Keynote speech in the International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes, Abu Dhabi, United Arab Emirates, 15 March 2010

by

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&
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“Expanded use of nuclear technologies offers immense potential to meet important development needs. In fact, to satisfy energy demands and to mitigate the threat of climate change – two of the 21st century’s greatest challenges – there are major opportunities for expansion of nuclear energy in those countries that choose to have it”.

from Report on “The Role of the IAEA to 2020 and Beyond”, prepared by an independent Commission at the request of the Director General of the International Atomic Energy Agency – 2008. I was a member of this Commission.
The Human Development Index (HDI) is directly dependent, in my opinion, on two main parameters: Per Capita Electricity Consumption and Female Literacy (U.N. uses three parameters to calculate the HDI: per capita GDP, Life Expectancy at Birth and Adult Literacy).

Nuclear is an important (in fact, inevitable) option for long-term sustainable availability of electricity - in the context of both the climate change threat and the depletion of fossil fuels.
The Global Nuclear Renaissance has four geographical dimensions:

1. Countries freshly starting a nuclear power programme.

2. Countries which have had a continuous and sustained growth, at various velocities, of the nuclear power programme over the last few decades, and are now accelerating growth.

3. Countries which had a rapid early growth in their nuclear power programme, have stagnated in the last couple of decades, but are re-starting their growth.

4. Countries which are contributing to global nuclear power growth through export of equipment and technology.
Nuclear Growth in USA & France

Net Electrical Power MW(e)

Years

USA

France

Source IAEA-PRIS
1. Very rapid growth in nuclear power generating capacity is possible once the knowledge base and skilled manpower resource pool have been established.

2. Continuity in growth is the key to Nuclear Knowledge Management.

3. Difficulties in Knowledge Management can arise during:
   (a) Launch stage of a nuclear power programme
   (b) Stagnation in nuclear power growth over an extended period
   (c) Introduction of a new reactor design

4. These difficulties can be overcome by leveraging international cooperation (bilateral, regional or through the IAEA)

5. The availability of wide-bandwidth, low latency network connectivity may be valuable in this context.
Three Stage Indian Nuclear Programme

**First Stage:**
PHWRs: Natural UO$_2$ fuels
Imported water cooled reactors: SEU/MOX fuels

**Second Stage:**
FBRs: (U-Pu) MOX / MC / Metallic Fuels (U-Pu Closed Cycle)

**Third Stage:**
Thorian Utilisation (Th-U$^{233}$) closed cycle
(Th-Pu/$^{233}$U MOX/ Metallic Fuels Molten salt fuels

Courtesy: H.S. Kamath
Closing the Nuclear Fuel Cycle in the Context of the Global Climate Change Threat

Fig. 1: Nuclear installed capacity with open and closed fuel cycle options

Closing the nuclear fuel cycle is essential if nuclear is to be a sustainable mitigating technology in the context of the climate change threat. This is in coherence with India’s three-stage nuclear programme.

from Chidambaram, Sinha & Patwardhan, Nuclear Energy Review 2007
Indian Department of Atomic Energy (DAE)

- Has a strong R&D base: Bhabha Atomic Research Centre, Indira Gandhi Centre for Atomic Research
- Has internal industrial organizations: UCIL, NFC, HWB, ECIL, etc.
- NPCIL encompasses all aspects of nuclear power plant technology within one organisation
  - Siting, Engineering Design, Safety analysis and HS&E
  - Procurement, Plant Construction and Commissioning, QA
  - Operation and Life extension of NPPs
- The nuclear power programme has a strong industry backup, which is increasing: BHEL, L&T, Walchandnagar Industries, etc.
- Training has been a continuous process.
### Training Schools of DAE

<table>
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<th>Training School</th>
<th>No. of years of existence</th>
<th>No. of disciplines</th>
<th>No. of TSOs graduated</th>
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<td>NFC-HWB, Hyderabad</td>
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<td>NPCIL</td>
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</tbody>
</table>

Those holding bachelor’s degree in engineering or technology and master’s degree in a Science discipline are eligible for the Training School programme.

Each affiliate Training School imparts specialized training in a chosen discipline:

- Imparting fundamentals and Training by practicing professionals ensures that implicit and tacit knowledge is passed on.

- Security of a job to those selected for training ensures their commitment.
PFBR Operator Training Simulator

A well trained operator is an asset for any Nuclear Power Plant

Need for Training Simulators

To ensure safe operation by the plant personnel
To impart comprehensive training to the operators before commissioning of the actual Plant
To enhance the knowledge and increase the efficiency of the operators
To conduct transient tests that are not practically possible in the real plant
To simulate Plant scenarios representing various states of the plant
To test the plant operating procedures

(Courtesy: Baldev Raj, IGCAR)
“for sharing knowledge and expertise”:

- World Nuclear University (WNU)
- Asian Network for Education in Nuclear Technology (ANENT)
- European Nuclear Engineering Network (ENEN)
- Asian Nuclear Safety Network (ANSN)
- University Network of Excellence in Nuclear Engineering (UNENE), Canada
- Shared “National Platforms”

... from this Conference Information booklet
ALSOS Digital Library for Nuclear Issues

(Washington and Lee University, Lexington, VA)

This Digital Library is a web-based collection of annotated references to resources that trace the development of nuclear science, the Manhattan Project, the Cold war arms race, .... as well as nuclear power. The materials referenced include books, articles, videos and website. Each annotation is vetted to assure accuracy and indexed to facilitate access.

This Library is registered with ‘Creative Commons’

“Creative Commons” creates a more flexible copyright model, replacing “all rights reserved” with “some rights reserved”

(from my talk in the International Conference on Digital Libraries, New Delhi 26 February 2010)
Online Information Resource Gateway: Lakshya

- In Hindi Lakshya means “Target”. Target for scientific knowledge.
- It is a gateway established by SIRD (BARC Library), providing easy access to all online e-resources in BARC through campus wide network.
- More than 3450 Full text E-Journals are accessible
- Eleven Databases including INIS, SCOPUS etc
- Six Encyclopedias and more than 35 online resources
- Available to all patrons on Campus wide Internet Network
- Trial access of digital resources promoted by scientific community/vendors
- Search selection: Journal titles wise, Broader & Narrow Subject category wise

(from my talk in the International Conference on Digital Libraries, New Delhi 26 February 2010)
INIS (International Nuclear Information System)

Mandate: "... to foster the exchange of scientific and technical information on peaceful uses of atomic energy".

SIRD, BARC is an Input Center to the INIS database from INDIA

- Operated by IAEA in collaboration with 122 Member States and 24 International organizations as on December 2009 and started in 1970
- Leading reference database for scientific literature published worldwide on the peaceful uses of nuclear science and technology
- Comprehensive international coverage by INIS Members and the INIS Secretariat
- Over 3 million bibliographic citations and abstracts of journal articles, scientific and technical reports, conference papers, books, patents, theses, laws, regulations and standards, and web documents
- Non-Conventional Literature (NCL) 2,00,000 full text documents
- A unique multilingual thesaurus
- Average annual increase of over 100 000 records
- Open access available to Internet users

(from my talk in the International Conference on Digital Libraries, New Delhi 26 February 2010)
Subject Scope
The INIS Database covers a broad range of subjects in areas of the IAEA’s interests and activities in nuclear science and technology:

(from my talk in the International Conference on Digital Libraries, New Delhi 26 February 2010)
Interactive Learning through Online Classroom
(using e-connectivity)

- High definition *interactive* video

- Each remote class room sees the Main class room as well as other remote class rooms on the screens

- Each student, remote or in the main class room, has the ability to:
  - Ask questions interactively
  - React to other questions and answers

- Teachers can teach in a coordinated fashion during the same lecture by having local backup tutors at each remote classroom.

* All this needs high-bandwidth (multi-gigabit/sec), low-latency network connectivity

Courtesy: P.S. Dhekne
National Knowledge Network (India)
Mentoring New Indian Institutes of Technology

Courtesy: S.V. Raghavan
We can have Global Virtual Classrooms for Nuclear Science and Technology transcending international borders, if high-bandwidth, low latency national networks are interconnected.

Such global classrooms could be very cost-effective. Convenient times for international connectivity will have to be selected, taking into account Time-zone differences. There could also be the need for language synergy.

A Virtual International School for Nuclear Training could be conceptualized, which should also include field visits to proximate nuclear installations and on-site additional laboratory training, while Interactive distance teaching can be in some key areas like:

**Reactor Physics**

**Nuclear Engineering**

Nuclear law
Regulatory process
Safety culture
Radiation protection
Etc.
Attracting (and Retaining) Young People to Careers in Nuclear Science and Technology

For talented Young People today, so many alternate attractive careers are available that special efforts are needed for bringing them - and also Faculty, of which also there is similar shortage - to Nuclear Science and Technology, to strengthen Nuclear Renaissance:

(1) **For young people**

Assured Careers as an Incentive, apart from monetary compensation

(2) **For Faculty**

Use Scientists and Engineers working in Nuclear Plants, Industry and Research Centres as Adjunct Faculty, and utilise distance education.

(3) **For both:**

Offer exciting Challenges in this field, participation in the field of Advanced Reactors and Fuel Cycle Activities (INPRO, Gen. IV)