

Report from Como:

Expanding Nuclear Power to New States - Defining Needs and Exploring Paths to Success

10-14 June 2008
Villa del Grumello, Como, Italy



Organized by



International Working Group - Landau Network-
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Texas Engineering Experiment Station
(TEES), College Station, TX, USA

in cooperation with



World Nuclear
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and Technology
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Research
Development
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Note to Readers

Today we witness growing energy demands everywhere, increasing prices for energy-related commodities on world markets and increasing evidence of the adverse impacts of man on our environment. Population growth forecasts lead only to concerns that the problems of today will continue to worsen unless changes are made.

Electrification of as many of our activities as possible offers a means to reduce inefficient combustion processes and thereby reduce greenhouse gas emissions. Intensive conservation and efficiency efforts can reduce electricity demand. Emphasizing low carbon electricity generating technologies as a blueprint for the future can meet future needs under the best attainable conditions.

Of the low carbon technologies, nuclear power is unique in that it can be expanded to provide orders of magnitude more power than at present, including base-load generation, special industrial applications and peak-load balancing for mixtures of power technologies. While the two most famous nuclear accidents remain in our minds, evolutionary improvements in nuclear power technology have created today an industry with impressive operational performance and new designs that promise enhanced safety, lower construction costs per kwh, and longer anticipated lifetimes than in earlier designs. Reflecting renewed confidence, new build orders and planning activities are increasing around the world.

Nuclear power offers promise to the developing areas of the world as well. Novel deployment arrangements offer opportunities for the experience gained in vendor States to be made available in developing countries until they are self-reliant, thereby accelerating the expansion of nuclear power under safe and responsible arrangements. New reactor designs of lower power offer features that should bring nuclear power to many more countries, as their designs are certified and as experience is gained in their operations and economic performance.

Nuclear power carries with it unique challenges for success and for responsible stewardship. Human resource development is the most critical infrastructure area required for success, together with access to nuclear power technology and the goods and services needed for sustained operations. For nuclear power to have a significant impact in the developing areas of the world, nuclear finance must change from being front-end loaded to recovering investments on the basis of revenues from the sale of nuclear generated electricity and other energy products once the reactors are in operation. Planning today to address nuclear wastes in a global manner will convince a public skeptical of how this legacy can be tamed. Preventing accidents, preventing the proliferation of nuclear weapons through the abuse of nuclear

power programs, and preventing terrorism involving nuclear plants, nuclear fuels and radioactivity are essential for nuclear power to contribute to the world's growing nuclear energy needs.

The issues surrounding the global expansion thus challenge us, one and all. International Working Group and Landau Network-Centro Volta is pleased to provide a non-governmental venue where intelligent pursuits of options and preferences can be explored, and where innovative ideas can be broached, however imaginative they might at first seem.

This Invited Technical Meeting has met this challenge and could serve as a point of departure for our future.

Maurizio Martellini
Secretary General, Landau Network - Centro Volta
and Executive Secretary, International Working Group

Como, Italy
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Expanding Nuclear Power to New States - Defining Needs and Exploring Paths to Success

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Expanding Nuclear Power to New States: Defining Needs and Exploring Paths to Success

Is the nuclear renaissance intended only for industrialized States, or will it also impact the developing areas of the world? Great differences exist within the latter group; some have nuclear power already, some have well-established capabilities that give them a substantial start on preparing for nuclear power; others have challenging issues of political stability, technical infrastructure or economic strength. Addressing the requirements for responsible stewardship of nuclear power while taking these challenges into account will improve the chances of success for those who hope to benefit from nuclear power.

Bringing together 14 experts from eight countries and one regional organization with about 30 interested experts from governments, NGOs, industry and academia, the participants considered what would be needed to implement nuclear power successfully in States with no nuclear power reactors or a few, bearing in mind safety and security requirements for success. The goal was to bring something to benefit the planning in the limited selection of countries able to engage and to provide insights into how the nuclear renaissance could and should encompass nuclear newcomers, especially in the developing areas of the world. This is the report of the meeting that was held at the Villa del Grumello, Como, Italy, from 10-14 June 2008.

I. Organization

The meeting was organized by the International Working Group - Landau Network Centro Volta and the Texas Engineering Experiment Station (TEES), in cooperation with the World Nuclear University (WNU), the International Sciences and Technology Centre (ISTC) of Moscow, the US Civilian Research and Development Foundation (CRDF), the Insubria Center on International Security, (ICIS), the Chamber of Commerce of Como, and with the support of the Italian Ministry of Foreign Affairs (MFA). The program included national program presentations and presentations on key topics by resource experts followed by discussions and panels (see Annex 1).

The IWG-LNCV is an informal and independent forum, drawing over the last seven years on the voluntary participation of governmental and non-governmental entities as well as the private sector. It is devoted to addressing and analyzing problems connected with Weapons of Mass Destruction and related proliferation issues, particularly in the nuclear sector.

II. Introduction

Nuclear power is now widely accepted as an important alternative source of energy for socio-economic development, with advantages over other sources, like energy reliability, security, and zero-carbon emission. Additionally, unlike other sources, it is global in character and thus available to any country. In contrast to other forms of energy production, States seeking to benefit from nuclear energy need a substantial legal and technical infrastructure to build and operate nuclear power plants in a safe and secure manner. They also need to ensure the operation is in conformity with the international non-proliferation commitments. Building up capability and acquiring the technology is a lengthy and demanding process. Exchanges of information and international cooperation are the key to assisting interested countries towards realizing the benefits of nuclear power.

Hence, the objective of the meeting was to provide an open, non-governmental forum to discuss the perceived needs of countries interested in nuclear power and the mechanisms available to promote its expansion. As such, the meeting brought together government, utility, and industry experts, plus academics in a very open discussion on the needs, concerns and trends in civilian nuclear power and its fuel cycle.

The meeting focused on 14 "Honored Guests" from 8 countries and one regional Atomic Energy Agency interested in nuclear power. Note that in the text of this report, these Honored Guests are referred to henceforth as "the Respondents." The 35 experts supporting this event represented a wide spectrum of nuclear power skills and interests. The Respondents come from countries that are seriously considering the nuclear option as part of their energy mix, those that are preparing to acquire their first nuclear power plant (NPP), countries that are expanding their generation of nuclear electricity and those that are advanced in all the steps of the nuclear fuel cycle.

The program of the Meeting is shown in Annex 1 and the List of Participants (Respondents and Experts) is also included in Annex 1. The Presentations and Reference Material are shown in Annex 2; these are available on the LNCV web site.

III. The Meeting

As stated in the title of the event, the meeting was designed to look in a positive sense at how nuclear power could contribute more widely to meeting mankind's energy needs - while avoiding accidents, inhibiting proliferation and preventing nuclear terrorism. The meeting provided a venue for countries interested in nuclear power to learn from others and to express their needs and preferences with the clarity required for concerted responses. Everyone came away with a better understanding of the promises and challenges associated with nuclear power and some ideas on new approaches that could help to accelerate the use of nuclear power to the benefit of mankind.

The meeting progressed through presentations and discussions over a wide spectrum of aspects related to the introduction or expansion of nuclear power. It covered: i) the steps for a successfully implementing a nuclear programme, ii) options between large and small / medium size reactors, iii) possible constraints affecting the introduction or expansion of nuclear programmes, iv) global energy partnerships and multilateral arrangements for cooperation and to secure the supply of fuel, and v) the costs, financial risks and funding possibilities for nuclear power.

Steps for Successful Implementation

Past experience indicates that while nuclear power is a high-tech power production option, successful implementation of nuclear power relies on basic and simple actions. Experienced managers shared their experience on common problems affecting project implementation, costs and duration of construction of nuclear power plants (NPPs). They emphasized the need for:

- Selecting a reactor design of proven operational record;
- Planning and implementing an adequate human resources development program in preparation for and during plant operation;
- Selecting contractors and suppliers carefully to avoid problems during construction, including a realistic evaluation of the risks associated with local manufacture and services;
- Avoiding design changes after project approval, as changes escalate the costs and may nullify design certifications carried out by regulatory bodies; and
- Securing a reliable supplier of fuel services.

The discussion of these practical matters was greatly appreciated.

Large, Small and Medium Size Reactors

The meeting considered the commercial nuclear power reactors available on the market today, most of which are designed for large grid applications and range in power from 1000 MWe to 1700 MWe. The new plants are all above 1000 MWe, however, medium scale reactors offered in the past are still available.

All of the current systems reflect evolutionary progress making them safer, simpler to operate and less expensive than earlier models. The nuclear renaissance is reflected in dramatic increases in orders and expansions of manufacturing capabilities on critical shortage areas (like large-scale forgings).

Particular interest was shown in new designs for smaller reactors in the range of 100-300 MWe, which would benefit applications involving small grids and limited infrastructure. These small reactors may be the only possibility for

many developing countries and may be attractive in that they allow for modular expansion with earlier returns than larger plants would offer. Economy of scale of large plants vs. phased expansion in the early days of a nuclear power program appeared to be important considerations, and shorter construction times, simplification and factory production of major plant components may attract a substantial market. Their economics could be attractive as two or more reactors can be built in series, which minimizes upfront cash outlay and provides for quicker return on investment. Furthermore, the possibility to use such smaller plants for co-generation is another advantage.

Technical specifications, safety features and estimated costs were presented for the 165 MWe South African Pebble Bed Modular Reactor (PMBR) and the 335 MWe Westinghouse IRIS pressurized water reactor (PWR) being developed by an international consortium. These two hold the promise that the initial reactors will be built in the next ten years. IRIS and PBMR are not yet licensed in their country of origin, let alone in any consumer country, though PBMR has applied for U.S. NRC Design Certification in 2008.

