INDIA ENERGY FORUM

11th Nuclear Energy Conclave

18th October 2019,New Delhi

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"Economics of Nuclear Power- Innovations towards Safer & Cost Effective Technologies"

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SOUVENIR

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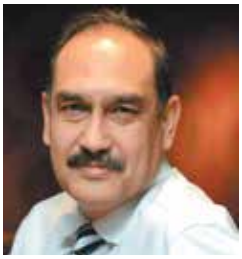

Dr Harsh Mahajan
Director, Mahjan Imaging

Shri S.M. Mahajan
Convener, Nuclear Group, IEF, Former ED, BHEL & Consultant (Power Sector)

Organiser

India Energy Forum: The Forum is a unique, independent, not-for-profit, research organization and represents energy sector as a whole. It is manned by highly qualified and experienced energy professionals committed to evolving a national energy policy.

The Forum's mission is the development of a sustainable and competitive energy sector, promoting a favourable regulatory framework, establishing standards for reliable and safety, ensuring an equitable deal for consumers, producers and the utilities, encouraging efficient and eco-friendly development and use of energy and developing new and better technologies to meet the growing energy needs of the society. Its membership includes all the key players of the sector including BHEL, NTPC, NHPC, Power Grid Corporation, Power Finance Corporation, Reliance Energy, Alstom and over 100 highly respected energy experts. It works closely with various chambers and trade associates including Bombay Chamber, Bengal Chamber, Madras Chamber, PHD Chamber, Observer Research Foundation, IRADE, INWEA,Indian Coal Forum, and FIPI.

Distinguished Chief Guest

Dr. Jitendra Singh

MoS (I/C) for DoNER, MoS in Prime Minister's Office,
Deptt of Personnel and Training, Deptt of Space and Atomic Energy

Hon'ble MoS, Dr Jitendra Singh (born 6 November 1956) is the Minister of State (MoS) (Independent Charge) for the Ministry of Development of North Eastern Region, Prime Minister Office, Personnel, Public Grievances and Pensions, Department of Atomic Energy and Department of Space.
He is a Bharatiya Janata Party (BJP) National Executive Member.

He was a professor of diabetes and endocrinology,a consultant and clinical practitioner, author of 8 books, and a newspaper columnist. He is the ex-Chairman, National Scientific Committee Diabetes, Research Society for Study of Diabetes in India. Shri Singh hails from a Rajput family.

He contributed over five thousand published articles in the press including a widely read syndicated column "Tales of Travesty". Author of five books, Elsvier published monograms and over a dozen chapters in various text books of Diabetes and Medicine for MD students. He was first ever medical professional to be conferred the coveted "Jamna Devi Gian Devi" award for journalism. Citation hails him as popular freelance journalist having so far contributed more than two thousand published articles in national regional press.

He has authored five books and three Monograms included three All-India popular books on Diabetes awareness, one of which titled "Diabetes Made Easy" was included in Best-seller section of "World Book Fair" held at Pragati Maidan in 2002.

He was Awarded Gold Medal for "Oration" at Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER), Pondicherry. He received the "Award of outstanding personality" from former union Health Minister, Mr. Ghulam Nabi Azad in 2009 Interestingly.

He was pioneered work on "Stress Diabetes in Kashmiri Migrants" published in "International Journal of Diabetes in Developing Countries" and hailed by World Health Organization (WHO).

Leading from the front

One of the largest and most respected companies in India's private sector, Larsen & Toubro boasts more than seven decades of multi-disciplinary capabilities technology, engineering, construction, and manufacturing experience.

In 1960s, L&T pioneered indigenous manufacturing technology for critical equipment for nuclear power projects in India, and has since contributed to virtually all India's indigenous nuclear projects. L&T has the distinction of being the first Indian company to execute orders for nuclear grade equipment for US and Europe.

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Ranked #22 in Best Employers
#1 in India

Ranked #135 in Best Regarded Companies
#5 in India

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PROGRAMME

09.00 a.m. – 09.45 a.m. **Registration and Networking Tea**

09.45 a.m. - 10.00 a.m. **Assembly of Delegates/ Speakers and Arrival of Dignitaries**

10.0 a.m. – 11.20 a.m. Inaugural Session

- Lamp Lighting
- Address by **Shri Anil Razdan**, President, IEF and Former Secretary, Ministry of Power, Government of India
- Address by **Dr.Srikumar Banerjee**, Chairman, Nuclear Energy Group, India Energy Forum and Chancellor Homi Bhabha National Institute
- Address by **Dr K N Vyas**,Secretary, DAE & Chairman, AEC on "Long term vision for Nuclear Energy"
- Address by **Dr Anil Kakodkar**, Former Chairman, AEC on "Nuclear Power- India's Development Imperatives"
- Address by **Dr R B Grover**, Member, AECon"Comparing electricity generation technologies from consideration of economics."
- Inaugural Address by the **Chief Guest,Dr Jitendra Singh**, MoS (I/C) for DoNER, MoS in Prime Minister's Office, Deptt of Personnel and Training, Deptt of Space and Atomic Energy
- Vote of Thanks by **Shri S M Mahajan**, Convenor, Nuclear, IEF and Former ED, BHEL

11.20 – 11.45 a.m. – Tea Break

11.45 a.m. – 1.15 p.m.: **Technical Session I: Growth of Nuclear Power for meeting Base Load demands- Opportunities & Challenges for Manufacturing Industry**

Chairman: Shri A K Balasubramanian, Director (Tech.), NPCIL

Distinguished Panelists

- **Dr. Dinesh Shrivastav**, CE, Nuclear Fuel Complex
- **Shri Nikita Mazein**, President, Rosatom Overseas
- **Dr Thomas Mieusset**, Nuclear Counciler, French Embassy
- **Shri YS Trivedi,** Sr. Executive Vice President, Larsen & Toubro Limited
- **Shri G K Pillai**, MD & CEO, Walchandnagar Industries Ltd.
- **Shri P P Yadav**, Executive Director (Nuclear Business), BHEL

1.15 pm -2.00 pm - Lunch Break

2.00 p.m. - 3.15 p.m.: **Technical Session II: Use of nuclear energy in Healthcare and Municipal Waste Treatment**

Chairman: Shri G NageshwarRao, Chairman, AERB

Distinguished Speakers

- **Dr Harsh Mahajan**, MD, Mahajan Imaging on Nuclear Energy for Diagnostics
- **Dr Sudeep Gupta**, Director, ACTREC, Tata Memorial Centre- Nuclear Energy for Therapeutics
- **Ms Kritika Kaur**, Management of Radioactive Waste in Health Care & Research Sectors, Nuvia India

3.15 pm to 3.30 pm: Tea

3.30 p.m. – 4.30 p.m.: **Technical Session III: Emerging Technologies for Economy and Enhanced Safety viz, Small & Medium Size Reactors, Passive Safety Features, Molten Salt Reactors**

Chairman: Dr AK Bhaduri, Director IGCAR

Distinguished Speakers

- **Dr. Srikumar Banerjee** on "Molten Salt Reactors"
- **Dr. Arun Nayak on "Concept design of Passive Safe Integral LWRs for Accelerated Capacity Building"**

4.30 pm :Summing Up and Vote of Thanks by **Sh SC Chetal**, Mission Director, AUSC n Former Director, IGCAR

ECONOMICS OF NUCLEAR POWER : Innovation towards Safer & Cost Effective Technologies

THE PERSPECTIVES

V.P. Singh, Member, Steering Committee, Former Executive Director, BHEL

EXPANDING ROLE OF ATOM FOR PEACE

The atom for energy has become critical for the clean energy transition. It has also expanded its role to other crucial areas like healthcare, agriculture, food and arange of industrial applications, to the benefit of mankind. The clean energy transition will become harder if nuclear energy is not made an integral and substantial part of low carbon energy mix – being the only non-fossil, clean source for continuous electricity generation for ages. This is vital for the energy security of the country.

THE THEME: ECONOMICS OF NUCLEAR POWER

The theme of the Conclave is the key to the availability of clean, affordable, non-fossil – 24x7 base load power for growing needs of India.

The world is looking back at Nuclear Power as a low carbon energy source, capable of meeting the growing needs of electricity along with renewables.

Nuclear Energy has to be commercially competitive vis-à-vis other sources like coal, hydro and renewables – to be a part of energy basket. This brings up the issue of economics of Nuclear Power – the theme of this Conclave.

With higher capital cost but lower fuel costs, Nuclear Power Plants (NPPs) are expensive to build but relatively cheaper to run. Pressurised Heavy Water Reactors (PHWRs) have demonstrated their competitiveness. In fact, if social, health and environmental cost of fossil fuels are also factored in, the competitiveness of NPPs improves on a levelised (i.e. lifetime basis) basis, Nuclear Power is an economic source of electricity generation combining the advantages of security, reliability and very low greenhouse gas emissions.

While nuclear power is an economic option, significant upfront capital costs are a barrier. The next generationadvanced reactors has promising projected cost reduction by virtue of their optimised and standard design, serial and reduced construction time by pre-fabricating more assemblies at factory (rather than site). The strict and enhanced safety features are also being provided in the advanced reactors.

GOVERNMENT SUPPORT FOR NUCLEAR POWER PROGRAMME

Government of India, as a matter of policy has actively supported the Nuclear Power Programme. Several steps taken to accelerate the programme include:

- Administrative & financial approvals, in one go, of 10x700 MW – PHWRs – one of the largest approvals of its type in the world. This would enable continuity of nuclear infrastructure utilisation in fleet mode implementation.
- Amending the Atomic Energy Act to enable Joint Ventures (JVs) with PSUs for augmenting financial resources in this sector.

• A Government budgetary support of Rs.3,000crores per annum to augment the equity capital for the NPPs.
• Augmenting the uranium fuel supply through contracts with many countries – increasing the availability of operating NPPs.
• Approval of further Light Water Reactors (LWRs) – 1000 MW capacity to be set up with Russian Federation.
• Resolution of issues related to Civil Liability for Nuclear Damages Act 2010 and creation of Indian Nuclear Insurance Pool.

NUCLEAR POWER – A COMPETITIVE SOURCE OF ENERGY

•Cost of Generation from NPPs is competitive as compared to other technologies even if system cost and externalities are not accounted for. For example, the electricity tariff from PHWRs, set up in India, are competitive, as detailed below:

Power Plant	Tariff (Paisa / Kwh)
TAPS 1&2	107
MAPS 1&2	216
KAPS 1&2	247
NAPS 1&2	258
RAPS 2 to 4	288
TAPS 3&4	293
KGS 1 to 4	313
RAPS 5&6	354
KNPP 1&2 (1000 MW)	410

• The average tariff of NPPs in 2017-18 and those of Thermal Power Stations commissioned in the same period are:

- NPPs : Rs.3.55/KWh
- Thermal Plants : Rs.5.20 to Rs.5.70 / KWh (excluding externalities like ghg etc.)

As to the renewables, the costs have to be loaded with storage systems / alternate generating cost; if these have to cater to base load operations.

•However, ensuring competitive tariffs for NPPs with enhanced safety features,is a continuous process by resorting to standard designs, increasing off-site pre factory assembles, improving efficiency and adopting suitable financing and business models.

INDIA ON GROWTH PATH OF NUCLEAR POWER

India has a well developed industrial infrastructure, quality accreditation, and qualified manpower, required for taking up nuclear power projects from concept to commissioning. Indian companies have developed heavy engineering facilities and capabilities for manufacturing Light Water Reactors (LWRs) with international cooperation besides indigenous design of PHWRs and FBRs. This will help foreign companies to maximise the local value addition for their projects in India necessary for enhancing their competitiveness.

Newer technologies being developed in India include:

- Advanced Heavy Water Reactor to be fuelled by thorium
- Pressurised Water Reactor to be fuelled by enriched Uranium
- Development activities in molten salt reactors

Safety first and environment foremost – appears to be guiding principal of Indian nuclear programme. India has a vision of becoming a major player in Nuclear Power Technology pursuant to its three stage developed programme. It plans to generate 25% of its electricity by 2050.

THE INDIAN NUCLEAR POWER PROGRAMME

- A mix of indigenous 700 MW – PHWRs; 500 MW – Fast Breeder Reactors (FBRs) and Light Water Reactors with international co-operation like Kudankulam (4 x 1000 MW), would form the bulk capacity addition in the medium term. The capacity build up could be summed up as follows:

-	Present installed capacity (22 Reactors)	:	6,780 MW
-	NPPs under construction (9 Reactors)	:	6,700 MW
-	NPPs sanctioned (12 Reactors)	:	9,000 MW
	Total	:	22,480 MW

These 21 NPPs – under construction and additionally sanctioned, would be commissioned by 2031.

- In addition to above, Government has approved project sites for setting up LWRs with international co-operation and PHWR & FBRs. These include:

Jaitapur 1-6 (6 x 1650 MW)	Maharashtra
Kowada 1-6 (6 x 1208 MW)	Andhra Pradesh
ChhayaMithiVirdi1-6 (6 x 1594 MW)	Gujarat
Haripur 1-6 (6 x 1200 MW)	West Bengal
Bhimpur 1-4 (4 x 700 MW)	Madhya Pradesh
6 x 600 MW FBR	

The above capacities will total up to a target of around 63,000 MW

PLANS FOR NEW REACTORS WORLD WIDE

- The quest for the future - low carbon energy world, is driving countries look at Nuclear Energy once again. Many new countries have entered into the generation of Nuclear Energy. Notable being UAE, Saudi Arabia, Bangladesh, Turkey, Qatar etc.
- Nuclear Energy capacity is increasing steadily in the world – with about 50 reactors under construction – mostly in Asia and also in Russia – in 15 countries.
- Further capacity is being created by plant upgrading and life time extension of existing plants.

• Total Reactors operating	:	450 Nos.
Number of countries	:	30 Nos
Combined Capacity	:	400 GWe
Share in World Electricity	:	11%

THE MANY USES OF NUCLEAR TECHNOLOGY (OTHER THAN POWER)

• There has been tremendous growth in the application of radiation and radio-isotopes, in diverse fields such as health care, industry, agriculture, food preservation, water resources management, environmental studies, municipal waste management etc.
• Application of radiation has already made huge impact on nuclear agriculture, food preservation, mutation of seeds, treatment of sewage, medical applications and industrial applications for quality / process control, seawater desalination, hydrogen productions & district heating etc.
• The applications of nuclear energy, in areas other than power, are expanding at a fast pace to the benefits of society at large. This will help in gaining the general public acceptance of nuclear energy.

NEXT GENERATION NUCLEAR TECHNOLOGIES

A new generation of nuclear reactors and related fuel cycles involving different technologies collectively known as generation IV, is being developed globally. The effort is to meet the criteria of sustainability, enhanced safety economics and proliferation resistance. The advantages include reduced capital cost, enhanced nuclear safety and minimum waste generation. These include:

- Molten Slat Reactor (MSR)
- Gas Cooled Fast Reactor (GFR)
- Super Critical Water Cooled Reactor (SCWTR)
- Sodium Cooled Fast Reactor (SFR)
- Lead Cooled Fast Reactor (LFR)
- Very High Temperature Reactor (VHTR)

CONCLUSION

• Nuclear Energy is the only clean and non-fossil source which can transform the energy space of the world to a low carbon energy future. This reliable, 24 x 7, bulk, base load energy can make a substantial difference in reducing the greenhouse gases and help mitigate the climate change. An optimum energy mix of nuclear, solar, wind and hydro- electric can indeed provide the growing energy need of the country without adversely affecting our environment and climate.
• The improved designs with many added safetyfeatures of advanced reactors ensure safety,while with more factory assembled sub-systems, and reduced project construction period would make Nuclear Energy more competitive in future.

In a nut shell, nuclear energy is poised to transform the energy scenario in providing not only unlimited and steady supply of clean electricity needed for the country's economic growth but also hydrogen as a clean fuel for transportation for many centuries to come.

Acknowledgement / References

1. *Reports / Studies on Economics of Nuclear Power by various organisations like World Nuclear Association / IAEA etc.*
2. *IAEA Report on next generation reactors*
3. *Vision of Nuclear Energy – Study by Vivekananda International Foundation*
4. *Extracts from the interview by Secretary DAE as published in Power Line*
5. *A MIT study on future of nuclear energy in carbon constrained world*
6. *Necessity of exploiting all energy sources to meet India's electricity needs – a presentation by Dr. R.B. Grover in March 2018 at UrjaVicharManch, India Energy Forum*

All the above are in public domain.

NUCLEAR POWER: INDIA'S DEVELOPMENT IMPERATIVE

The Vivekanand International Foundation (VIF) constituted a Task Force to conduct a study on Nuclear Power :India's Development Imperative. The Task force looked at questions linked to nuclear power sector dispassionately andthe choices available to provide base load energy for India's growth,

The Task force was constituted from various energy experts, stake holders from the manufacturing industry, power developers, R& D Centres andvendors and was chaired by Dr Anil Kakodkar, former Chairman, DAE. The Task Force completed its study and submitted its report entitled " Nuclear Power: India's Development Imperative".Executive Summary of this report is reproduced below with the permission of VIF

EXECUTIVE SUMMARY

1. India's energy consumption has been growing at a CAGR of six percent over the last decade. With the completion of the national grid and universal electrification of households, the demand curve will rise more steeply in the future. This trend will be reinforced by a move towards Electric Vehicles (EVs). The power sector will have to respond to the twin challenges of increased access to electricity and meeting stringent emission norms. Both have to be done at affordable prices. The environmental pressure is already forcing a change in the composition of India's energy portfolio with a premium on clean energy. The renewables will have a greater share in India's energy mix in the future. The tariff for wind and solar energy has also come down, but does not reflect the cost of balancing power needed when wind or solar are unavailable. Nor does it include the grid cost in terms of backing down balancing power plants, or operating them at sub-optimal level, when renewable power is available. In the spectrum of choices available to provide energy for India's growth, the share of nuclear as a key source of stable, non-fossil base load power will have to go up.

2. In the Paris Conference on Climate Change, India committed to increase its share of non-fossil fuel in total installed power generation capacity from 30 percent in 2015 to 40 percent by 2030. The renewables currently account for 35.7 percent of India's installed power generation capacity. The government has announced plans to increase renewables to 175 GW by 2022 from 70.6 GW as on 30 September 2018. This will entail balancing power sources that can rapidly respond like hydro or gas, since wind and solar are intermittent sources of energy and adequate base-load power capacity which can only be supplied by coal or nuclear.

3. Being an intermittent source of energy, renewables cannot provide base-load power critical for India's economic growth. At present, this requirement is essentially met by coal, which accounts for 55 percent of India's commercial primary energy supply1. Its share in India's power generation is 75 percent. However, rising environmental concerns make it imperative to significantly enlarge the share of a non-fossil source of stable, base-load power.

4. Nuclear energy can supplement coal as a source of stable, base loadpower, not supplant it. At present, it accounts for around two percent of India's installed capacity. However, the target of ramping up nuclear power from 6.7 GW at present to 63 GW by 2032 will increase its share in India's electricity generation portfolio to around ten percent. The presently sanctioned capacity is 22.48 GW to be progressively realised by 2031. There is thus a need to open up additional projects to realise the target of 63 GW and a more efficient project implementation framework for their timely completion.

5. As a source of base-load power, nuclear power has to be compared with coal, not renewables. In any comparison with coal, emission costs must be factored in. Broadly speaking, the country's energy mix should be determined on the basis of the availability of different energy resources and their pricing. Left to itself, the market would determine the evolution of this energy mix. This may or may not be consistent with the long-term energy or environment security of the country for which a sizeable contribution from nuclear energy is vital. State policy to steer the energy mix towards long term national interest is, therefore, important. Without factoring grid/system costs of renewables, nuclear tariff may appear high. We should recognise that energy security can become a bigger challenge in the years to come. A well-designed financing and pricing policy should, therefore, be put in place at the earliest. Thus, as a minimum, measures to create at least a level playing field for nuclear energy recognising its strengths in energy security and absence of CO2 emission, are necessary.

6. In order to provide a level playing field, nuclear power should also be given incentives as provided to the renewable sector. It needs a 'must run status', as nuclear plants run on a continuous basis. Without this facility, there will have to be a steep increase in tariff to recover high capital cost. There are other incentives given to wind and solar power, which are presently not available to nuclear power in India. Loading for external costs is part of the cost evaluation of tariff from different sources of energy in the United States and the European Union. This is not so in India due to the direct and indirect subsidies given to solar and wind power by both the Central and State governments.

7. After a pause in the post –Fukushima phase, construction of nuclear plants has again picked up in the West. The US (20 %), EU (20 %) and China (10%) will retain a substantial share of the nuclear sector in their energy mix in the future2. Interestingly, Japan, has also decided to retain nuclear power as part of its energy mix. The Fifth Basic Energy Plan approved by the Japanese Cabinet in July 2018, calls for nuclear energy to account for 20%-22% of the country's power generation by 2030. This is double the share of nuclear energy in the Indian energy mix (10 %) even if the nuclear programme is to be ramped up to 63 GW by 20323.

8. Germany decided not to expand its nuclear power program postFukushima and rely on gas and wind energy. India does not have the option to depend upon gas; imported LNG is too expensive for the power sector. Reliance on gas has also increased Germany's emission levels and made it difficult for the country to achieve its 2020 greenhouse gas reduction target4. Germany could ramp up renewables on a large scale as it can bear the cost, and has access to regional grids to supply balancing power. India does not have the option of a regional grid as most of the neighbouring countries, with the exception of Bhutan, are net importers of electricity. Bhutan exports power to India but does not have the scale to match India's requirements.

9. China entered the civil nuclear power sector later than India. It attempted expansion of its domestic programme and exports simultaneously. There is no conflict between the two. Exports help achieve scale and bring down costs. India should also aim at emerging as a global manufacturing hub for nuclear equipment and material. This task will be facilitated if Indian companies are part of an international supply chain. For this they have to be globally competitive in terms of price and quality.

10. Ramping up the nuclear power sector from 6.7 GW to 63 GW by 2032 will require considerable resources, financial discipline and reorganisation of the nuclear sector to bring in more players who can invest in expanding capacity. The government's announcement of funding to the tune of Rs.3000

crores per annum for building ten reactors in fleet mode is a welcome step, but falls short of financial requirements.

11. For import of Russian reactors for Kudankulam, 1, 2, 3, 4, 5 & 6, NPCIL has negotiated soft credit. While making financing easier, the foreign credit sometimes limits scope of 'localisation'. For the Indian industry to grow in capacity, progressive indigenisation is essential. This is also needed to bring down costs and tariff.

12. There are other modes of financing. In the case of the UAE and the UK, they have allowed foreign companies not only to construct, but also to operate their nuclear power plants for extended periods. Applying this model to Indian conditions would require an amendment of the Atomic Energy Act. There are intermediate solutions such as encouraging PSUs like the NTPC and IOCL to form joint ventures with the NPCIL. This can be implemented within the present Act.

13. The NPCIL has to bring down the cost of construction to ensure that nuclear power continues to be affordable in the future. A key to realising this is to nurture optimum manufacturing capacity where there is not only good competition, but also confidence about continuity of work orders for competitive industries. Continuous orders are necessary for the vendor industry to invest in expansion of capacity. It also has to evolve procedures for fleet-mode construction. The government has to allow flexibility in procurement procedures. Internally, company procedures must assure quality manufacturing and construction without interruptions. This also needs an increase in trained manpower. This will also generate considerable employment.

14. To propose an increase in the share of nuclear power at a time when the power sector is witnessing a large number of NPAs may seem audacious, but increase in electricity generation capacity cannot be avoided if growth in economy has to take place at a rapid pace. Today, India's per capita energy consumption is a third of the world average. With high emphasis on domestic manufacture in nuclear sector, the government's target of increasing share of manufacturing in the GDP would also be facilitated. Since, this has to be achieved within the constraints of emission norms that are expected to become progressively more stringent, it is clear that nuclear power is not a luxury, but a necessity for India.

15. China's case is instructive. With the same cost constraints, and share of coal in energy profile as India, China is seeking to make nuclear power ten percent of its total energy requirement by 2030. Its civil nuclear programme started much later than India, nevertheless, it has focused on exports since inception. It also has a multiplicity of reactor types to avoid dependence on a single source. By using economies of scale, it has gone further and faster in indigenising technology and lowering production costs. Till recently, we could not access global markets, but that is possible now. We should now be proactive in exploring the global market not only for our PHWRs (Pressurised Heavy Water Reactors), but also globally explore the much larger market for LWRs (Light Water Reactors). This could be both for equipment and components for LWRs of different designs and also for indigenously designed PWRs for which work is currently in progress.

16. The Inter-governmental Panel on Climate Change (IPCC) released its report in October 2018 in Incheon, South Korea. This is a sequel to the agreement adopted at the Paris Summit on Climate Change in 2015, which called for keeping global warming "well below" 2° Celsius (C) and above pre-industrial temperature levels. The agreement also urged all countries to "pursue efforts towards 1.5° C". The IPCC report brought out the difference between the 2° C target agreed and the more ambitious 1.5°

C goal in terms of impact on poverty, agriculture and rise of sea level. It also brought out the cost of different adaptation and mitigation measures. Though the report does not represent an agreement at the government level, it underlines the need for de-carbonisation of global economy5.

17. The IPCC report does not suggest specific solutions. However, a recent study by MIT, released on the eve of the IPCC report, says that nuclear power has to be part of the energy mix in any pathway to a 1.5° C future. The report captioned 'The Future of Nuclear Energy in a Carbon Constrained World' points out that 'as the world seeks deeper reductions in electricity sector carbon emissions, the cost of incremental power from renewables increases dramatically'. The report suggests that 'including nuclear in the mix of capacity options helps to minimise or constrain rising system costs, which makes attaining stringent emission goals more realistic.' The report gives recommendations for policy intervention to ensure that 'public policy to advance low-carbon generation should treat all technologies comparably.' It also calls for a reduction in the cost of producing nuclear power6.

18. The concept of carbon pricing is at a nascent stage in India. The government has introduced the Energy Efficiency Certificate and a coal cess. However, there is resistance to the idea, as it burdens the downstream industry. India is far below the world average in electricity consumption and has to use its available coal reserves. However, over a period of time, increase in the share of non-fossil fuels is essential. This is reflected in government policy, but, more needs to be done.

19. The current debate on the power sector in India is characterized by concern over low demand, stressed assets and the need to bring down tariff to compete with renewables, which have fallen to Rs. 2.5 per unit. However, the spot power price in September 2018 touched almost a 10year high of Rs 17.61 per unit on the Indian Energy Exchange (IEX) of spot prices. The spike was attributed to the decline in wind and hydroenergy at this time of the year, coupled with constraints in the movement of coal to thermal power plants. While spot prices do not indicate a long term trend, they underline the difficulty of relying on renewables, which are an intermittent source of energy. The problem will get worse as the share of renewables in India's energy mix increases with the government's goal of 175 GW of renewables by 20227.

20. The coal import bill last year was more than USD 9 billion. There seems to be an increasing trend for coal imports. In comparison to coal, the cost of nuclear fuel is a negligible component of operating costs of a nuclear power plant.

21. India is developing a three- stage nuclear power programme to make full use of its abundant Thorium resources. An MIT report brings out the potential of various reactor models, including small modular reactors. India has to maintain its technological perch in the nuclear field. There is an ongoing programme to develop nuclear reactor systems for the second and the third stages along with the indigenous PWR. Safety upgrades are also likely to continue to be an ongoing feature. We would also need to develop nuclear reactor systems that can deliver energy at high temperatures for non-electricity purposes such as hydrogen production or reactor systems that would enable a faster approach to large scale Thorium utilisation such as Accelerator Driven Subcritical Reactor Systems (ADSS). The goal of a decarbonised economy will require the greater use of non-fossil hydrogen for mass electrification and the use of heavy transport, heating and industry8.

22. The rapid ramping up of installed nuclear power capacity from 6.7 GW to 63 GW by 2032 would require the government to provide substantial resources to NPCIL. This cannot be managed through

internal accruals alone. There is also a need to look at financing models used by other countries, including the UAE and the UK, where credible international vendors with significant pre-existing domain expertise in nuclear power plant operation are allowed to acquire equity and operate the plant, while the government gives long term tariff guarantees. This, however, would require amending the existing Atomic Energy Act. NPCIL has to ensure timely completion of projects within the budget. Indian companies should form strategic tie-ups with international majors to be part of the international supply chain.

23. Some of the major recommendations made by the Task Force include : (i) Energy security is likely to become a bigger challenge in the years to come. A well-designed financing and pricing policy to steer the required transition in the energy mix should, therefore, be put in place as early as possible ; (ii) In order to provide a level playing field, nuclear power should be given incentives as provided to the renewable sector ; (iii) Timely completion of projects to minimise interest during construction. (iv) Rapid capacity expansion through credit. (viii) The government must provide additional resources over and above annual support pledged to NPCIL so far.

24. Nuclear power will be an indispensable component of India's national strategy to secure energy self-sufficiency. The expansion of the programme has to be combined with indigenisation to bring down costs. This would be in keeping with the Make in India programme and generate employment for 40,000 persons directly or indirectly. Nuclear power provides an option to harmonise India's developmental needs with increasingly stringent emission norms which are inevitable as global warming worsens

COMPARING ELECTRICITY GENERATION TECHNOLOGIES FROM CONSIDERATION OF ECONOMICS

Shri R B Grover, Member, AEC and Emeritus Professor, HBNI (FBR + Thorium)

Several global leaders, including Prime Minister of India, have expressed concern about climate change and have made commitments to pursue policies to decarbonize the economy. Globally electricity generation contributes only 40% of carbon emissions, but electricity sector is the first target of policy makers for decarbonization. The next target is the transport sector, and all are advocating electrification of the transport sector. All these developments imply that energy technologists and energy economists have to find ways and means to rapidly increase electricity generation from low-carbon sources. It is important to remember that for a technology to succeed, it should be robust as well as economical.

While it is challenging to decarbonize energy generation, technologies based on which it can be done are well known and they are nuclear, hydro and renewables like solar and wind. Nuclear and hydro have been around long enough and have been extensively studied and scrutinized. However, this cannot be said for solar and wind. Solar and wind are intermittent sources and are available during favourable weather conditions. A grid manager cannot rely on them to meet demand variation. Rather they are one of the causes of demand variation on the residual generators that are characterized by the capability todispatch on demand. Imposed demand variation on dispatchable generators has technical and economic consequences.In the long run, technical consequences manifest as economic consequences.

From the point of a consumer of electricity, economical would mean that it should be affordable. Cost to consumer comprises costs of generation, transmission and distribution. In case, electric supply is not reliable, a consumer has to invest in back-up solutions such as inverters. A consumer also wants electric supply to be resilient that is supply should not be disrupted by events such as those resulting from severeweather. If train movement is interrupted due to poor visibility in winter months arising from fog, and fuel carrying wagons cannot move, it should not interrupt power plant operation. And that would call for on-site storage of fuel. In case of gas supply pipe network, there should be enough redundancy in the network so that a break in a pipeline due to any reason at one location doesn't disrupt gas supply. Alternate could be a technology where fuel for several weeks or months can be stored on site.

Reliability of supply has to be ensured by the manager of the electrical system by matching supply with demand. There is a cost attached to managing anelectrical supply system. System costs are the total costs accrued beyond the perimeter of a generator to supply electricity at a given load and at a given level of security of supply. An electricity system has several generators connected to it and addition of a new generator influences the whole system. System effects measure the impact that the integration of a generator has on the whole electricity system.

Dispatchable technologies like nuclear, coal and gas have low and similar system effects. Until the advent of variable renewable technologies, system managers didn't pay attention to system effects. However, technical and economic system effects of variable renewable technologies (offshore wind, onshore wind and solar) are significant and mostly unaccounted for.Additionally, system cost rises with increase in penetration of intermittent sources. While academically studies have been done to calculate system costs, they are yet to be included in national policy frameworks. As a result, it is not possible to establish as to who is paying these costs. In most countries, transmission and connection costs are borne by the grid operator and then transferred to the public via an increase in transmission tariffs. The costs related to additional balancing requirements, as well as back-up and adequacy costs, are generally borne by other dispatchabletechnologieswithout any explicit or implicit compensation.

Levelized Cost of Electricity Generation (LCOE) is the method used to compare different technology options. Method of calculating LCOE doesn't include any parameter to differentiate between intermittent and dispatchable technologies. Result is that system costs are not allocated to the generator that causes them. Modelling studies done prior to integrating a generator to the grid can bring out cost of integration and provide guidance for planning and result in appropriate attribution of costs. Improved characterization of system costs will help all market participants and policy makers to identify such costs and plan for a better integration of all low-carbon technologies. National Electricity Plan Volume II, which is still at draft stage, does recognize issues associated with integrating intermittent sources, but detailed system studies in this area are needed.

In addition, technologies will always have positive or negative externalities and a science-informed national policy framework is needed to factor in all externalities. Such a framework cannot be built in one stroke and has to evolve based on academic studies and field experienceat the national and global level.

Nuclear has low system costs, low external cost and nuclear establishment in India has developed necessary expertise. Nuclear and renewable have to co-exist to decarbonize electricity generation. A policy framework based on academicstudiesthatexplicitly identifies system costs will be helpful to all market participants. Information available of the website of US Energy Information Administration provides an idea of system costs. Major components of the US average price of electricity for 2018 were generation 60.5%, transmission 12.5%, and distribution 27%.

To conclude, nuclear power is the economically optimal choice to satisfy stringent carbon constraints.It is cost-competitive when comparison is made on the basis of overall cost. Nuclear industry has to buckle up to accelerate rate of growth of nuclear installed capacity to make its contribution to decarbonization.

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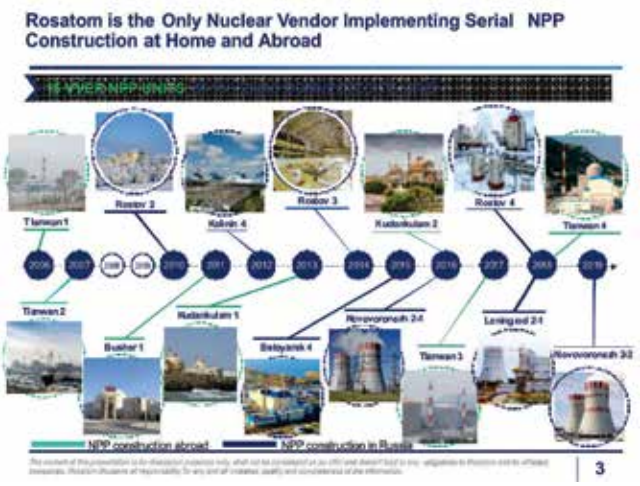
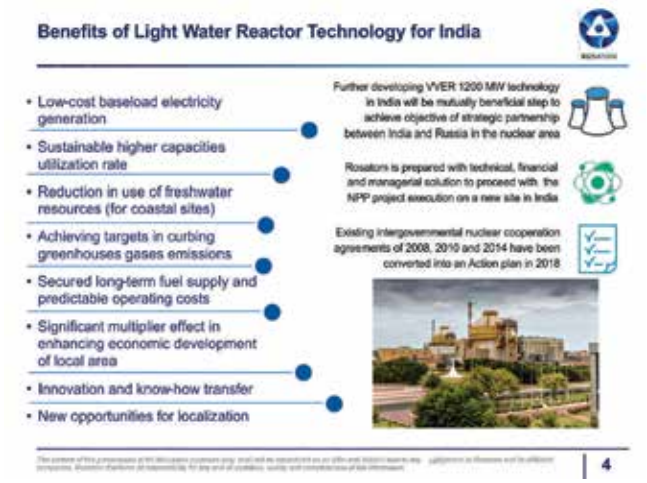
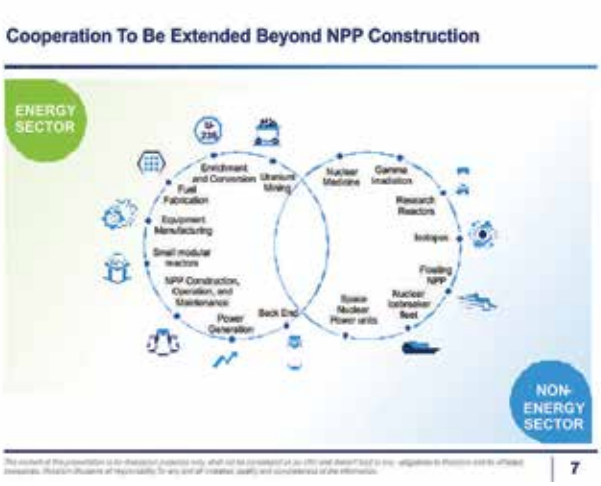
IMPLEMENTATION OF THE PERSPECTIVE COOPERATION BETWEEN RUSSIA AND INDIA IN THE NUCLEAR AREA

Shri Nikita Mazein, Vice President, Rusatom Overseas

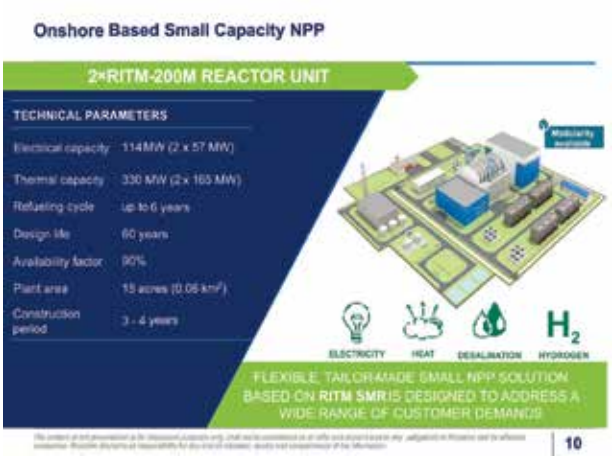







World's First Floating Nuclear Power Plant (FNPP)
AKADEMIK LOMONOSOV
FNPP
COMMISSIONING DATE:
2019
FIRST-OF-A-KIND
FLOATING NUCLEAR POWER PLANT
8


FNPP: Optimized Mobile Solution of Power Supply in the Coastal Areas
2×RITM-200M REACTOR UNIT
ELECTRICITY
HEAT
DESALINATION
TECHNICAL PARAMETERS
Electric capacity 100 MW
Refueling cycle up to 10 years
Design life 60 years
Displacement 12 000 tons
Length 112 m
Beam 25 m
Draught 4.5 m
by 9 000 t – displacement reduction
by 28 m – length reduction
by 5 m – beam reduction
30% – capacity increase
9


Onshore Based Small Capacity NPP
2×RITM-200M REACTOR UNIT
TECHNICAL PARAMETERS
Electrical capacity 114MW (2 x 57 MW)
Thermal capacity 330 MW (2x 165 MW)
Refueling cycle up to 6 years
Design life 60 years
Availability factor 90%
Plant area 15 acres (0.06 km²)
Construction period 3 - 4 years
ELECTRICITY
HEAT
DESALINATION
HYDROGEN
FLEXIBLE, TAILOR-MADE SMALL NPP SOLUTION
BASED ON RITM SMR IS DESIGNED TO ADDRESS A WIDE RANGE OF CUSTOMER DEMANDS
10


Towards New Partnership Horizons
SHIFT FROM THE PROJECT FOCUS TO
COMPREHENSIVE STRATEGIC COLLABORATION
Rosatom's VVER technology is one of the most successful among the lightwater reactors units built around the globe in recent decades
Rosatom has proved to be a reliable long-term strategic partner of India and is willing to extend cooperation beyond the current level
Rosatom is prepared to develop comprehensive collaboration agenda in the new areas:
Cooperation with Indian companies in the third countries
Joint development of civil nuclear energy products
Localization of the NPP equipment and fuel
11

GROWTH OF NUCLEAR POWER FOR MEETING BASE LOAD DEMANDS- OPPORTUNITIES & CHALLENGES FOR MANUFACTURING INDUSTRY

Shri A.K. Balsubrahmanian, Director (Technical), NPCIL

Nuclear Power Corporation of India has a programme of capacity addition to the tune of 15000 MWe targeted for completion by 2031. This includes sixteen 700 MWe PHWRs and four 1000 MWe PWRs. Beyond the current four 700 MWe PHWRs under construction/commissioning, the implementation of the remaining twelve 700 MWe PHWRs is on a Fleet Mode. Having mastered the PHWR technology indigenously, the Indian industries form back bone of the programme. With the above sanctioned projects, there will be continuity of orders for supply, supply cum erection and EPC packages. For the PWRs being implemented with Russian collaboration, progressive indigenisation of supplies is envisaged. These projects will provide opportunities for the Indian industries for participation in supply and erection contracts.

The challenge today is to generate electricity at a competitive price. In order to meet this challenge, there is a need to reduce cost, reduce manufacturing cycle time and to reduce total project implementation time. NPCIL has taken several measures in this direction which, inter alia, include design standardisation, standardised procurement specifications, simplification of equipment qualification, etc. Given the technical expertise available with the industry, reduction in manufacturing cycle time for critical and long manufacturing cycle equipment can be achieved by better planning and scheduling. Similarly, EPC package vendors need to look into the details of the package and work out a disciplined and cost & time effective implementation strategy.

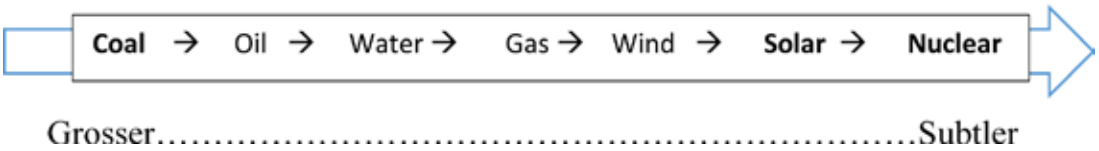
In the Fleet Mode implementation, the projects will run with overlapping schedule and hence resource augmentation including trained & skilled manpower will be required to meet the demanding project schedules.

With a strong synergy between NPCIL and Indian industry with a keen focus on the above mentioned areas, Fleet Mode projects can be implemented successfully.

"ASSAULT ON ATOM…FOR A BETTER TOMORROW"

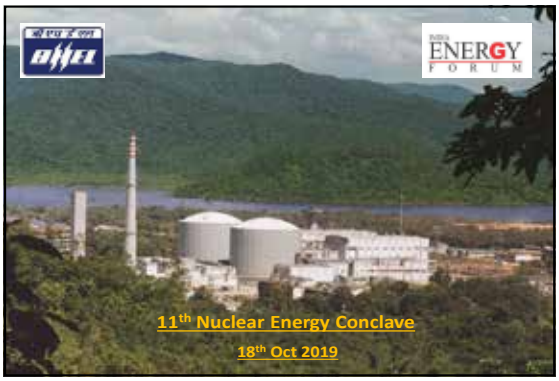
Shri P P Yadav, Executive Director - Nuclear Business Group, BHEL

Subtler forms of Energy are being realised to be of greater overall benefits than the grosser forms. Our future energy pathways have therefore to be based on a sustainable model moving from Grosser ways to Subtler ways of harnessing the required energy…

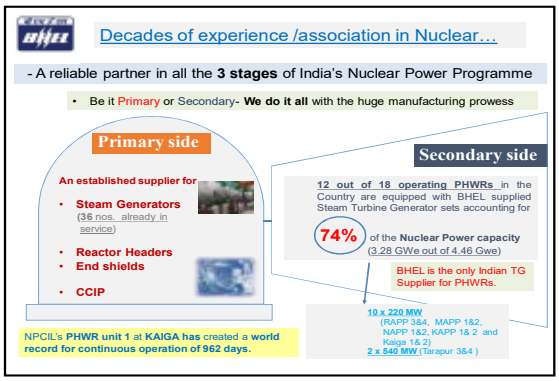


Even before India's independence, way back in 1944, the great visionary, Dr. Homi Jehangir Bhabha recognized the absolute necessity of Atomic Energy and laid the foundation of India's 3-stage Nuclear Power Programme.
The assault on Atom has however been not happening with the same pace as we have been firing Coal in Thermal Power Plants. As a result, the contribution of Nuclear Power in the total installed capacity of the country has been continuing at a meagre level of around 2% which is much below the worldly average of about 11%. In fact, the world's total installed Nuclear Power Capacity is more than our Country's total Power capacity coming from various sources.

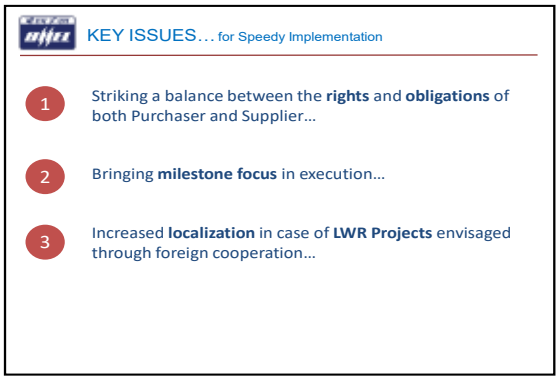
Even though the Nuclear contribution at this stage is not at the required level, a good foundation has been laid for fast tracking the Nuclear Power.Govt. of India accorded approval for setting up of 10 indigenous 700 MWe PHWRs (Pressurised Heavy Water Reactors) in a fleet mode on 18th May, 2017 for progressive launching and implementation of these reactors over coming years at identified sites. It is a matter of great satisfaction that the fleet mode implementation of these reactors is now currently underway (Tenders both on Primary side and Secondary side are in various stages of evaluation by Nuclear Power Corporation of India). Domestic Industry is eagerly looking forward for early finalization of orders. Undoubtedly, Nuclear Power is now gaining momentum and is poised for a quantum jump in the coming years…


ENERGY FORUM
11th Nuclear Energy Conclave
18th Oct 2019


Who we are …and ….what we do…
WE ARE…
WE SERVE…
WE HAVE…


Decades of experience /association in Nuclear…
- A reliable partner in all the 3 stages of India's Nuclear Power Programme
Be it Primary or Secondary- We do it all with the huge manufacturing prowess
Primary side
An established supplier for
Steam Generators (36 nos. already in service)
Reactor Headers
End shields
CCIP
Secondary side
12 out of 18 operating PHWRs in the Country are equipped with BHEL supplied Steam Turbine Generator sets accounting for
74%
of the Nuclear Power capacity (3.28 GWe out of 4.46 Gwe)
BHEL is the only Indian TG Supplier for PHWRs.
10 x 220 MW (RAPP 3&4, MAPP 1&2, NAPP 1&2, KAPP 1& 2 and Kaiga 1& 2)
2 x 540 MW (Tarapur 3&4)
NPCIL's PHWR unit 1 at KAIGA has created a world record for continuous operation of 962 days.


Fully geared up to address the upcoming Business opportunities……
Have proven Turbine island solution for the forthcoming 700 MW PHWRs
Our EPC model is based on
Integration competencies
Deep understanding of both Thermal & Nuclear power systems and local requirements
Maximum in-house manufacturing strength (Steam Turbine, Generator, Moisture Separator Re-heater, Condenser, LP Heater, Other major equipment of TG island including piping, Complete Controls & Instrumentation…)
Capability for simultaneous construction activities at multiple sites
Integrated Project Management approach
- Accordingly a most suitable Techno-Commercial proposal for 6x700 MWe 'TG island' on 'EPC' basis is under evaluation with NPCIL
Have multiple centres for addressing the needs of Primary Side Equipment.


KEY ISSUES… for Speedy Implementation
1
Striking a balance between the rights and obligations of both Purchaser and Supplier…
2
Bringing milestone focus in execution…
3
Increased localization in case of LWR Projects envisaged through foreign cooperation…


Thanks !
P P Yadav
Executive Director, BHEL
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Website:www.nuvia-group.com

Year of incorporation: 2010

Legal status: Pvt Ltd Company

Employees: 15

Annual turnover: €1Mn

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- Leak test/swipe test
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- Preparation and review for dosimetry documentation
- Preparation and review emergency procedures.
- Radiation Surveys
- Radiation Safety Consultancy
- Layout design of radiation installations
- Radiation Shielding Calculation & Evaluation
- Safe transport of radioactive material
- Safe disposal of radioactive waste
- Land Remediation
- Health Physics Operational Support

RADIOACTIVE WASTE MANAGEMENT IN HEALTHCARE AND RESEARCH SECTORS

Ms. Kritika Kaur, Technical Manager and Radiological Safty Officer, NUVIA India Pvt. Ltd.

Radionuclides, in the form of sealed and unsealed sources, are extensively used in medicine, industry, agriculture, research and various other applications. Such applications could result in generation of significant quantities of solid and liquid wastes and occasionally gaseous wastes. Much of the solid waste consists of contaminated items, such as paper, plastics, glassware, equipment, animal carcasses, excreta and other biological waste. Some of the solid wastes may have large activity and small volumes as in the case of spent sealed sources.

Liquid radioactive wastes comprise of aqueous and organic streams, such as patients' urine (primarily in thyroid cancer therapy) and effluents from decontamination processes. In many applications of radionuclides, the radioactive waste generated may comprise of short-lived radionuclides, which may be managed by providing storage for decay. However, in applications, which involve long-lived radionuclides, an appropriate waste management programme should be in place prior to the start of the work with radionuclides.

The management of waste arising from the use of radionuclides requires effective planning and provision of adequate facilities at institutional and/or national level. The emphasis is on the protection of people and environment from the undue exposure to ionising radiation emitted by the radioactive waste. There are many simple and practical procedures that may be used for the management of waste such as waste characterisation, classification and segregation.

The topic covers the managerial, administrative and technical procedures related with safe handling and management of radioactive waste, from its generation to its release from further regulatory control through a clearance mechanism, or its acceptance at storage or disposal facility.

PASSIVE SAFE INTEGRAL LWR OPTION FOR ACCELERATING NUCLEAR CAPACITY BUILDING

Dr. A.K. Nayak , Reactor Engineering Division, Bhabha Atomic Research Centre

Abstract

The well laid down three stage Indian nuclear power programme is essential for sustainably achieving the objective of large-scale nuclear energy deployment in India with domestic nuclear fuel resources in closed fuel cycle. India is well on its way to meet this objective with the help of several advanced reactor and fuel cycle technologies that have been under various stages of deployment, demonstration, and development in the different units of DAE.
India needs to multiply its energy production soon to meet the growing energy demand and to have a minimum per capita energy consumption comparable to our Asian counterparts. Currently, the coal based thermal power plants supply major share of electricity production in India, however, most of them are likely to retire in next 2 to 3 decades considering their design life to be completed and no further extension. The imminent threat of global climate change and our commitments to reduce the green house gas emissions, has imposed a very high priority for urgently enhancing the share of low-carbon energy technologies in the national energy mix. In this context, nuclear energy has to provide a major share of this energy mix as base load capacity. Accordingly, there is an urgency to significantly escalate the rate of deployment of nuclear power within the coming 2 to 3 decades.

Keeping the above objectives in mind, an innovative design of a Passive Safe Integral LWR (PSIR) is presented here which is an important candidate for fulfilling the urgent need for speedy and large scale deployment of nuclear power to address climate change concerns and are targeted to replace large number of retired coal plants which will happen in near future. PSIRs are advanced PWRs that typically produce electric power of150 MW(e) (2x150 MWe can be connected to one turbine). These plants are to be built in factories and shipped to sites for installation.

Why this technology?

✓ **Adopting proven LWR technology for power production:** The LWR technology is more than six decades old and it is well proven. PSIR shall use the core configuration of a standard LWR design. Thus, it will be an extension of India's 1st stage nuclear power program.

✓ **Modularity in both manufacture and deployment:** All components of Nuclear Steam Supply Systems are housed inside the pressure vessel. Thus the PSIR is like a power pack which is built in factory and shipped to the place for installation. This will accelerate the capacity building in short time.

✓ **Flexibility in operation:** Having several units of same size in one site, gives the flexibility of usage as per load demands.

✓ **Make-in India:** All components of PSIR can be manufactured in India including the RPV for which the current hydraulic press and forging capability are available in domestic industries.

✓ **Short construction schedules:** Fabrication of the integral reactor which comprises of major components (reactor pressure vessel, steam supply systems, pressuriser, pumps) can be made in centralized

manufacturing facilities and integrated as a single power pack, and will be directly transported by rail to the site for installation thus reducing lot of time for site related activities for installation.

✓ **Reduction in IDC:** Because of reduction in construction times, the interest during construction (IDC) is substantially reduced. This makes it very competitive with large reactors where IDC is a major cost component due to large construction time delay. Because of short construction time, return from investment starts early. So investors will have large confidence.

✓ **Lesser investment with early returns:** Because of small investment cost per reactor with early returns, large numbers of investors will be interested for investment.

✓ **Integral reactor module making it inherently safe:** PSIRs are integral reactors which contain all major equipments like pressure vessel, steam generator, pressurizer and pump inside the reactor vessel and thus avoiding large coolant piping which practically eliminates LBLOCA.

✓ **Passive safety features making it "walk away safe reactor":**

- PSIRs have advantage of small core size which requires less amount of decay heat to be removed as compared to large reactors.
- This enables use of several passive safety systems in its design to remove the small decay heat during any transients or accidents without leading to higher fuel temperatures leading to even hydrogen production thus qualifying for "no impact in public domain".
- Thus, these reactors have potential to replace retired coal plants or other such industries without requiring new sites for construction.

✓ **Superiority over advanced reactors with passive systems:**

- Current Gen III+ reactors also use several passive safety systems in their design.
- However, in these reactors, under certain accident conditions involving multiple failures, there is a possibility of clad surface temperature increasing beyond permissible limits, which may lead to hydrogen generation.
- In extreme events resulting in multiple safety failures, core meltdown may also occur. Hence these reactors have provision for hydrogen mitigation and core catchers in their design.
- On the contrary, in PSIR, being small integral reactor with passive safety systems, clad surface temperature is always below the permissible limit in all postulated accidental conditions and hydrogen generation and core meltdown is practically eliminated by design under extreme events.

✓ **Large experience in technology development and demonstration of passive safety systems:** The technology for passive safety systems has been extensively used in AHWR . BARC has large experience in development of the enabling technologies for such passive safety systems and demonstrating them in full scale facilities over past two decades. These technologies can be directly used in PSIR for achieving the safety goals, while using the proven technology of LWRs for power production.

✓ **Harnessing benefits of international civilian nuclear co-operation agreement:** The fuel for PSIRs can be imported under the international civilian nuclear co-operation agreement.

✓ **Options for thorium burning:** While PSIR is designed to use conventional enriched uranium as fuel like in standard PWRs, but it can still burn thorium with LEU so as to make it proliferation resistant.

Why 150 MWe?

- Safety criteria for these plants are:
a) 400 deg.C for all plant conditions,
b) no hydrogen production or core melt in extreme events with failure of all engineered safety systems fulfilling the criteria of "walk away safe reactor".
- Indian forging capability for vessels is currently limited. So this indirectly limits size of reactor core to 450 MWth or 150 MWe for this type integral PWR. Internationally, the largest integral PWR is 1000 MWth or 330 MWe having vessel size of 6.2 m diameter.
- The 150 MWe size reactor vessel weight is around 400t whereas the 330 MWe size reactor vessel weight is 1300t. In view of this, road transport and assembly for installation is possible with 150 MWe PWR than 330 MWe PWR for Indian conditions.

Thus considering the domestic manufacturing capability, transportation by road/rail, ease in installation and safety, 150 MWe plant is chosen.

Large number of PSIRs can be sited in retired coal plants or similar sites even closer to population centres. PSIRs can easily compete with large sized PWRs because of advantage of "economy of numbers" as compared to "economy of scale", and "factory built and assembled in site" thus reducing interest during construction cost (IDC) significantly. Being small size with less capital cost involved, it is easy for Government or PSUs to invest with realizable returns on investment within small period. Hence, these reactors can be built through a consortium of Government-PSUs providing the abandoned land for retired coal plants and engaged with NPCIL for construction and operation of PSIRs. PSIRs will give enough confidence of manufacturing, erection and operation of PWRs with complete indigenous technologies thus serving as stepping stone for building large sized PWRs in future. Hence, PSIRs will serve as a viable option for energy security of India by 2050.

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DISTINGUISHED SPEAKERS

Profile of Shri Anil Razdan

President, IEF and Former Secretary, Ministry of Power, Government of India

Born on December 7, 1948, Delhi, India. Anil Razdan joined the Indian Administrative Service in 1973. He is an alumnus of St. Stephen's College, Delhi University for B.Sc (Hons.) Physics (1965-68) and Faculty of Law, Delhi University for LL.B (1968-71) He has been a Visiting Fellow of the University of Oxford. He was awarded the National Science Talent Scholarship, 1965-68, the Delhi University Merit Scholarship in Law, 1970, and the National Merit Scholarship, 1971. He was awarded the Hiralal Daga Gold Medal in Law, Delhi University 1971, as well as the Law Union Prize. He practiced law in the Delhi High Court in 1971-72

Shri Anil Razdan was Secretary to the Government of India, Ministry of Power in 2007, 2008. He has held various significant assignments in the energy sector in the Government of India and the Government of Haryana. He has been Additional Secretary and Special Secretary with the Ministry of Petroleum and Natural Gas in the Government of India.

He was associated with negotiations for nuclear power reactors and non-proliferation issues in the Department of Atomic Energy. In the Ministry of Power as Joint Secretary, he handled issues relating to energy conservation, hydro-power, transmission, rural electrification, operations management, policy planning and external assistance/ international cooperation. He was Chairman and Managing Director of the North East Electric Power Corporation (NEEPCO). He was on the Board of Directors of Power Grid Corporation of India, National Hydroelectric Power Corporation, Rural Electrification Corporation, Tehri Hydro Development Corporation, Sutlej Jal Vidyut Nigam, Narmada Hydro Development Corporation, Bhakra Beas Management Board and Power Finance Corporation as well as the Tala Hydroelectric Project Authority in Bhutan. He crafted the Prime Minister's 50,000 MW Hydropower Initiative in 2003 using satellite imagery. While working as Additional Secretary and Special Secretary in the Ministry of Petroleum and Natural Gas he was on the Board of Directors of Oil and Natural Gas Corporation, Indian Oil Corporation, Gas Authority of India Ltd., .

He was instrumental in bringing about significant international interest and investment in super critical thermal power generation equipment manufacture in India, which has led to the setting up of world class power equipment manufacture by leading global manufacturers. He piloted the new Hydro Power Policy, 2008, the Revised Rajiv Gandhi Grameen Vidyutikaran Yojna (Rural Electrification Programme) 2008, the Restructured Accelerated Power Development and Reform Programme 2008,

Sh Razdan is the President of India Energy Forum

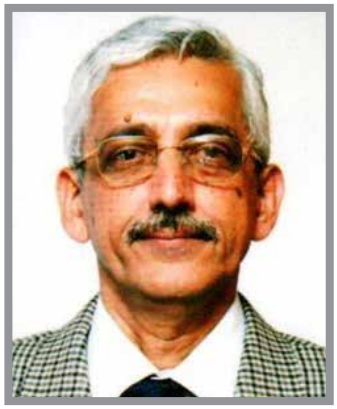
Profile of Dr. Srikumar Banerjee

Chancellor, HomiBhabha National Institute, Mumbai

Dr. Srikumar Banerjee is Chancellor, HomiBhabha National Institute, Mumbai. He served as Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy during 2009-2012 and as Director, BhabhaAtomic Research Centre (BARC) during 2004-2010. He also served as Chancellor, Central University of Kashmir, Srinagar (2012-2017), HomiBhabha Chair Professor (2012-2017) and Chairman, Board of Governors, Indian Institute of Technology, Kharagpur (2014-2017). He is currently holding Distinguished Visiting Professor positions at Indian Institute of Technology, Kharagpur and University of Delhi.

His major research contributions are in the areas of phase transformations in zirconium and titanium alloys, effects of radiation on order – disorder transitions and tailoring microstructure and texture of nuclear structural materials through thermo-mechanical processing. He has over 350 research papers, co-authored a book titled Phase Transformations: Examples from titanium and zirconium alloys and co-edited six books. As Director, BARC, he co-ordinated research in nuclear fuel cycle, design of innovative reactors, applications of radiation and isotope technology in agriculture, health care, food preservation and industry. He initiated capacity building activities both in front and in back end of the nuclear fuel cycle.He is currently engaged in research in advanced nuclear fuel cycle, policy for sustainable energy and metallurgy of actinides.

His honours include ActaMetallurgica outstanding paper award (1984), Bhatnagar prize in Engineering Sciences (1989), INSA prize for Materials Science (2001), Humboldt Research Award (2003), Indian Nuclear Society award (2003), Padmashri (2005), MRSI Distinguished Materials Scientist of the year (2008), National Metallurgist award (2008), Excellence in Science and Technology Award of Indian Science Congress Association (2009), MRSI CNR Rao prize in Advanced Materials (2011), Presidential Citation of American Nuclear Society (2012),Platinum Medal of The Indian Institute of Metals (2012), W.J. Kroll Medal from ASTM (2012) and R.W.Cahn Award for Nuclear Materials from ElsevierPublishers (2016). He is recipient of Doctor of Science (Honoris Causa) from eleven universities and institutes. He is a fellow of Indian Academy of Sciences, Indian National ScienceAcademy, Indian National Academy of Engineering, National Academy of Sciences, India, The World Academy of Sciences (TWAS) and International Nuclear Energy Academy (INEA).



Profile of Shri K N Vyas

Chairman, AEC and Secretary, DAE

Shri K.N.Vyas is a Mechanical Engineering Graduate of MS University, Vadodara and a graduate of the 22nd Batch of BARC Training School. Joining the Department in 1979, he commenced his career with forays into nuclear reactor fuel designs. In those early days of the oncoming computer age, he managed to gain substantial skills and proficiency in computer programming and developed programmes to carry out fuel performance analysis of nuclear fuels, which modeled fuel design aspects like irradiation swelling, fission gas generation and release, pellet-clad interaction, etc. The insights gained by these studies led to the design of the 7X7 cluster for BWRfuel havingsuperior performance characteristics.

Subsequently, he went on to expand his repertoire, working in various projects on fuel analysis and design for the upcoming power reactors as well as towards design of novel fuels needed for strategic applications. He also gained expertise in thermal hydraulics and stress analysis and contributed towards analysis of critical reactor core components. As a fuel design engineer, he provided key inputs to fuel manufacturing units like Atomic Fuels Division and Nuclear Fuels Complex.

As a team member in Reactor Projects Group, he has played a crucial role in the completion of strategic projects executed by BARC. He has played an important role in indegnisation of special materials as well as several fabrication &test equipment used in fuel fabrication. His expertise was useful in evolving the design of Test Blanket Module and associated systems, planned to be installed at the ITER project, a fusion reactor under construction in France, by a multinational scientific consortium.

Shri K.N.Vyas is a recipient of several honours and awards such as the Indian Nuclear Society Outstanding Service Award, 2011, Homi Bhabha Science and Technology Award, 2006 and the Dr. N. Kondal Rao Memorial Award, 2017. He is a Fellow of Indian National Academy of Engineering, 2015.

Profile of Dr Anil Kakodkar

Former Chairman, AEC

One of India's most distinguished scientist Dr. Anil Kakodkar (born on 11th November, 1943) joined the Bhabha Atomic Research Centre (BARC) in 1964,. He became the Director of BARC in the year 1996 and was the Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy, during the years 2000 -2009. Currently he is DAE Homi Bhabha Chair Professor at BARC.

Dr. Kakodkar has worked for the development of the atomic energy programme in India throughout his professional life. Focus of his work has been on self-reliant development of nuclear reactor systems to address the Indian programme requirements. He succeeded in developing various systems for the pressurized heavy water reactor, in building the Dhruva reactor and development of Advanced Heavy Water Reactor that realizes the next generation objectives

He was among the chosen few involved in the first successful Peaceful Nuclear Explosion Experiment that India conducted on May 18, 1974 at Pokhran. And later, he played a key role in the series of successful Nuclear Tests conducted during May 1998, again at Pokhran. India also demonstrated nuclear submarine powerpack technology under Dr. Kakodkar's leadership.

Dr Kakodkar championed observer status for India at CERN (European Centre for Nuclear Research), partnership in the ITER (International Thermonuclear Experimental Reactor) project and exemption for nuclear trade from Nuclear Supplier's Group(NSG).

Current Key Engagements

- Chairman, Solar Energy Corporation of India
- Chairman, Solar Energy Research Advisory Council, JNNSM
- Member, Mission Steering Group, JNNSM
- Member, Atomic Energy Commission
- Member, World Economic Forum's Global Agenda Council on Energy Security (2011-2012)
- Member, ONGC Energy Centre Trust

Academic Honours: He was made doctor of science by many universities including IIT Bombay, Kharagpur, Delhi, IGNOU, Jamia Hamdard, Pravara Institute of Medical Sciences, Visvesvaraya Technological University, Rani Durgavati Vishwavidyalaya, University of Lucknow, Dr. D.Y.Patil University, Shivaji University, Goa University, Tilak Maharashtra University, Pt. Ravishankar Shukla University and Thapar University

Padma Awards: Dr. Kakodkar has been honoured by Padma Sri – 1998, Padma Bhushan – 1999 and Padma Vibhushan - 2009

International Recognitions:

- Recipient of Rockwell Medal for Excellence in Technology – 1997
- Member, International Nuclear Energy Academy
- Hon. Member, World Innovation Foundation
- Was a Member, Council of Advisors of World Nuclear University
- Member, International Nuclear Safety Advisory Group (INSAG) – 1999-2002.
- 2009 USIBC Award for Expansion of U.S.-India Trade Relations
- Appointed Officier de l'Ordre de la Legion d'Honneur by President, French Republic – 2011
- Presidential Citation from American Nuclear Society

Profile of Dr. R B Grover

Member AEC and Homi Bhabha Chair

Dr. Grover occupies Homi Bhabha Chair instituted by the Department of Atomic Energy (DAE) and has been a member of the Atomic Energy Commission since 2011. He studied mechanical engineering at Delhi College of Engineering, Nuclear Engineering at Bhabha Atomic Research Centre and received a Ph.D. from the Indian Institute of Science, Bangalore.

He has been working in the DAE for about four and a half decades and was Principal Adviser during October 2010 to February 2013. As a nuclear engineer, key contributions made by him include thermal hydraulic analysis of the fuel and the core of a research reactor, process design of primary systems and equipments for a compact reactor, and studies related to growth in energy requirements.

He conceptualized the setting up of the Homi Bhabha National Institute as a university level institute. Concurrent with other responsibilities, he led it for eleven years. He participated in negotiations with other countries and international agencies leading to opening of international civil nuclear tradewith India.

He was conferred with a Padma Shri in 2014 and has received several awards. He is a fellow of the Indian National Academy of Engineering, and the World Academy of Art and Science.

Profile of Shri S M Mahajan

Convenor of the Nuclear Energy Group IEF and its Board Member

A Former Executive Director of BHEL, where he served for 39 years in various functions and Units including in Nuclear Power Plant Component manufacturing. He is Consultant in Manufacturing Technology specifically in Welding and machining areas. He is also an Industry Expert with Standard Chartered Bank

Closely associated with Ministry of Electronics in its various industry & new technology funded projects for industrial application. He is Vice President of Asian Welding Federation- a body of Asian & Asean Countries for development of welding technology and skill development. A former President of Indian Welding Society and its Life Time Achievement Awardee, he is well known and accomplished in the field

Sh Mahajan is B.Tech from DCE and M.Tech from IIT Delhi and is widely travelled abroad

Profile of Shri A.K. Balasubrahmanian

Director (Technical) Department of Atomic Energy

Shri A.K. Balasubrahmanian is a Mechanical Engineering Graduate from Regional Engineering College (now NIT), Kozhikode. After completing one year orientation course in Nuclear Science and Engineering from BARC Training School (28th Batch), he joined the erstwhile Nuclear Power Board (now NPCIL) under the Department of Atomic Energy in 1985. He has about 33 years experience in Design, Development, Engineering, Pre-project studies, Design co-ordination, Safety Review, Stress Analysis & Seismic qualification, Procurement, Construction and Commissioning of Nuclear Power Plants. He is credited with design, development and implementation of First of a kind Reactor Control & Shutdown systems for TAPS-3&4. He is equally versatile in PHWRs and LWRs, having worked in design & engineering of these reactor systems. He has participated in the preparation of Regulatory Codes and has been instrumental in obtaining Regulatory Consents & Clearances for various projects. He has experience in technical discussions with International reactor vendors.

Shri Balasubrahmanian has made significant contributions in the implementation of 220 MW, 540 MW & 700 MW PHWR projects and 1000 MW PWR (KKNPP) in the areas of his expertise. He has made extensive contributions in safe and continued operation of PHWR based stations, particularly in the area of coolant channels. Shri Balasubrahmanian has been conferred with NPCIL Technical Excellence Award and a number of other NPCIL awards in recognition of his outstanding contributions to the Nuclear Power Programme.

Shri A.K. Balasubrahmanian is a Distinguished Scientist of the Department of Atomic Energy. As Director (Technical), he is responsiblefor design, engineering, procurement, safety analysis, technology development and Health, Safety & Environment functions in NPCIL.He is Chairman of a joint venture company: NPCIL-Indian Oil Nuclear Energy Corporation Ltd. He is a Member of the Board of Management of Heavy Water Board and Nuclear Fuel Complex.

Profile of Dr. Dinesh Srivastava

Chief Executive, Nuclear Fuel Complex

Dr. Dinesh Srivastava, the Distinguished Scientist and Chief Executive of NFC, is a Metallurgical Engineer from the University of Roorkee. He joined the 28th batch of BARC Training School, Mumbai in 1984. Subsequently, he was posted to BARC, Mumbai and served in various capacities for more than three decades. He has obtained Doctorate degree from the Indian Institute of Science (IISc), Bengaluru.

Dr. Srivastava has contributed exclusively in the development of advanced structural materials of extreme strategic value for Nuclear Energy program in India. He has published more than 150 research papers.

Dr. Srivastava has been the recipient of many Honours and several prestigious Awards including Binani Gold Medal; National Metallurgist Day Award from the Indian Institute of Metals; DAE Excellence Award, Homi J Bhabha Science & Technology Award and Vasavik Award for Science & Technology.

Profile of Shri Nikita Mazein

Senior Vice President Rosatom Overseas

Mr. Mazein is presently serving as Vice President of Rusatom Overseas, a subsidiary of the State Atomic Energy Corporation "Rosatom" in charge for contractual negotiations regarding nuclear power projects of the Russian design worldwide. He is responsible for new projects of Rosatomin South Asia anddeveloping thenational industry participation and localization models.

Mr. Mazein has extensive working experience in heavy engineering, energy, metals & mining industries responsible for sales,production cooperation arrangements, technology transfer, overseeing strategic marketing and corporate strategy,executing merger & acquistion transactions and establishing joint ventures. Prior to joining Rusatom Overseas Mr. Mazein has been associated with Atomenergomash, Rosatom's equipment engineering and manufacturing division, and Severstal, a leading Russian metala & mining company.He is a member in several India–Russia investment and trade promotion organizations and partnerships.

Mr. Mazein holds Ph.D. degree from the Moscow State University.

Profile of Shri Thomas MIEUSSET

Nuclear Counsellor at the French Embassy in India

Since September 2019, Thomas MIEUSSET is nuclear counsellor at the French Embassy in India. Until Summer 2019, he was nuclear counsellor at the French Embassy in South Africa.

He was appointed to this position in 2016, following a year as senior executive at the international relations department of the French Alternative Energies and Atomic Energy Commission (CEA).

From 2010 to 2015, he was senior executive at the international relations department of the French nuclear regulatory body (ASN). He was in charge of bilateral relations with North America and several European countries. He was also the ASN's point of contact for the Multinational Design Evaluation Programme (MDEP), initiative of national regulatory bodies for the review of GEN III reactors (EPR, VVER…).

In 2001, he joined the French Alternative Energies and Atomic Energy Commission (CEA), serving as R&D engineer in the reactor studies department of the nuclear energy division. He contributed to the development and validation of a system code used for thermal hydraulics studies. He also contributed to the training and supervision of foreign staff in the framework of an associated laboratory with several countries.

He began his career in 1999 as deputy nuclear counsellor for nuclear affairs at the French Embassy in China.

Mr. Thomas MIEUSSET, 19 years of experience in the field of nuclear energy, holds a master degree in fluid mechanics and hydraulics.

Profile of Dr. Fawzi ISSA

Nuclear Director EDF Mumbai

Fawzi Issa has been working for the EDF Group since 2003, he holds a PhD in Signal Processing, a MSc in Electrical Engineering and an Executive MBA. Dr Fawzi Issa started as a Research Engineer in charge of high-speed power line communications using power distribution networks. He then joined the nuclear power generation division where he dealt with skills development as full scope simulator Instructor and later on real time operation of two nuclear reactors as Deputy Operations Department Manager. From 2012 to 2017, Dr Issa took over the position of Managing Director of EDF South Africa, he represented the EDF Group for Southern Africa and focused on cross border regional projects along with the nuclear new build program of South Africa. Since 2017, Dr Issa has relocated to Mumbai where he currently is the Deputy Director of the Jaitapur nuclear power project and ensures local coordination with various stakeholders as Director of EDF Mumbai office.

Profile of Shri Yogeshchandra S Trivedi

Senior Vice President & Member of Board:
- Heavy Engineering IC, Larsen & Toubro Limited, India

Popularly known a YST, he is B.E. (Met) and M.Tech E Welding Technology. With Larsen & Toubro since 1983 , currently Senior Vice President&Member of Board head th-Heavy Engineering Div, L&T Heavy Engineering LLC, Oman and- L&T Special Steels&Heavy Forgings, India

Achievements: Setting up L&T's Hazira Works - one offinest manufacturing facilities anywhere in the World.

Technology development & manufacturing of:

o Critical equipment for IndianNuclear Program (PHWR - 700MWe& 500MWe)
o Submarine for Indian Navy – AB2/HY100 steels
o World's largest ThermonuclearReactor – ITER Project, France
o World's largest Ethylene OxideReactor for Petrochemical Industry
o Hydrocracker Reactors – VanadiumSteels
World's single largest order ($ 421mn) for 22Vanadium Steel Hydrocracker Reactors for Kuwait National Petroleum Company
Leadership role to resolve issues related toCivil Liability for Nuclear Damage Act 2010

Participationand Contributions:

- 1981: IIM National MetallurgistGold Medal
- 2006: IIW LP Mishra Memorial Awardfor Outstanding Contribution in field of Welding Tech.
- 2011: Conferred IIM-KK Award for "Contribution in Industrial field" in Gujarat
- 2012: Sustainability Award – fromthe President of India
- 2014: Chairman, FICCI Working Groupon Civil Nuclear Energy 2014-15
- 2015: Distinguished VisitingProfessor at M S University, Baroda
- 2015: Member of Apex AdvisoryCommittee, Indian Welding Society ,
- 2015: Member of Advisory Board ofCapital Goods Skills Council (CGSC), CII and Rewards) in-line with best practices in performance appraisals

Profile of Shri G K Pillai

MD & CEO, Walchandnagar Industries Ltd

Mr. G.K. Pillai,is presently, Managing Director & Chief Executive Officer, of Walchandnagar Industries Limited, Pune.

Graduating from BITS, Pilani, in the year 1973, Mr.Pillai started his professional career in the field of Control Valves with Instrumentation Limited, Palakkad, (Kerala), and worked there till 1994. Thereafter, he ventured into the Private Sector and was with a U.S. Joint Venture – Fisher Sanmar Limited at Chennai, where, he rose to become the Chief Executive. He was also the Chief Executive of Tyco Sanmar at Chennai.

Mr.Pillai took over the reins of Heavy Engineering Corporation (HEC) Limited, Ranchi in May, 2007, as the Chairman and Managing Director. With some very innovative management initiatives, Mr.Pillaisteered the Company out of the red and since then, the Company has been making profits.

In recognition of his performance, he was bestowed upon with several national and international awards, including, the "SCOPE Excellence Award"in October, 2009, presented by the Hon'ble Prime Minister of India.

Government of India entrusted him with an additional responsibility of Chairman & Managing Director of HMT Machine Tools Limited.
Aftersuperannuatingfromboththeseorganizationson31stDecember,2011,Mr.PillaijoinedWalchandnagar Industries Limited, where, he is at present the Managing Director & Chief Executive Officer.

Mr.Pillai has been a recipient of various awards and recognitions and some of them are as given below :-

Awards Received:
i. Awarded "SCOPE Excellence Award" for the year 2007-08 from the Hon. Prime Minister, Dr.Manmohan Singh, on 15th October, 2009.
ii.Indian Nuclear Society Award for "Industrial Excellence" in January, 2010.
iii. Bestowed with the "Outstanding Contribution to the Industry" Award by The National Industrial Conclave 2010.
iv. Awarded the "BRPSE Turn Around Award".
v. Bestowed with the "Leadership Award" from The Asia-Pacific HR Congress in Bangalore on 3rd September, 2010.
vi. Awarded the "ENGINEER OF THE YEAR" Award by the Institution of Engineers (India) – Palakkad, Kerala Chapter on 15th September, 2013.

He is also a keen Speaker and has delivered talks in various national and international symposiums and also to educational and training institutes all over the country.

Professional Bodies
i. Past Chairman, CII Jharkhand State Council
ii. Past President, PMA, Ranchi Chapter
iii. Vice Chairman, Energy Saving Commission, World Foundry Congress(Ex)
iv. Member CII National Committee on Capital Goods & