must be assured. This goal has been developed and restated in many ways, leading to a myriad of different requirements with different degrees of detail. Some of these are at the level of safety goals, whereas others set out specific objectives but still at a high level. More prescriptive regulatory regimes define more explicitly the design approaches to be employed, the procedures and analysis approach to be used, and the specific objectives which must be met.

In all cases, the need to protect the worker and public from the effects of accidents is recognised. Some countries address the safety requirements in terms of frequencies of release to the environment or doses to individuals, others in terms of damage states without associated frequencies whereas others provide requirements in terms of system performance. Laws, regulatory requirements and practices, as well as design and manufacturing codes and quality assurance requirements related to high safety class pressure boundary components, differ from country to country.

There are some important differences in legal bases and regulatory regimes which may be major difficulties to obtaining full harmonisation of requirements and may also impose limitations on using the work of other Regulatory Authorities, including:

- the form in which top level safety goals are expressed and developed;
- whether meeting regulatory standards is mandatory;
- the degree and form of licensee/vendor documentation;
- the processes used in the regulatory review; and,
- the way operating experience is incorporated in the regulatory review;
- the nature of the regulatory authorities' quality assurance system.

The basis of many regulations is strongly coupled to historical and social /political factors. Past events and accidents as well as research results have played a key role in the regulatory approaches being followed currently. There was a clear realization among the participants that there remains inertia behind existing regulatory frameworks that could pose obstacles when considering changes to existing regulations.

The ECCS expert group found commonalities in approaches to ECCS evaluation and regulation. These commonalities are often based upon reactor types, and offer the potential for harmonisation of licensing bases and safety goals in this area. In particular, a process that relies on sharing technical data and analysis capabilities will lead to opportunities for greater technical cooperation that could lead to a technical consensus for a performance based framework to regulation. The expert groups discussed the potential for achieving harmonisation given the current set of various regulatory approaches followed and concluded that a successful path to harmonisation would be to "start anew" with a performance-based framework of regulations.

The ECCS expert group found that placing an emphasis initially on specific reactor types provides the most common ground upon which to cooperate and share results of design reviews. This work will be a catalyst for further technical cooperation and sharing of results.

In the area of digital I&C requirements, there appears to be a higher degree of similarity regarding the regulatory requirements imposed on the licensee/designer than on the regulatory assessment practices.

The expert group on severe accidents concluded that a significant degree of similarity exists in the regulatory processes for reviews performed to ensure that design requirements have been met, and independent analyses and calculations performed by the regulators to verify and/or validate the acceptability of the design. Many countries follow the basic objectives defined in IAEA Safety Guide GS-G-1.2, "Review and Assessment of Nuclear Facilities by the Regulatory Authority." All participating countries perform detailed reviews of the safety analysis to various extents, including independent confirmatory analyses and calculations. The group also noted that there is a general level of design requirements that is in line with the IAEA Safety Requirements in applying a deterministic approach, for example defence in depth, single failure criteria, and safety margins. Likewise, there are similarities in the application of probabilistic methods in complementing the deterministic approach.

The experts concluded that a considerable degree of similarity exists regarding the Severe Accident qualitative requirements, including the scope, level of defence-in-depth approach, supporting principles, deterministic analysis, and probabilistic safety assessment quality, scope and methodology. However, it was concluded that the numerical safety goals were different.

The MDEP participants identified opportunities for greater technical cooperation in areas such as sharing technical data and analysis capabilities among the participating countries. The added cooperation among MDEP members will allow for increased knowledge transfer through the exchange of information and will help in convergence of multinational regulatory practices.

The Working Group on Component Manufacturing Oversight (WGCMO) found that component manufacturing is currently subject to multiple inspections and audits similar in scope and in safety objectives, but conducted by different organisations. The formation of multi-national regulatory teams to perform inspections of component manufacturers will improve effectiveness and efficiency in the regulatory assessment of highest safety class components. This approach, using a multi-national auditing or inspection team, may also be viable for the nuclear power plant owners, similar to the NUPIC process in the United States.

The WGCMO found that for the design and manufacture of highest safety class pressure boundary components, adherence to design codes and standards is a minimum requirement in showing adequacy. Additional country specific criteria also needs to be satisfied by design and manufacturing organisations. From a survey conducted amongst the regulatory authorities it was clear that regulatory requirements were fundamentally the same for all of the highest safety class components that are part of the pressure boundary. The various design codes and standards are not fundamentally different, although their scope may differ. Further convergence by the code organisations could be beneficial but would require substantial effort. Initially, it is beneficial to establish a retrievable data base of the differences.

PART III CONCLUSIONS AND ASSESSMENT

1. General Conclusions of the Pilot Project

Completion of the pilot project, and the experience gained to date from cooperation among France, Finland and the U.S. on the EPR design review, provided sufficient information to support the following general conclusions:

1. increased multinational cooperation on new reactor regulatory activities is highly desirable and highly feasible;

2. convergence on selected reference regulatory practices is feasible and should be pursued;

3. convergence on reference regulatory requirements should remain a long term goal and progress towards that goal will be facilitated by the near-term MDEP programme of work.

The use of "regulatory practices" as used in this report, is defined as programmes and processes used by the regulators to accomplish safety reviews. Regulatory requirements are the criteria and standards that the regulators apply in making regulatory and safety decisions.

The pilot project demonstrated that is a significant benefit in continuing a multilateral effort to cooperate on new reactor reviews. The pilot project also demonstrated that MDEP provides a reasonable framework for working together to identify areas for cooperation. The goal of MDEP is not to independently develop

new regulatory standards, but to build upon the similarities already existing and existing harmonisation in the form of IAEA and other safety standards.

The results of the pilot project identified that full convergence of regulatory requirements is not feasible in the short-term (i.e., for the reactor designs currently under review). However, participating countries should continue with cooperation initiatives, as increased cooperation is a prerequisite to convergence. Cooperation will allow a better understanding of each other's processes to encourage and facilitate eventual convergence. Increased understanding developed through cooperation will also allow increased use of the regulatory assessments carried out by other regulatory authorities, while ensuring that the ultimate decision making authority remains with the each country's regulatory authority. In addition, there is benefit to formalizing our interactions and cooperative arrangements for specific reactor designs. The Policy Group concluded that convergence should be pursued on specific reference regulatory practices which will help in further cooperation. Convergence on practices is considered more useful and feasible, as a first step, than convergence on regulations because regulatory practices are generally not written into law and are easier to change than the regulations themselves.

2. Next Steps

Opportunities for enhanced cooperation were identified in specific technical areas within existing regulatory frameworks. The pilot project also identified areas where enhanced cooperation would be facilitated by establishing reference regulatory practices. These opportunities will be pursued through the development and implementation of a revised Multinational Design Evaluation Programme. The focus of the new programme will be on enhanced cooperation on design evaluations and inspections. The specific recommendations developed from the pilot programme activities constitute the foundation of the new programme, and successful implementation of the recommendations will result in tools that can be used to enhance the ability of regulatory authorities to cooperate in reactor design evaluations, vendor inspections, and construction oversight, leading to more efficient and more safety-focused regulatory decisions.

The goals of the revised programme are to:

1. increase knowledge transfer through the exchange of information on regulatory practices used by the participating countries in their design reviews;

2. identify similarities and differences in regulatory practices;

3. move toward convergence on specific reference regulatory practices in order to facilitate more effective and efficient reviews of new reactor designs;

4. increase stakeholders understanding of regulatory practices on an international basis; and

5. enhance the ability of regulatory authorities to cooperate in reactor design evaluations, vendor inspections, and construction oversight.

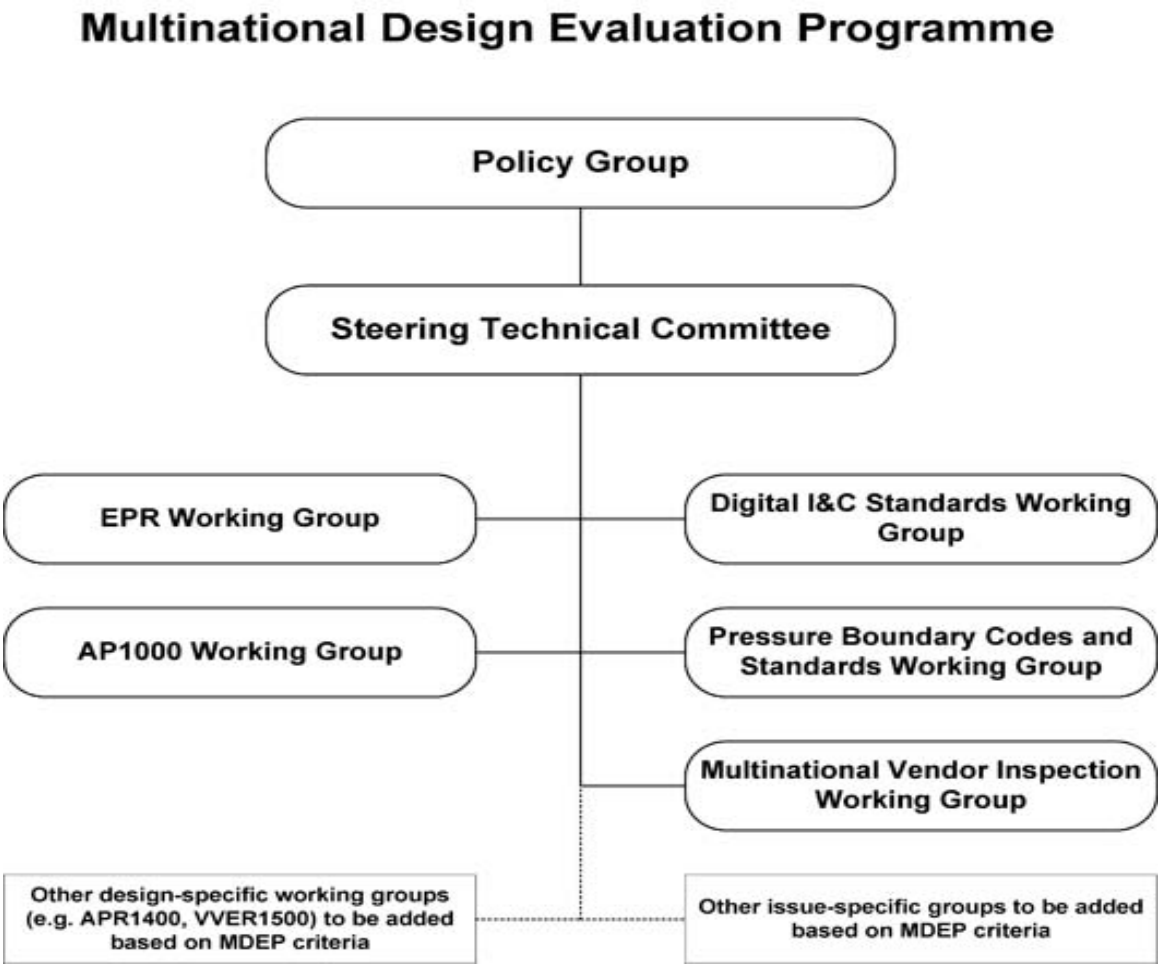
The revised programme will be implemented under the MDEP Policy Group and the STC, with NEA continuing to serve the Secretariat function. Two types of working groups will be formed under the STC:

1. Design specific working groups to share information and cooperate on specific reactor design evaluations. Criteria for establishing design specific groups is: the interest of three or more regulators with a formal request or application from a vendor or utility for regulatory action, a commitment to active participation in the topics, and a commitment to provide current information through the MDEP library. A

working group will absorb the activities currently being undertaken by the US, Finland and France to share information on the EPR review as part of MDEP Stage 1.

2. Issue-specific working groups to address regulatory process issues such as component manufacturing oversight, and technical issues such as digital instrumentation and control standards. Participation in issue specific groups will be open to interested MDEP regulators and to IAEA, and will be based on active participation in the topic and the availability to provide up to date information through the MDEP library.

The chart below illustrates how the programme will be organised.



(Note: The MDEP Library discussed in the OECD/NEA report is not depicted in the above chart.)

The working groups identified above will be responsible for implementing the following activities. These activities were identified as actions that are achievable in the near term, and will result in improved international cooperation. The implementing strategies discussed below are preliminary. Actual methods and schedules will be developed by the STC or the appropriate working group.

MDEP Activities

1. Share information and cooperate on specific reactor design evaluations under current reviews.

Background: Based on the experience of cooperation on the review of the EPR design between Finland, France and US, a working group will be created for each new reactor design that is under review by three or more of the participating countries. Participants in these working groups will be the countries who are actively reviewing, or preparing to review, the specific reactor design. The goal will be to maximize interaction and cooperation on design reviews among experts to make technical analysis more robust and to optimize the resources needed to perform national assessments.

Implementing Strategy: This action will be implemented by design specific working groups. The working groups will first identify the similarities and differences in the designs submitted by applicants in each country and ensure a clear understanding of the basis for those differences (regulatory requirements; utilities requirements to the vendor...). Based on the findings, the working group will focus technical cooperation through knowledge transfer on technical reviews already performed and mutual assistance on technical reviews to be performed. To be efficient, each country involved in a working group will identify a delegate for meeting preparation and send relevant experts according to the agenda of the meetings. Meetings will be hosted and take place in participating countries. Interaction with the vendor of the specific design may take place based on the programme of work. The NEA will provide secretariat services for the meetings and activities. The working groups will share the results and outputs of their interactions with nonparticipating countries as appropriate. The EPR working group will continue and a new Working Group will be created for the AP 1000 design. Additional groups for designs such as the ESBWR, APR 1400 and the AES 2006 may be set up based on the established criteria.

2. Undertake a multinational vendor inspection cooperation programme

Background: If a determination can be made by the various national regulatory authorities that the design and quality codes taken as a whole are equivalent, i.e., they provide an acceptable level of quality and safety, then it may be possible for one country's regulatory authority to credit inspections performed by other countries to the extent inspections are performed. It should be noted that the level of vendor oversight by regulators varies considerably from country to country. This variability also needs to be taken into account in deciding how much of another regulators work can be credited. Also, some countries have unique requirements. With the large number of vendors supplying nuclear grade components, both electrical and mechanical, it will not be possible for any regulatory authority to inspect all but a fraction of the vendors. While it may not be possible to fully credit another regulator's vendor inspection programme and limited scope inspections may be necessary for notification of substantial defects or specific requirements applicable in other countries, a multi-national vendor inspection programme will be able to provide insights on the effectiveness of quality programmes of a larger number of vendors which, can be shared by all participating countries. It should be noted that several inspections of component manufacturers have already been carried out with multinational participation and/or observation.

Implementing Strategy A working group will be established. The group will identify areas of commonality and differences between regulatory practices of participating countries in the area of vendor inspection programmes. The working group will develop an overall framework and timeline for the conduct of inspections of vendors and a protocol for sharing results among

national regulatory authorities. Longer term, the working group will develop a draft international inspection programme and conduct a pilot vendor inspection with a multinational regulatory team to test the programme. The programme of inspections should be coordinated with the design specific working groups.
Near-term outputs will be accomplished in one year. Longer term outputs will be accomplished in approximately two years.

The NEA will provide secretariat services for the meetings and activities. Representatives from the participating countries with knowledge of vendor inspection and quality programmes will participate as necessary to accomplish the stated outputs.

3. Converge on codes and standards for pressure boundary components by completing an evaluation of their similarities and differences

Background: The primary expected output of this activity is a retrievable data base of the similarities and differences among the codes and standards used in the design of pressure boundary components. The initial effort will emphasize similarities and differences among the codes and standards used in the U.S. (ASME), France (RCCM), Japan (JSME), and Korea (KEPIC). Owing to the history of these codes and standards, and previous efforts to compare them, these codes and standards are believed to be a credible starting point. Subsequent activities to reconcile any differences or determine the equivalence of similar requirements among these codes are the province of the code organisations but the database of similarities and differences will be useful to designers and to regulators. Recognising that Codes and Standards are periodically revised, an additional output is the development of a protocol to keep the database current. As a following effort, comparisons of these codes and the Russian codes and standards will be undertaken to identify the similarities and differences with the other codes and standards.

Implementing Strategy: A working group will be established. The group will perform an assessment of the similarities and differences and develop a preliminary database for the ASME, RCCM, JSME, and KEPIC codes and standards within approximately one year. Efforts regarding the Russian codes and standards will continue for at least another year. The working group will act as enablers for the codes and standards organisations who, by the nature of this work, will ultimately perform the tasks.

The NEA will provide secretariat services for the meetings and activities. Representatives from each of the participating countries with knowledge of codes and standards will participate, and will interact with representatives of the codes and standards bodies to identify the similarities and differences. The Working Group members will provide the effort needed to structure the database.

4. Evaluate the similarities and differences in codes and standards in all areas beginning with Digital Instrumentation & Control standards.

Background: In moving towards convergence, the codes and standards used in design, manufacture, installation and construction of new reactor designs are fundamental. It will be useful, therefore, to carry out a regulatory comparison to identify the similarities and differences. In the case of the latter, an evaluation should be conducted of whether the differences are significant, or merely different ways of expressing essentially the same requirements. The codes and standards considered should include those related to quality assurance, design change control, and any others that might have an affect on the safety of the facility. The programme has already identified that a comparison of the Digital I&C standards is worthwhile.

Implementing Strategy A working group will be established for digital I&C standards. The working group will interact with the organisations in charge of the standards to seek their participation in performing a comparison exercise. The working group will then analyse the result of the comparison exercise and identify which differences should be rated as priority for increased convergence work. As a long term goal, the working group should interact again with the relevant organisations with the aim of getting increased convergence. Discussions on this issue will also take place in the design specific working groups and, therefore, effective coordination is required to ensure adequate exchange of information and to avoid duplication.

Other potential issues (following digital I&C) that may be looked at are conventional components (e.g., diesel generators, pumps, etc.) to be used in nuclear systems.

5. Complete an evaluation of the similarities and differences in the overall scope of the regulatory review and analysis for severe accidents and develop a draft reference scope of review

Background: The goal of this activity is agreement by the MDEP participating regulatory agencies on a reference level of the overall scope of the regulatory review and analysis. This could be based on IAEA recommendations. A long term goal is a harmonised scope of the regulatory review and analysis in the area of severe accidents.

Implementing Strategy Work on this issue is currently being performed in NEA and IAEA. It is necessary to assess this ongoing work before proceeding with any activities under MDEP. Accordingly, the STC will review and assess the issue and provide any proposed actions at the next PG meeting.

6. Compare how top level safety goals are derived, expressed, achievement is judged among the participating countries, and determine the extent to which they can be considered equivalent.

Background: The overall goal of safety regulation is to ensure that licensees operate their facilities so that risks to people and the environment are at an acceptable level. This goal is expressed in the form of top level goals which are used to derive more detailed goals for particular situations and equipment. The top level goals are expressed in different ways and this means that, firstly, it is not obvious if they are equivalent and, secondly, lead to different approaches to and forms of, the more detailed goals. To enhance cooperation in using other regulators assessments and understanding of how decisions have been reached, it is important to have a good understanding of these top level goals and the extent to which they are equivalent.

Implementing Strategy Work on this issue is currently being performed in NEA and IAEA. It is necessary to assess this ongoing work before proceeding with any group in MDEP. The programme will monitor IAEA and NEA publications due out at the end of 2008. The STC will review and assess the issue and provide any proposed actions at the next PG meeting.

7. Compare the approaches used for taking account of operating experience in regulatory reviews for new reactors.

Background: All new reactor designs claim to be improvements on previous/current designs in terms of safety and effects on the environment. An important factor in demonstrating this improvement is to consider the operational experience feedback (OEF) from similar plants, other

reactors and relevant non-nuclear facilities, both within the country and internationally. The initial survey showed a wide range of approaches used in different countries and it is necessary to understand these differences and how they affect the regulatory review process if use is to be made of other regulators reviews. A particular issue is the approach used by regulators when considering completely new types of reactor design for which no direct operating experience is available.

Implementing Strategy Work in these areas is being performed by the CNRA Working Groups on Operating Experience (WGOE), on Regulation of New Reactors (WGRNR) and on Inspection Practices (WGIP). MDEP members will communicate and exchange information with these groups and report back to the STC on how operating experience is being applied to new reactors and how construction experience is being collected, shared and used for new build.

8. Develop a programme to collect, share, and use construction experience feedback In regulatory reviews.

Background: New plant construction is currently underway in several countries and several are in the process of reviewing applications or assessing new reactor designs. Sharing information concerning construction experience and inspection will be helpful. The CNRA Working Group on Regulation of New Reactors (WGRNR) will prepare a report on the collection of construction experience for reactors or other nuclear facilities including methodology, criteria, etc. This new data base should allow regulators to share experience during the coming new phase of construction which can be incorporated into their regulatory oversight and improving their inspection programmes.

Implementing Strategy: Based on the CNRA initiative, a specific MDEP working group will not be established in the near term. The MDEP members will observe the activities of the CNRA WGRNR and provide a forum for communicating information between the MDEP members and the CNRA working group. NEA will facilitate this action.

9. Develop a legal framework and the necessary agreements that will support the free exchange of information, including the results of independent analysis and research, among MDEP participants.

Background: In order for the MDEP to be successful at fulfilling its goal of leveraging the work of peer regulators in the licensing of new nuclear power plant designs, a legal framework needs to be developed that will facilitate the sharing of technical information among MDEP participants. Because each country has its own unique policies and requirements regarding the release/sharing of information, including security considerations, a legal framework must be developed that is acceptable to all participating MDEP regulators.

Implementing Strategy: The expected output of this action is an agreement document that details the procedures regarding the access and dissemination of technical information among MDEP participants. The NEA will take the lead in drafting the legal document. The goal is to reach agreement on a legal framework within 6 months.

10. Establish a "library" to collect and share regulatory documents of common interest describing design requirements or guidance, review process and inspection programme of new reactors. Complement this regulatory library with a list of technical reviews already performed and available for free exchange of information on request

Background: Enhanced cooperation can be fostered through the use of modern information technology, such as, the creation and maintenance of an interactive, regulatory knowledge management system, available to all MDEP participants, for collecting and sharing information relevant to new reactor design evaluations. Such cooperation should take the form of sharing regulatory documents of common interest describing design requirements and guidance, the review process, and the inspection programme for new reactors. These documents should be provided by, and accessible to, the participating regulatory authorities. This will address the MDEP goal of increased knowledge transfer among regulatory authorities

Implementing Strategy: A list of reviews already performed and available for free exchange of information on request will be included in the library. To enhance cooperation, it will be beneficial to include in this list a brief summary of the content and regulatory background of each document. A standard model for this summary will therefore be developed.

Modern, information technology tools and methods will be employed to facilitate such sharing and cooperation. This could consist of an information technology application such as an interactive website on which research by topics, countries and reactor design could be performed.

A searchable working library of publicly available documents should be available for use by the end of 2008. The NEA will have the lead for establishing the library with oversight by the STC.

3. Structure of MDEP going forward

It is the judgment of the Policy Group that the best way to meet the long terms goals of MDEP is to focus on cooperation and convergence of regulatory practices that will eventually develop into convergence of regulatory requirements. Progress towards harmonized regulatory practices and requirements for Generation IV reactor designs will be a natural outgrowth of the activities discussed above, and may be implemented through a separate working group under the STC in the structure proposed. The eventual inclusion of future reactor activities as a working group, in addition to the inclusion of the current Stage 1 activities as a design specific working group, obviates the need for a three stage programme. Therefore, all stages of MDEP will be combined into a single programme with the structure previously described.

Funding is necessary in order for the technical secretariat to carry out its support functions and will be collected equally from each of the participating countries. Membership of MDEP will remain as is for the present time. The programme will explore methods to share information with other non-MDEP countries interested in new build.