Many countries entered the nuclear age using reactors of this size range. Other advantages of small reactors are their enhanced safety features, fewer restrictions on siting, operational simplicity, high security and reduced proliferation risks. These advantages lead to a reduced requirement for infrastructure development by the recipient country. It was noted that no prototypes of such new small reactors are available from which to derive real data and operational costs. Hence, more information on their competitiveness in cost and deployment strategy is needed to attract potential buyers.

Many developers have expressed interest in small reactors; IAEA documents identify over 60 design studies. There is a clear need to consolidate efforts to produce power reactors in the range of 100-300 MWe that offer walk-away safety, cost reductions through simplification (especially through the use of nuclear battery concepts designed for long term operation with no refueling), and enhanced resistance to terrorism through underground silo construction.

Possible Constraints

Human Resources

Availability of qualified human resources was identified as perhaps the most important constraint on the expansion of nuclear power. There is a shortage of major skills at the technician and engineering level, not only in the nuclear industry but also in the conventional construction/manufacture industries. This problem is exacerbated by the shortage of students applying for engineering programs and the ageing of the current specialized workforce.

The shortage is particularly intense in the areas of licensing, construction and operation of nuclear power plants, and access to nuclear power by the

developing areas of the world will be affected by the increasing competition for such skills in the global market. The same applies to conventional commercial skills, such as personnel to negotiate contracts and the purchase of essential goods and services, etc. These shortages could add significantly to the timescales of deliveries and costs for future orders.

Hence, countries deciding to introduce nuclear power or expand their generating capacity need to start to recruit and train personnel as soon as possible. In the case of newcomer countries, planning, staffing and training should start in earnest at least 15 years before the expected reactor commissioning. While 15 years sounds like eternity to many, some experts are concerned that 15 years is too low and may be misleading.

The Supply Chain

The impact of vulnerabilities in the supply chain for major nuclear-qualified mechanical heavy equipment was highlighted as a significant concern for future developments in nuclear power. Even with the current orders, let alone future orders, this supply chain is already overloaded. This issue is important not only for nuclear heavy equipment but also for fossil-fired generating equipment such as gas turbines, boilers, etc. Hence, capabilities to manufacture reactor pressure vessels, rotors for turbine generators and large power transformers are a concern to be addressed by supplier countries.

As the nuclear renaissance proceeds, the vendor industry and the respective governments will address these supply chain constraints. However such constraints may have pronounced impacts on countries interested in ordering new nuclear power plants.

Nuclear Waste Management

As utilization of nuclear energy expands, the accumulation and disposition of spent fuel will become matters of increasing concern, and with it, the issues of radioactive waste management and the ultimate geological isolation of conditioned wastes. Three technical options were discussed:

- a. Geological storage of intact spent fuel assemblies, in which the radioactivity decays to equal uranium deposits before mining in about 300,000 years;
- b. Separation of uranium and plutonium and conditioning the remaining wastes for geological storage, in which the radioactivity decays to equal uranium deposits before mining in about 9,000 years; and
- c. Separation of uranium and plutonium and other transuranic elements (neptunium, americium and curium) with transmutation of all transuranics in fast neutron reactors, together with separation and isolation of cesium, strontium and technetium, and conditioning the remaining nuclear waste for which the radioactivity decays to equal uranium deposits before mining in about 300 years.

Options (a) and (b) are available today. Option (b) reduces the volume of waste dramatically, thereby posing reduced space and heat dissipation requirements on repositories. Option (c) represents further improvements on (b); (c) is under research and development (both the partitioning and transmutation components). Those involved anticipate that commercial scale partitioning and transmutation facilities could be in operation in about 25 years.

A decision on how a nuclear power program intends to address spent fuel disposition and radioactive waste management - recognizing the time and cost issues - is an important to convincing politicians and gaining public acceptance of nuclear power. This is a key issue now for countries having nuclear power and wishing to expand their generation of nuclear electricity. For newcomers, it poses an unresolved question that left unanswered creates hesitancy at best. Addressing nuclear waste in a responsible manner must be an essential component of any successful nuclear power program.

In addition to the disposition of spent fuel and wastes arising from that aspect of nuclear waste management, ultimately the nuclear power reactors will reach their end of service and have to be decommissioned. Various well-proven decommissioning technologies have been demonstrated in many countries and should be used when informing the government and the public. Decommissioning costs are estimated to be on the order of 9-15% of the capital cost of an NPP. However, when these costs are discounted, they represent only a small percentage of the investment cost and even less a percentage of the generation cost. Decommissioning costs are spread over the operating life of the reactors, which are expected to be sixty years or more. Thus, annual payments to the decommissioning fund get smaller as the plant design lifetimes get longer. In the US, for example, the costs for decommissioning are today estimated at less than 5% of the cost of electricity generation.¹

Mechanisms for Cooperation

Each country has its own policies and mechanisms to manage their respective future energy requirements. Those policies and mechanisms reflect national priorities, technical abilities, regional arrangements, etc. Bilateral and multilateral mechanisms are available and options are increasing to assist interested countries in formulating their nuclear power policies. Although there should be no shortage of uranium or enrichment or fuel manufacturing in the foreseeable future, concern was expressed regarding the possibility of politically motivated interruption of fuel or services.

Bilateral Mechanisms

¹ Information on decommissioning activities in the U.S. including photographs can be found at <http://www.connyankee.com/html/decommissioning.htm> and <http://www.yankeeerowe.com/>.

Most, if not all nuclear cooperation in the past took place under bilateral intergovernmental arrangements. This mechanism will be intensified as emerging countries look at technical and financial partnerships to meet their future energy developments. Indeed, the nuclear renaissance is taking place in an increasing atmosphere of bilateral interaction, bundling extensive technical support by vendors, joint utilities with vendor and host partnership, progress towards international reactor design certification and support for host country regulatory development. Indeed, many new memoranda of understanding (MOUs) have been signed in recent months and existing bilateral cooperation agreements strengthened.

Multilateral Mechanisms

The participants were greatly interested in the conditions and flexibility offered under the Global Nuclear Energy Partnership (GNEP), the International Uranium Enrichment Corporation (IUEC) and the increasing level of assistance provided by the IAEA to member states. They recognized that such activities could facilitate the introduction or expansion of nuclear power in emerging countries:

- Multilateral approaches can facilitate the expected expansion in the civilian use of nuclear energy while addressing concerns about the sensitive aspects of the fuel cycle (for example, when regional countries apply cooperative models such as the European Supply Agency (ESA) or the Brazilian-Argentine Agency for Accounting and Control of Nuclear materials (ABACC);
- Reliable fuel services could offer solutions for countries choosing nuclear power without requiring them to invest in the development of costly and politically sensitive enrichment and/or reprocessing facilities without undermining a State's sovereign right to pursue the development of nuclear energy for peaceful use under the provisions of the NPT and under IAEA safeguards;
- Guaranteed access to enriched uranium by the International Uranium Enrichment Centre at the Angarsk Electrolysis Chemical Combine in Russia is available today to new members. At present, IUEC participation includes the Republic of Kazakhstan (10%) and negotiations with Armenia are at advanced stage for another 10%. The major holder, TENEX, will retain 51% of the company shares (TENEX is not involved in taking spent fuel back, but this step may be negotiated with other Russian enterprises.)
- The IAEA should continue to play a key role in ensuring that the benefits of nuclear technology are shared and expanded. Furthermore, it should assist emerging countries to gain access to the required information for sound technical decisions related to the nuclear option and assurances of supply.

- New political arrangements were also presented that could enable nuclear power to reach further into the developing areas of the world:
 - A Convention on Nuclear Power was proposed with a view to creating a new system intended to facilitate the adoption of nuclear power by many more States than might otherwise be able to succeed. Under this specific proposal, the IAEA would administer and that the nuclear industry would execute arrangements for the assured provision of goods and services necessary for nuclear power.
 - The possibility of creating regional power generation centres on extra-territorial sites was presented, which would be based on agreements between host countries and the IAEA. Such arrangements could involve additional countries and could offer advantages to the host country, regional participants, vendor countries and the international community.

Economics and Risks

The economic factors and risks involved in nuclear power, including the anticipated costs and available financing options were considered. While some countries are able to finance nuclear power under existing arrangements, creating new mechanisms that allow debts to be retired based on the sale of electricity produced by the reactors would extend access to nuclear technology to additional countries in the developing areas of the world.

The projection of future costs depends on being able to anticipate infrastructure development and maintenance, site acquisition and preparation, NPP purchase and construction, and NPP operation and maintenance costs during the various phases of plant life. Fuel supply, replacement of plant components, spent fuel management and plant decommissioning all factor into the overall cost.

Each cost component must be estimated, but the actual costs may reflect conditions that may change for reasons peculiar to each. Externalities to the estimated costs offer the highest risks. For example, increased costs of construction materials (up by 50% since 2004), component manufacturing bottlenecks (like heavy steel component fabrication), construction problems in seemingly routine matters (e.g., concrete quality), regulatory and licensing requirements resulting in greater safety and security with higher costs, and availability of skilled labor are all likely to challenge accurate forecasting. Against these possible cautions, consideration should be given to the following:

- While capital costs for the construction of NPPs of any size are high in relation to many other power production technologies, fluctuations in nuclear fuel costs have little impact on the costs of electricity

production. That said, nuclear fuel costs are bound to increase as the cost of uranium rises. For now, for example, the cost per kilowatt-hour has consistently decreased over the years in the U.S. to the point where nuclear generated electricity now costs less than all other electricity production technologies. Coupled with the long operational lifetime of NPPs of 60 years and potentially longer, the economics of nuclear power must be seen as long-term investments with positive prospects for energy security, financial return and mitigation of global warming;

- The nuclear industry has seen gains in energy availability due to power up-rating through plant modifications and increased capacity factors achieved (average above 85%) compared with much lower availability of alternative sources. Future prospects for new fuels (annular UO₂ fuels to reduce centerline temperatures and cermet fuels are expected to provide significant enhancements to existing and new NPPs;
- New reactor designs are of modular construction, use passive safety features and hence require smaller volume nuclear islands and less hardware. Some are designed to facilitate inspection and servicing while producing power, thereby increasing plant capacity factors. The Areva EPR, for example, advertises the expectation of 95% availability. Consequently, new NPPs are expected to be less expensive to construct and maintain than earlier models of the same power output.
- Smaller reactors (range of 100-300 MWe) may make it practical for countries with limited grids to implement nuclear power for electricity and potable water production. With low unit costs, shorter construction times and flexibility for incremental expansion to increased output, such systems appear to offer opportunities for easy entry and phased growth for countries that are not ready for larger commercial NPPs.

Safety and Security

One theme that was repeated throughout the meeting was the fact that nuclear power is unique in the safety and security concerns that are intrinsic to this power production technology. Reminded of the axiom that “an accident anywhere would be an accident everywhere,” the global interdependency of nuclear power nations was emphasized. In the event of an accident, in addition to its immediate consequences and the costs to the unfortunate host country, could poison public acceptance affecting new nuclear power plants, undermine public approval of existing NPPs, create additional costly regulations with required expenses and by combination, and reduce the ability of nuclear power to contribute to moderating global warming. Similarly, the occurrence of a nuclear terrorist attack, or the proliferation of nuclear weapons through the misuse of nuclear power applications, could correspondingly dampen enthusiasm for and increase the

costs of nuclear power. The participants discussed how safety, nonproliferation and the prevention of nuclear terrorism were thus central parts of nuclear power and that preventing accidents, proliferation and terrorism were interests that all nuclear power States must share.

Presentations by Participants

The Respondents described their national plans and needs for the introduction or expansion of nuclear power in their respective countries.

- Argentina has an electric generation capacity of 24,100 MW today, of which 34% comes from hydropower plants, 57% from fossil fuels, 8% from nuclear and the remaining 1% is imported. By 2030, nuclear generation is projected to reach 10,000 MW.
- In Brazil, hydropower will continue to be the major source of electricity (72%), complemented by thermal sources (28%). In 2005, the generation capacity was 92,800 MW. The National Energy Plan projects an additional 31,000 MW for 2010-2035, of which 6,000 MW would come from new nuclear power plants. The total thermal production (conventional sources + nuclear) is expected to remain around 30%.
- For Jordan, the current electricity generation capacity (thermal) amounts to 2,170 MW. With an estimated demand annual growth rate of 7%, Jordan will need to duplicate its present capacity by 2030. A feasibility study for a possible deployment of a NPP by 2020 is being conducted with the assistance of GNEP.
- Malaysia is largely dependent on natural gas (over 70%) for its electricity generation. In 2000, the government approved a fuel diversification policy that opens the possibility for nuclear generation. A group identified as Nuclear Malaysia is pursuing several initiatives to inform the government and the public in preparation for a decision on nuclear option.
- Mexico has in operation the twin BWR nuclear power plant at Laguna Verde, which is showing world-class performance. The long-term energy plan (2010-2030) stipulates that 12% of the total electricity (about 100,000 MW) to be generated at the end of this period will be by nuclear power.
- For Namibia, the Government is collecting information on the different aspects and options for the introduction of nuclear power in the country. Namibia is exploring the use of its large uranium resources in relation to its interests in nuclear power.
- Nigeria's present electricity generation capacity amounts to 3,500 MW from natural gas and 1,650 MW from hydro sources, which represents half of the actual demand. The Nigerian Government has reaffirmed its

determination to initiate a nuclear power program and Nigeria plans to build 4,000 MWe of nuclear capacity by 2025.

- Vietnam completed the required national legal framework (Atomic Law enacted on June 2008), has selected a site and will go for international bids for their first two 1000 MW nuclear power plants. A feasibility study concluded that an additional 10,000 MWe would be needed for 2021-2030, part of which will be nuclear power.

Shortages in present and projected qualified manpower are expected to affect all aspects of decision-making (implementing preparatory steps, regulatory and safety issues, radioactive waste management, etc). Education and training related to managing nuclear programs is a critical problem affecting the global expansion of nuclear power. This also applies to industrialized nuclear countries. Hence, for the nuclear renaissance to materialize in the emerging countries, a massive education and training program is in need in the wide spectrum of activities supporting a nuclear power program.

IV. THE QUESTIONNAIRE

A Questionnaire was prepared for consideration by the Respondents to gather their insights on nuclear power. The Questionnaire was divided broadly into two types of questions. The first type sought to elicit the general characteristics of the countries represented by Respondents. The responses to those questions are summarized in the bar charts below. The second part of the Questionnaire addressed opinions and preferences; those results are presented later in this report.

The responses² represent a small sample and, as such, the results presented here are not statistically significant. Moreover, as this meeting had no official nature, the participants' responses do not necessarily reflect the official views of their governments. Nevertheless, the opinions of these experts, given their exposure to the information provided during the meeting, provides some interesting perspectives regarding the potential for expanding nuclear power to developing countries.

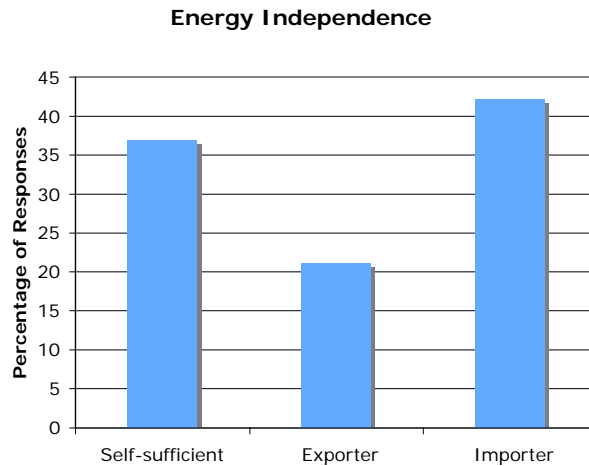
Country Characteristics

Question 1. Is your country:

- Self-sufficient for energy production
- Exporting power to neighboring countries

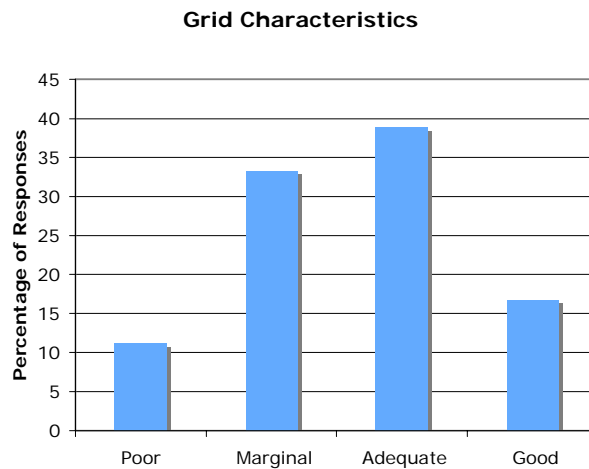
² Data gathering and organization has been pursued by Roberta Ballabio and Giulio Mancini, Landau Network-Centro Volta, and Danielle Peterson, Pacific Northwest National Laboratory.

- Importing power from neighboring countries



Question 2. Characterize your country's system for electricity transmission and distribution, overall (check all that apply):

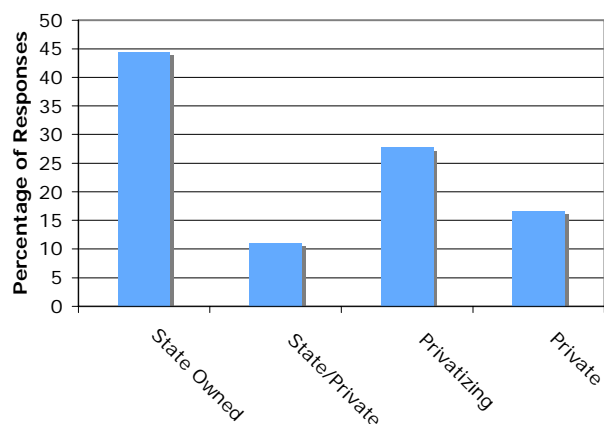
- Underdeveloped (prone to brown- or black-outs)
- Stable but expanding to meet increased demand, including integration of limited grids within your country
- Interconnected to neighboring country or regional grid systems
- Fully developed and interconnected to other grid systems



Question 4. Are your electrical utilities:

- State-owned
- Private but State-operated
- Undergoing privatization
- Fully privatized

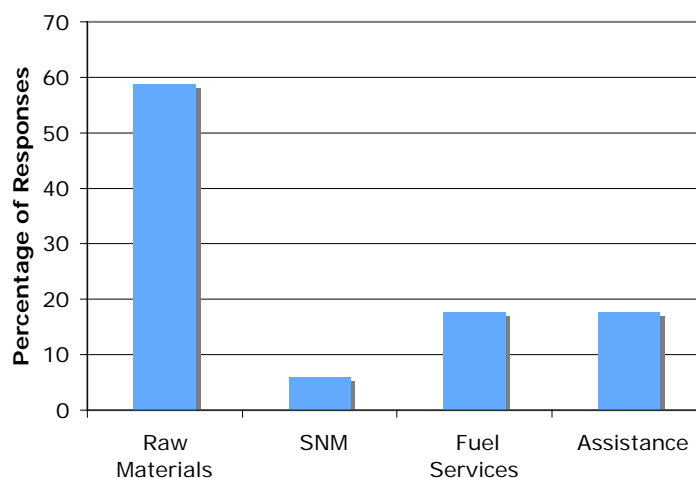
Utility Ownership



Question 5. Which, if any, of the following offer realistic possibilities for your country to be a supplier of nuclear materials or technology, on the international market?

- Raw materials (uranium or thorium ore)
- Special nuclear materials (U-233, enriched uranium, or plutonium)
- Other fuel services, including fuel fabrication
- Technological advice and assistance

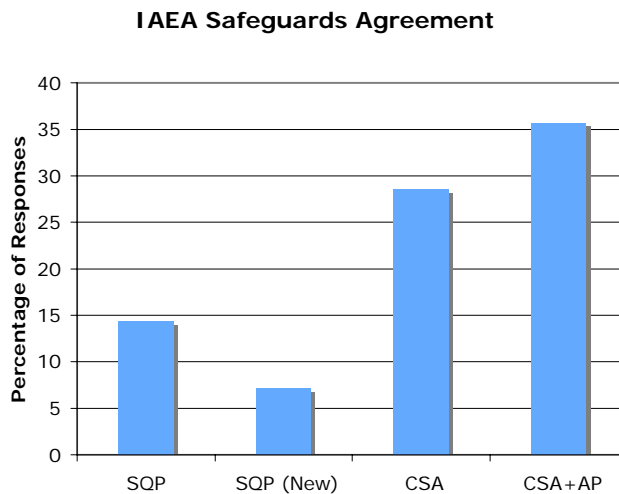
Supplier Capabilities



Question 6. What level of IAEA safeguards agreement is currently in force for your country?

- Small quantities protocol (traditional)
- Small quantities protocol (modified)

- Comprehensive safeguards (INFCIRC/153-type)
- Comprehensive safeguards (INFCIRC/153-type) with an Additional Protocol (INFCIRC/540)



Preferences and Opinions

The second type of questions in the Questionnaire sought the opinions and preferences of the Respondents for nuclear power deployment. Some of the questions in this category provide advice to organizations concerned with implementing programs aimed at stimulating future nuclear power applications.

The responses represent a small sample and, as such, the results presented here lay no claim to general statistical insights or significance. Moreover, as this meeting had no official nature, the participants' responses do not necessarily reflect the official views of their governments.

The pie charts below show the combined results for all of the Respondents. The results are weighted to reflect their priorities according to the following scheme:

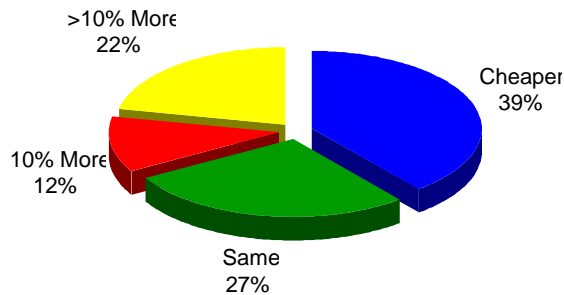
Maximum number of points = number of options (the maximum number of points was assigned to responses that were either not ranked or were ranked as first priority)

Lower numbers of points = maximum minus 1,2,3, etc. Example, if there were four options, a ranking of 2 would provide 3 points, while a ranking of 3 would provide 2 points.

Question 1. What is your best estimate of how the cost of nuclear electricity production would compare to your country's current base-load electricity?

- Nuclear would be cheaper
- Nuclear would cost about the same
- Nuclear would be more expensive, but by less than 10%
- Nuclear would be more expensive, by more than 10%

Anticipated Cost of Nuclear Electric



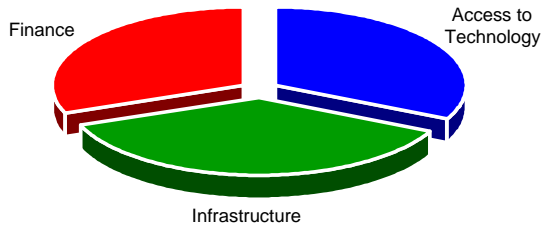
Q1 Data Table					
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Cheaper	5	0	0	0	20
Same	3	0	1	0	14
<10% More	1	0	1	0	6
>10% More	2	1	0	0	11

The Respondents felt that nuclear energy would be cheaper or would cost about the same as current base load sources (about 2/3 of answers) when all factors affecting the total costs are equally considered. It is interesting to note that most States appear to view nuclear power in a positive light as far as economics go.

Question 2. Which of the following would you consider to be your principal challenge(s) for nuclear power?

- Access to technology, including nuclear reactor and balance of plant, access to reliable fuel over the lifetime of the reactor, access to waste disposal facilities, and access to other goods and services necessary for the safe and economical operation of your nuclear power plant;
- National infrastructure necessary for responsible stewardship, including legislative and regulatory framework, utility expertise and supportive services as necessary, including skilled personnel;
- Finance, including financial support necessary to develop and maintain the infrastructure required, financing necessary to select and prepare the site and to provide the grid capacity required, and financing necessary to purchase, construct and commission the NPP.

Principal Challenges



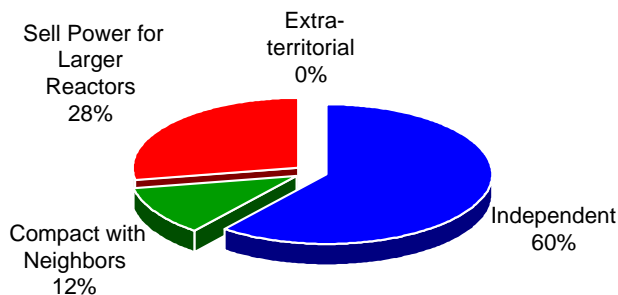
Q2 Data Table				
Ranking ⇒	0 or 1st	2nd	3rd	Total Points
Choice ↓				
Technology	6	1	2	22
Infrastructure	8	0	1	25
Finance	3	4	0	21

The responses show that the three issues are central to the global expansion of nuclear power. Addressing all three in a constructive manner offer a promising agenda to extend the reach of the nuclear renaissance.

Question 3. In relation to procuring your nuclear power plant, would you prefer to:

- Remain independent
- Form a compact with neighboring States to purchase and operate a NPP
- Enter into a binding relationship to sell nuclear generated electricity to neighboring States as a means to help justify larger reactors?
- Establish an extra-territorial site through a treaty with the IAEA, on which the IAEA would organize the selection and construction of a nuclear power plant, organize the operation of that NPP through a competent nuclear utility, and organize the regulation of the site and the NPP?

Procurement Preference

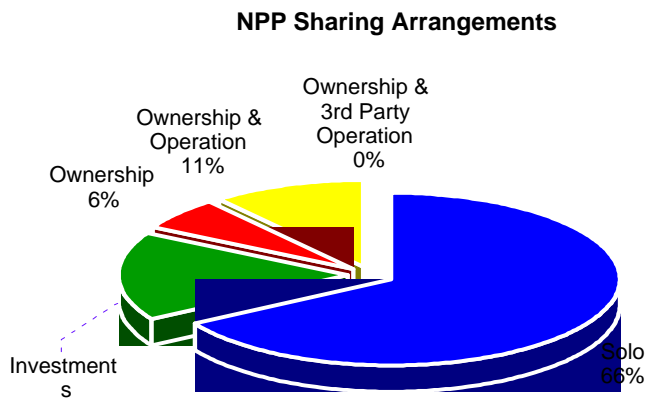


Q3 Data Table					
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Independent	13	0	0	0	52
Compact	1	0	3	0	10
Sell Power	3	4	0	0	24
Extra-territorial	0	0	0	0	0

Remaining independent is clearly important to the Respondents. Compacts with neighboring countries may provide a way forward in some cases. As answers to this question and to the next one show, in participants' opinion States are primarily interested in acquiring their own nuclear power reactors without restrictive obligations. It is interesting to note how nuclear power is in some way an atypical good, with prestige playing a role besides economic reasons.

Question 4. If your country were to consider sharing arrangements relating to nuclear power development, which would likely be explored:

- Nuclear power development by a single state, with only electricity being shared across interstate grid interconnections
- Shared investment in infrastructure and transmission grids
- Shared reactor ownership
- Shared reactor ownership and operation
- Shared ownership with operation by a third-party



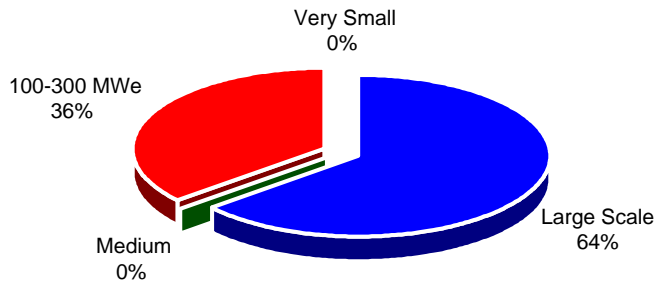
Q4 Data Table						Total Points
Ranking => Choice ↓	0 or 1st	2nd	3rd	4th	5th	
Solo	11	0	0	0	0	55
Investments	2	2	0	0	0	14
Ownership	1	0	0	0	0	5
Ownership & Operation	1	0	1	0	0	9
Ownership & 3 rd Party Operation	0	0	0	0	0	0

The message here appears to be that while sharing arrangements may prove to be useful, most States value their independence.

Question 5. Recognizing the “rule of thumb” that no single power plant should represent more than 6-10% of total grid capacity, do you anticipate that your next (first, as appropriate) nuclear power plant would consist of:

- One or two large scale reactors each generating 1000 MWe or more?
- One or two intermediate scale reactors each generating 600 MWe or more?
- One or more small scale reactors each generating 100 - 300 MWe?
- One or more very small reactors each generating less than 100 MWe?

Reactor Size Preference



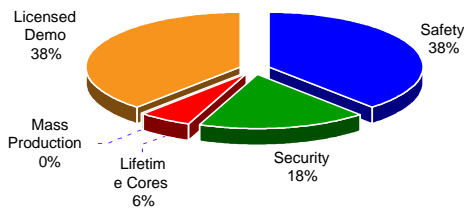
Q5 Data Table					
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Large Scale	8	0	0	0	32
Medium	0	0	0	0	0
100-300 MWe	3	0	2	0	14
< 100 MWe	0	0	0	0	0

The Respondents showed interest in large scale NPPs of 1000 MWe and more, and reactors in the range of 100-300 MWe. The latter size allows ease of introduction into small grids and manageable increments to stimulate economic development.

Question 6. Whether for your first nuclear power plant or not, if new small reactors are to be designed primarily to meet the needs and challenges of the developing areas of the world, which of the following would be important for you:

- Making the reactors “walk-away-safe” and demonstrating that this is so
- Guaranteeing that there are no unacceptable security risks associated with the plants
- Aiming for lifetime cores that would require no refueling over the life of the reactor (ca. 60 years)
- Designing the systems for mass production and ease of on-site construction
- Building a full-scale, full function demonstration reactor in the vendor State, which would be licensed and operated as a test bed and showroom model

Small Reactor Preferences

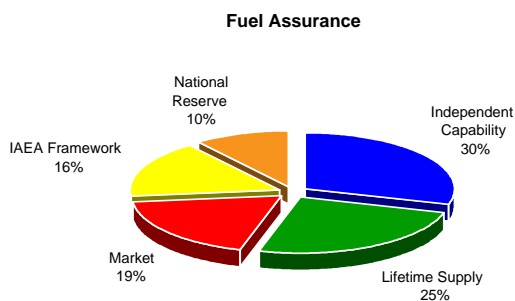


Q6 Data Table						
Ranking ⇒	0 or 1st	2nd	3rd	4th	5th	Total Points
Choice ↓						
Safety	6	1	0	0	0	34
Security	2	0	2	0	0	16
Simplicity	1	0	0	0	0	5
Cost	0	0	0	0	0	0
Proven Reliability	6	1	0	0	0	34

This defines two markets as predominant, one that allows easy entry and growth, the other being the largest plants. It also emphasizes the need to deploy small reactors on the basis of proven, licensed technology.

Question 7. Which would you prefer in relation to assuring fresh fuel supply:

- Developing your own capabilities, recognizing the financial risks involved
- Purchasing a lifetime supply of fuel as part of the NPP contract from the reactor vendor
- Playing the market, qualifying two or more suppliers and entering into long-term contracts to maintain freedom of choice
- Participating in an international framework centered on the IAEA that would match suppliers and buyers under terms embodied in a convention on nuclear power
- Establishing a national strategic reserve to hedge against supply disruptions



Ranking ⇒	0 or 1st	2nd	3rd	4th	5th	Total Points
Choice ↓						
Independent	6	1	0	0	0	34
Lifetime Supply	5	1	0	0	0	29
Market	3	1	1	0	0	22
IAEA Framework	3	1	0	0	0	19
National Reserve	1	1	1	0	0	12

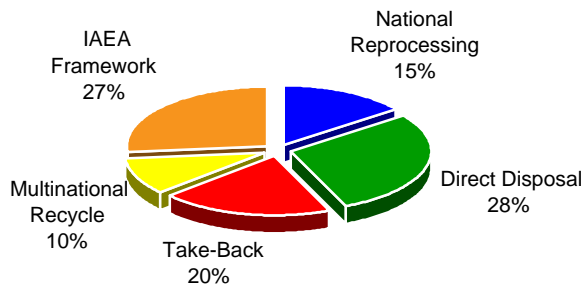
There are no clear advantages here, suggesting that each of the options might attract adherents.

Question 8. In relation to spent fuel disposition, what option(s) would you consider:

- Establish your own reprocessing plant and recycle the plutonium and/or uranium contained in the spent fuel
- Dispose of the fuel in a geological repository
 - i. Create your own geological repository
 - ii. Pay someone else to take your waste
 - iii. Participate in an international nuclear waste repository
- Arrange for spent fuel disposition as a part of the purchase contract for the NPP through the vendor (under a fuel leasing arrangement or multi-phase contract)
- Participate in a multinational recycle center

- Participate in an international framework centered on the IAEA that takes possession of your spent fuel shortly after final discharge from the reactor and transports that spent fuel to an international spent fuel reception center pending processing, assuming that: a) you pay only a fixed surcharge on nuclear generated electricity; b) you have no further obligations regarding your spent fuel once removed; and c) no waste products are returned to you

Spent Fuel Disposition



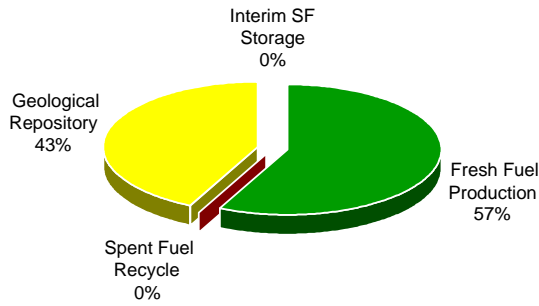
Q8 Data Table						Total Points
Ranking ⇒	0 or 1st	2nd	3rd	4th	5th	
Choice ↓						
Independent Capability	3	0	0	0	0	15
Direct Disposal	5	2	0	0	0	29
Take-Back	4	0	0	0	0	20
Multinational Recycle	2	0	0	0	0	10
IAEA Framework	3	3	0	0	0	27

Even in a small number of countries as represented in these responses, the preferences are far from clear suggesting that more needs to be done to create a consensus.

Question 9. Under appropriate conditions might your country be interested in *participating* in facilities located in your region:

- An internationally-operated Spent Fuel Reception Center, for monitored storage of spent fuel
- An internationally-operated Fresh Fuel Production Center, including enrichment and perhaps fuel fabrication
- An internationally-operated Spent Fuel Recycle Center including transmutation reactors and nuclear waste conditioning
- An International Nuclear Waste Repository

Participation in Regional Facilities



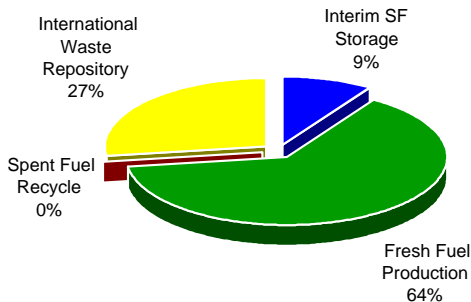
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Interim SF Storage	0	0	0	0	0
Fresh Fuel Production	6	0	0	0	24
Spent Fuel Recycle	0	0	0	0	0
International Waste Repository	3	2	0	0	18

These results suggest that the Respondents see fuel production as an activity that could provide benefits in economic development and assurance of supply, while participation in a geological repository would be an attractive means to solve a nuisance problem.

Question 10. Under appropriate conditions might your country be interested in *hosting*:

- An internationally-operated Spent Fuel Reception Center, for monitored storage of spent fuel
- An internationally-operated Fresh Fuel Production Center, including enrichment and perhaps fuel fabrication
- An internationally-operated Spent Fuel Recycle Center including transmutation reactors and nuclear waste conditioning
- An International Nuclear Waste Repository

Hosting Regional Facilities

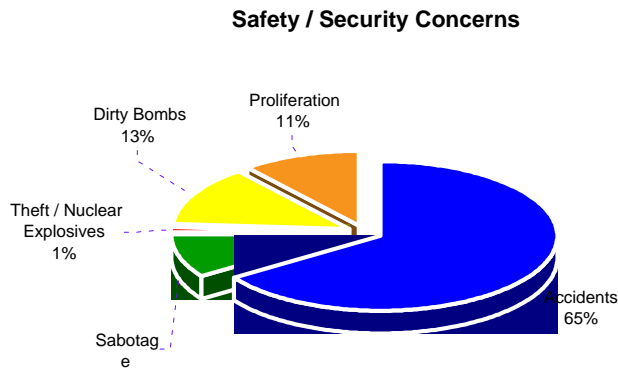


Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Interim SF Storage	1	0	0	0	4
Fresh Fuel Production	7	0	0	0	28
Spent Fuel Recycle	0	0	0	0	0
International Waste Repository	3	0	0	0	12

The most interesting response was the apparent willingness of some of the Respondents to hosting a geological repository. In addition to the preferences shown, some of the Respondents were not interested in hosting any international facilities on their home territories.

Question 11. Which of the following concerns you most?

- An accident involving a nuclear power plant anywhere
- Nuclear terrorism involving sabotage of nuclear plants or transport systems
- Theft of nuclear materials leading to the manufacture and use of one or more nuclear explosive devices (in your country, or elsewhere)
- Theft of hazardous radioactive materials for use in a radiological weapon
- Proliferation of nuclear weapons by a State through the misuse of its peaceful nuclear activities



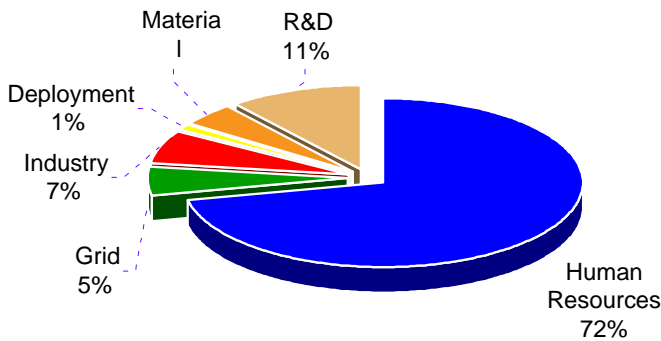
Q11 Data Table						
Ranking =>	0	2nd	3rd	4th	5th	Total Points
Choice ↓	or 1st					
Accidents	11	0	0	0	0	55
Sabotage	1	0	1	0	0	8
Theft / Nuclear Explosives	0	0	0	0	1	1
Dirty Bomb						
Proliferation						

Nuclear accidents and their potential impact on the health and well-being of nations, and on the nuclear power option, dominate the concerns expressed by the Respondents.

Question 12. What specific areas would you most welcome assistance?

- Human resource development
- Electricity infrastructure planning
- Relationships with industry
- Reactor design, construction, licensing, operation
- Materials
- R&D

Preferences for Future Assistance



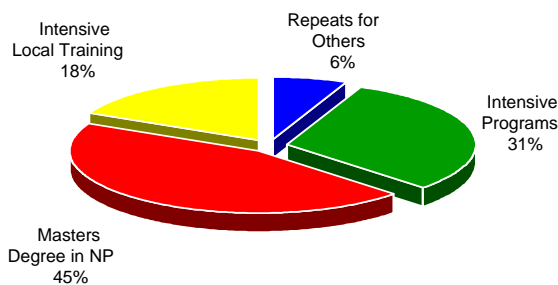
Q12 Data Table							Total Points
Ranking ⇒	0 or 1st	2nd	3rd	4th	5th	6th	
Choice ↓							
Human Resource Development	11	0	0	0	0	0	66
Electricity Infrastructure	0	1	0	0	0	0	5
Industry	1	0	0	0	0	0	6
Design, Construction, Licensing	1	5	0	0	0	0	31
Materials	0	0	1	0	0	0	4
R&D	1	0	1	0	0	0	10

Human resource development is the most pressing concern that the Respondents emphasized.

Question 13. What sort of activities would help most to prepare for nuclear power:

- Repeating this program for different participants
- Creating an intensive program designed for a larger number of participants at an existing campus somewhere
- Creating a degree-program for nuclear power deployment, focusing on nuclear technology, nuclear law, nuclear economics, and nuclear business planning
- An intensive program (1 - 2 months) available in your country or nearby

Future Support Programs

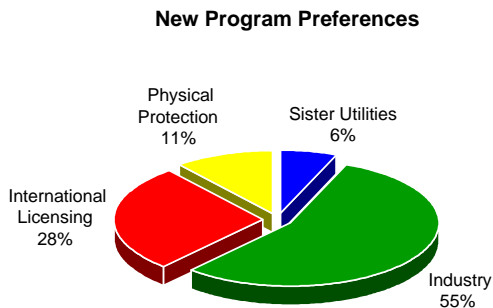


Q13 Data Table					
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Repeats of This Meeting	1	0	0	0	4
Intensive Programs	4	1	0	0	19
MENP	5	2	0	0	28
Intensive Local Program	2	1	0	0	11

The Respondents signal the need for further education and training tailored to their needs. Human resource concerns dominated many of the discussions.

Question 14. Are existing programs and mechanisms adequate to meet needs of your country, or would you prefer to see:

- Organized arrangements for “sister utilities”
- More focused attention from the nuclear industry and industry bodies on States with limited or no nuclear power programs (vendors, other sectors, IAEA, Nuclear Energy Agency, WANO, WNA, WNU, EPRI, INPO, NEI, WNTI)
- Standardization of licensing, including criteria and review methods, “sister regulatory bodies,” MDEP, IAEA guides
- Physical protection adequacy and the relevant bilateral programs, IAEA material protection programs, WINS



Q14 Data Table					
Ranking ⇒	0 or 1st	2nd	3rd	4th	Total Points
Choice ↓					
Sister Utilities	1	0	0	0	4
Industry	9	0	0	0	36
International Licensing	3	2	0	0	18
Physical	1	1	0	0	7

The responses suggest the concerns of the Respondents that the nuclear renaissance is more for industrialized countries and that additional out-reach programs can only help countries in the developing areas of the world to implement nuclear power in a successful way.

IV. Findings

Observations

As evidenced in the performance of existing nuclear power plants in a number of countries, the likelihood of successful operation is high, the rewards are significant and their duration is very long term (60 years or more).

For countries acquiring an additional nuclear power plant when they have continued to expand their fleet over the years, the challenges are relatively modest. Complications do arise from introducing new designs, but countries like France, Japan, Korea and others are able to proceed with confidence based on the capabilities they have nurtured. For countries like the United States and the United Kingdom, restarting nuclear power programs after a long hiatus, re-building a defunct nuclear industry will take time and likely result in delays.

The challenges to countries pursuing nuclear power for the first time are daunting. The extent to which the nuclear renaissance has much of an impact, particularly on the developing areas of the world will depend on their commitments and the extent to which these countries have opportunities to succeed that improve their chances.

To implement nuclear power extensively and successfully, countries included under the heading of the *developing areas of the world*³ will have to overcome challenges affecting: 1) the infrastructure required for responsible nuclear stewardship; 2) access to the technology and essential goods and services required to obtain, operate and maintain nuclear power plants; and 3) finance to cover their costs until the revenues generated through the sale of electricity or other products retire any and all debts incurred.

Each of these combine a number of topics, and actions to stimulate the global expansion of nuclear power will in the end depend on the extent to which decisive steps are taken. Robust solutions will yield greater results.

Under *infrastructure*, several steps may be beneficial:

- 1) Human resource development was very much on the minds of the participants in this meeting. Creating an "International Nuclear Power Academy" (INPA) is one possibility for the international community to help provide the critical skills needed for success, including specialists in the technical, legal and business dimensions of nuclear power. INPA could offer programs tailored to practical needs, ranging from limited term highly focused topics to degree programs. For example, a Master's Degree in Nuclear Power could focus on specifying, selecting, building, operating, and maintaining nuclear power plants. INPA should be created and operated under the wings of the principal international, national and nongovernmental organizations having vested interests in the safe and secure use of nuclear power, with cooperative arrangements with universities, the nuclear supplier industry and nuclear utilities. Given the international nuclear community established around the IAEA, locating INPA and somehow tethering it to the Agency would merit consideration.
- 2) Infrastructure sharing / transition arrangements are now being pursued that allow new nuclear countries to benefit from experience. France and Russia are entering into joint operating arrangements with local utilities in countries where they sell nuclear power plants. Additional steps could create a range of options to facilitate different circumstances and preferences:
 - a. Developing common standards for sharing operating arrangements including phased transition to local operation and shared liability could be pursued as a means to establish common standards.

³ "developing areas of the world" is a term taken from Article IV of the NPT.

- b. Developing the basis for a common design certification process would streamline generic licensing of specific reactor models. Work on such an approach is underway under the “MDEP” arrangements. The countries that will benefit most from MDEP should participate in formalizing it.
- c. Regional power sharing might be accomplished through various means based on agreements between participating countries, which might have one country be responsible for the siting, licensing and operation of the NPP, or some shared arrangement could be agreed. An extraterritorial arrangement, for example, could provide benefits to secure the stability of ownership and operation, when the countries affected and the international community might welcome the additional protections. Extraterritorial arrangements might disappear over time as the capabilities of the host countries mature.

Under the heading of access to technology, goods and services, the following might stimulate the confidence of suppliers and buyers and hence enable broader realization of peaceful nuclear power applications.

- 1) There is a clear indication of interest in power reactors in the range of 100-300 MWe and the possibilities that such reactors would allow countries to adopt nuclear power in smaller increments with less financial exposure than the large-scale commercial NPPs. IRIS and the PBMR may be early candidates in this regard. A substantial market for such systems should develop especially once the first plants are licensed and their performance can be established. Further development of systems designed for low infrastructure requirements (essentially walk-away safe systems that cannot have catastrophic accidents) should achieve cost reductions through simplification (lifetime cores requiring no refueling and hence no fuel handling requirements or procurement demands) and through mass production and accelerated assembly. The development of future systems should have substantial input from the prospective users of such systems.
- 2) Back-end fuel cycle arrangements are not adequate to stimulate nuclear power growth. From a technological, environmental and security perspective, aiming towards the option of extracting all transuranics from spent light water reactor fuel and consuming them in fast neutron systems provides the means to organize spent fuel disposition and waste management in an optimal manner. The technology for recovering transuranic elements from spent fuel and consuming them in appropriate burner systems needs to be developed and put in place as the technological basis for spent fuel management. In the meantime, IAEA-monitored international spent fuel reception centres could provide a pragmatic means to remove spent fuel on the promise of future disposal, providing a means to remove any motivation for countries to establish

indigenous reprocessing programs that could be used if the country were to pursue nuclear weapon ambitions.

- 3) Geological repositories are essential and a global network of international repositories would assure that all countries would cope with their waste in a responsible manner. Noting that some of the participants expressed a willingness to consider hosting geological repositories, steps should be taken to explore how such an approach might be pursued, noting the very long time intervals involved and the need for a formal legal basis protecting the interests of the host country(ies) and the countries making use of such installations.
- 4) Given the extraordinary investments required to establish the infrastructure required for nuclear power (technical, legal, financial, human, ...), countries that decide on nuclear must protect their ability to operate the plant over its lifetime. Fuel assurances are one aspect of this, but there are many other goods and services required for success, and disruptions for any reason can jeopardize the operation of the NPP. While there are commercial arrangements and operational modalities that any country can adopt to decrease its risks, countries from the developing areas of the world are often more susceptible to customer preference and commercial disadvantage than more established nuclear power users. A "convention on nuclear power" could create a basis for assuring the rights of all nuclear countries and hence could serve as a means to accelerate the global expansion of nuclear power.

Under the heading of economics and finance, four considerations might be fruitfully explored.

- 1) As electrification proceeds, considerable investment is required to create and expand the electricity distribution grid to assure its adequacy and reliability. Designing for stable operation, ease of expansion and incorporation of mixes of generating capabilities are essential to getting it right.
- 2) New large scale plants producing well above 1000 MWe offer economies of scale and while some countries in the developing areas of the world are able to accommodate such large systems, many cannot. Establishing regional power sharing arrangements could provide attractive costs, enhance power supply reliability and encourage security and cooperation. Further consideration of sharing, perhaps incorporating disparate economies, could be usefully considered.
- 3) Small reactors provide a means to introduce nuclear power in increments. Staging construction allows a country to develop its infrastructure while expanding to create economic development. Small reactor designs should be optimized for use in the developing areas of the world, including flexibility of operation to serve expanding markets.

Power stations including two or more reactors could be optimized to maintain reasonably constant combined power output when one of the reactors is down for service, for example. Small reactors will be most welcome if the marketing arrangements include licensing and operating each design in the Vendor State. As in the introduction of any large-scale system (commercial airliners, for example), the licensing and confirmatory assessment costs should be amortized over the anticipated client base.

- 4) To really stimulate global nuclear power expansion, a super fund might be created that could serve to facilitate financing by offering countries, based on their financial need, with a means to enter into a long-term “energy mortgage” that could be repaid by the revenues generated once the power plant commences operations. Such a “forward financing” arrangement could be established through a fund created under carbon credits, through the investment of OPEC countries and/or through combined G8 contributions. Such a fund might be established under the auspices of the World Bank or its regional development banks.

Conclusions

From the large number of topics presented and discussed, a number of points arose as important for planners and decision makers on future nuclear power developments.

- 1- The availability of qualified human resources was identified as the number one concern and, possibly, the main constraint for the introduction or expansion of nuclear power programmes.
- 2- International multilateral initiatives to further peaceful uses of nuclear energy are new. They seek to find a balance between legitimate divergent concerns over the inalienable rights of NPT Parties regarding the peaceful use of nuclear energy, the concerns of some regarding the ability to misuse certain nuclear technologies to aid the design and/or manufacture of nuclear weapons, and the proprietary concerns of the high-tech companies that have perfected the equipment and operational modalities at their expense. There is little experience in the implementation of the mechanisms envisaged, and elements like access restraints and eligibility criteria need to be considered together with the natural evolution of technology development. These considerations must be clarified, and practical demonstrations will be needed on how these multilateral initiatives will enhance the States’ confidence in the proposed assurances of long-term fuel cycle services.
- 3- The IAEA role in assisting newcomer states in general energy planning and decisions on whether to pursue civilian nuclear power should continue and be enhanced. Technical support for establishing

appropriate infrastructure, regulations, training of personnel and promotion of safety and security culture are particular areas for attention.

- 4- Technically feasible solutions for spent fuel handling disposal do exist, but the problem is global and international solutions appear most practical. Further implementation of new nuclear power programs should not be delayed awaiting common or final solutions, as dry or wet storage for spent fuel is practical for the near term. International cooperation in geological repositories should be pursued as a means to provide alternatives to national repositories.

AKNOWLEDGEMENTS

All participants express their appreciation to the organizers for the financial support and to the agencies that cooperated to arrange the meeting and provide a wide range of highly qualified resource persons. These contributions resulted in the successful implementation of an intense and substantive program.

VI. ANNEXES

Annex A: Program

<i>Day One: Tuesday, 10 June 2008</i>		
09:30h	<i>Welcome Remarks and Introduction</i>	<i>Maurizio Martellini, Chair, Secretary General, LNCV Paolo Serpi, Italian Foreign Ministry David Boyle, Nuclear Security Science and Policy Institute (TEES) Thomas Shea, World Nuclear University (WNU) Waclaw Gudowski, Deputy Executive Director, International Science and Technology Center</i>
10:30h	<i>Introductions & Brief Presentations</i>	<i>Participants</i>
11:45h	<i>Keynote Speech</i>	<i>Dr Robert Hawley, CBE, Vice Chancellor-WNU and former CEO, British Energy, "Hawley's Rules for Successful Nuclear Power"</i>
14:00h	<i>Panel 1: The Nuclear Showroom: Large-Scale Nuclear Power Reactors</i>	<i>Waclaw Gudowski, ISTC, Chair Chaim Braun, Stanford University: A Market Survey Adrian Collings WNA, The Global Nuclear Renaissance: an Industry View Jukka Laaksonen, Radiation and Nuclear Safety Authority - STUK, Regulation of new nuclear build in Finland [to be presented by Dr Roger Howsley]</i>
16:00h	<i>Panel 2: Low-Infrastructure, Limited Grid Reactors</i>	<i>Tom Shea, WNU, Chair Marco Ricotti, POLIMI, The IRIS Reactor David Wimpey, PBMR, The Pebble Bed Modular Reactor</i>
17:30h	<i>Keynote Speech</i>	<i>H.E. Ambassador Dr. Mohamed Shaker: The NPT Regime: Challenges for Future Security</i>
<i>Day Two: Wednesday, 11 June 2008</i>		
09:30h	<i>Panel 3: Critical Goods & Services</i>	<i>Bob Hawley, Chair Alexey Grigoriev, Texsnabexport, IUEC-Angarsk, Meeting the World's Enrichment Needs Maria Katsva, Ux Consulting: Nuclear Fuel Markets Charles McCombie, Arius: Nuclear Waste Management</i>
12:00h	<i>A Convention on Nuclear Power: Introduction & Reading Assignment</i>	<i>Maurizio Martellini, LNCV Tom Shea, WNU</i>
14:00h	<i>Panel 4: Nuclear Security: Preventing Terrorism and Proliferation</i>	<i>Roger Howsley, Chair Roger Howsley, WINS: Best Practices / Physical Protection Heather Looney, U.S. National Nuclear Security Administration (NNSA), Reducing Proliferation Risks through National Programs of Cooperation Sonia Moreno, Argentina, Autoridad Regulatoria Nuclear (ARN), and Tom Shea, IAEA Safeguards</i>
16:15h	<i>Keynote Speech: Tariq Rauf, IAEA</i>	<i>The Future of the IAEA: Recommendations from the Eminent Panel on Nuclear Fuel Assurances</i>

Day Three: Thursday, 12 June 2008

9:30h	<i>Keynote Speech: Edward McGinnis, DOE</i>	<i>The Global Nuclear Energy Partnership: From Vision to Reality</i>
10:15h	<i>Panel 5: Regional & International Initiatives Aimed at Global Expansion of Nuclear Power</i>	<i>Tariq Rauf, Chair</i> <i>Vladimir Kagramanyan, IPPE: Global Nuclear Power Challenges</i> <i>Charles McCombie, SAPIERR</i> <i>Fiona Simpson, NYU</i> <i>William Szymanski, DOE: GNEP Reliable Fuel Services</i>
13:30h	<i>Panel 6: Brainstorming Session: Building the Nuclear Enterprise to Stimulate Nuclear Expansion while Preventing Accidents, Proliferation and Nuclear Terrorism</i>	<i>Maurizio Martellini, Chair</i> <i>Vladimir Kagramanyan, IPPE</i> <i>Margot Mininni, NNSA</i> <i>Sonia Moreno, ARN</i> <i>Tariq Rauf, IAEA</i> <i>Tom Shea, WNU</i> <i>Fiona Simpson, NYU</i>

Day Four: Friday, 13 June 2008

09:30h	<i>Panel 7: Infrastructure Building</i>	<i>David Boyle, Chair</i> <i>Fanny Bazile, CEA, French Perspective</i> <i>Chaim Braun, Stanford: Summary of Current Fuel Assurance Initiatives</i> <i>Anne Starz, IAEA: IAEA Programs to Prepare for Nuclear Power</i> <i>Craig Welling, USDOE, GNEP Infrastructure Development</i>
14:00h	<i>Keynote Speech: Holger Rogner, IAEA</i>	<i>Projecting costs, financial risks and novel financing possibilities</i>
14:45h	<i>Panel 8: Nuclear Economics</i>	<i>Holger Rogner, Chair</i> <i>Chaim Braun, Stanford: Making nuclear power profitable</i> <i>Marco Ricotti, POLIMI, The Economics of Small Reactors</i>
17:00h	<i>The Questionnaire</i>	<i>Giulio Mancini, LNCV</i> <i>Danielle Peterson, PNNL</i>

Day Five: Saturday, 14 June 2008

09:30h	<i>Priorities for Nuclear Power Initiatives: Questionnaire Results</i>	<i>Giulio Mancini, LNCV</i> <i>Danielle Peterson, PNNL</i>
10:30h	<i>Closing Statements</i>	<i>All</i>
12:00h	<i>Final Adjournment</i>	<i>Maurizio Martellini</i>

Annex B: List of Participants

Honored Guests

1. **Eng Ahmed ALDHONI**
Generation Planning Dept. National Electric Power Co. NEPCO, Jordan
2. **Dr. Gustavo ALONSO**
Senior Scientist, Departamento de Sistemas Nucleares, Instituto Nacional de Investigaciones Nucleares Carretera, MÉXICO
3. **Mr. Namulo ANDREAS**
Ministry of Mines and Energy, NAMIBIA
4. **Dr. Kamal ARAJ**
Commissioner for International Cooperation, Jordanian Atomic Energy Commission, JORDAN
5. **Dr. Paulo BARRETTO**
Former Advisor to the Brazilian Government, Advisor to the Nuclear Security Science and Policy Institute, College Station TX, United States
6. **Dr. Le Chi DUNG**
Deputy Director General, Vietnam Agency for Radiation and Nuclear Safety (VARANSAC)
7. **Mr. Adnan Haji KHALID**
Senior Director (Management Programme), Malaysian Nuclear Agency (Nuclear Malaysia), Malaysia
8. **Mr. David MBIDI**
Nampower, NAMIBIA
9. **Ms. Sonia FERNANDEZ MORENO**
Senior Advisor, Nuclear Affairs and Institutional Communication Department Autoridad Regulatoria Nuclear (ARN), ARGENTINA
10. **Dr. Noramly bin MUSLIM**
Chairman, Malaysian Atomic Energy Licensing Board (AELB), Ministry of Science, Technology and Innovation (MOSTI), MALAYSIA
11. **Dr. Mahmoud NASREDDINE**
Director General, Arab Atomic Energy Agency
12. **Mr. Guillermo ORTEGA**
Comision Federal de Electricidad, Mexico, MÉXICO
13. **Dr. F. Erepamo OSAISAI**
Director General, Chief Executive, Nigeria Atomic Energy Commission, NIGERIA
14. **Mr. Pham Le PHU**
Deputy Director, Nuclear Power and Renewable Energy Projects Pre-Investment Board EVN (Electricity of Vietnam)

Speakers & Other Participants

1. ***Ms Roberta BALLABIO***
Landau Network - Centro Volta, Como, Italy
2. ***Dr Fanny BAZILE***
Forecast Director, Nuclear Energy Division, CEA, Gif Sur Yvette, France
3. ***Dr David BOYLE***
Nuclear Security Science and Policy Institute, Texas Engineering and Experimental Station, College Station, United States
4. ***Dr Chaim BRAUN***
Stanford University, Palo Alto, United States
5. ***Dr Alexander BRYUSOV***
Institute of Physics and Power Engineering, Obninsk, Russian Federation
6. ***Mr Adrian COLLINGS***
Director, Policy Development, World Nuclear Association, London, UK
7. ***Prof. Giorgio CONETTI***
Deputy Rector, University of Insubria, Como, Italy
8. ***Ms Liubov DRODZOVA***
Moscow Power Engineering Institute, Moscow, Russia
9. ***Dr Alexey GRIGORIEV***
Director General, Texsnabexport, Moscow, Russian Federation
10. ***Dr Wacław GUDOWSKI***
Deputy Executive Director, International Science and Technology Center, Moscow, Russian Federation
11. ***Dr Robert HAWLEY***
CBE, Vice Chancellor, World Nuclear University, London and former CEO, British Energy
12. ***Dr Roger HOWSLEY***
Director, Krios Consulting Ltd, Wilmslow, UK
13. ***Dr Vladimir KAGRAMANYAN***
Institute of Physics and Power Engineering, Obninsk, Russian Federation
14. ***Dr Maria KATVA***
Ux Consulting, Washington DC, United States
15. ***Ms Heather LOONEY***
U.S. National Nuclear Security Administration (NNSA), Washington DC, United States
16. ***Mr Giulio MANCINI***
Landau Network - Centro Volta, Como, Italy
17. ***Dr Charles McCOMBIE***
Executive Director of the Arius Association, Switzerland

18. **Mr Edward McGINNIS**
Deputy Assistant Secretary, Corporate and Global Partnership Development, U. S. Department of Energy, Washington DC, United States
19. **Ms Margot MININNI**
U.S. National Nuclear Security Administration, Washington DC, United States
20. **Prof Dr Maurizio MARTELLINI**
Secretary General, Landau Network - Centro Volta, Como, Italy
21. **Ms Danielle PETERSON**
Pacific Northwest National Laboratory, United States
22. **Prof Franco PORCELLI**
Scientific Attaché, Italian Embassy in Cairo
23. **Dr Tariq RAUF**
Head, Verification & Security Policy Coordination, IAEA, Vienna, Austria
24. **Prof Dr Marco RICOTTI**
Polytechnic of Milan (POLIMI), Italy
25. **Mr Piero RISOLUTI**
Manager, Radioactive Waste Disposal, Nuclear Technology Department, ENEA, Italy
26. **Dr Hans-Holger ROGNER**
IAEA, Vienna, Austria
27. **Mr Paolo SERPI**
Minister and Special Envoy, Italian Ministry of Foreign Affairs
28. **H.E. Ambassador Dr. Mohamed SHAKER**
Egypt
29. **Dr Thomas SHEA**
Director, Global Nuclear Policy Forum, World Nuclear University, London
30. **Dr Fiona SIMPSON**
New York University, New York, United States
31. **Ms Anne STARZ**
Nuclear Energy Department, IAEA, Vienna, Austria
32. **Mr William SZYMANSKI**
Senior Program Manager, Office of Nuclear Energy, United States Department of Energy, Washington DC, United States
33. **Dr Craig WELLING**
United States Department of Energy, Washington DC, United States
34. **Dr David WIMPEY**
Divisional Manager: Plant Engineering, Pebble Bed Modular Reactor Ltd, Centurion, South Africa

Annex C: List of Presentations

June 10,2008

- 1) *Dr Paolo Barretto, Brazilian Energy Challenges and prospects for expanding nuclear power generation*
- 2) *Dr David Boyle, Nuclear Security Science and Policy Institute- Texas A&M Institute*
- 3) *Dr Chaim Braun, Barriers to Commercialization of Advanced Nuclear Heat Technologies*
- 4) *Mr Adrian Collings, The global Nuclear Renaissance: a view from industry*
- 5) *Dr Le Chi Dung and Mr Phan Le Phu, Current Status of Nuclear Energy Development in Vietnam*
- 6) *Dr Robert Hawley, Hawley's Rules: Recommendation for Commercially Successful Nuclear Power*
- 7) *Mr Adnan Khalid and Dr Noramly B.M., Planning for the Sustainable Energy Development in Malaysia*
- 8) *Dr Jukka Laaksonen, Regulation of new nuclear build in Finland [presented by Dr Roger Howsley]*
- 9) *Prof Dr Marco Ricotti, IRIS: a comprehensive approach to implementing nuclear power in countries with smaller electric grids*
- 10) *H.E. Ambassador Dr Mohamed Shaker: The NPT Regime: Challenges for Future Security*
- 11) *Dr David Wimpey, The Pebble Bed Modular Reactor: an Attractive Future Option*

June 11,2008

- 1) *Dr Alexey Grigoriev, International Uranium Enrichment Center (JCS IUEC)*
- 2) *Dr Roger Howsley, Security Best Practice: Learning from Experience*
- 3) *Ms Heather Looney, Reducing Proliferation Risks through National Programs of Cooperation*

- 4) *Dr Maria Katsva, Nuclear Fuel Market: Uranium*
- 5) *Dr Charles McCombie, Critical Goods & Services: Nuclear Waste Management*
- 6) *Dr Tariq Rauf, The Future of the IAEA: Nuclear Non-Proliferation and Nuclear Disarmament*

June 12,2008

- 1) *Dr Charles McCombie and Ewoud Verhoef, The SAPIERR projects: European Concepts for shared storage and disposal facilities for radioactive waste*
- 2) *Mr Edward McGinnis, The Global Nuclear Energy Partnerships- From Vision to Reality*
- 3) *Dr Vladimir Kagramanyan, Global Nuclear Power Challenges*
- 4) *Dr Fiona Simpson, Assurances of Supply: Politics and Prospects*
- 5) *Mr William Szymanski, The Global Nuclear Energy Partnerships- Reliable Nuclear Fuel Services*

June 13,2008

- 1) *Eng Ahmed Aldhoni, Generation Expansion Plan Nuclear Option*
- 2) *Dr Fanny Bazile, Nuclear Power Infrastructure Development- The French Perspective*
- 3) *Dr Chaim Braun, Nuclear Fuel Assurances: Initiatives and Prospects*
- 4) *Dr Chaim Braun, Nuclear Power Expansion: A Market Survey*
- 5) *Prof Dr Marco Ricotti, Competiveness of Small-Medium, new generation Reactors: a comparative study on Capital and O&M Costs*
- 6) *Dr Holger Rogner, Projecting Costs, Financial Risks and novel financing possibilities*
- 7) *Ms Anne Starz , IAEA Assistance to Nuclear Power Newcomers*
- 8) *Dr Craig Welling, The Global Nuclear Energy Partnerships - The Infrastructure Development Working Group (IDWG)*

Annex D: Reference Materials

- 1) Considerations to Launch a Nuclear Power Programme, IAEA, 2007
- 2) Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA, 2007
- 3) The UK Capability to Deliver a New Nuclear Build Programme, Nuclear Industry Association, 2008
- 4) IAEA Safeguards: Staying Ahead of the Game, IAEA, 2007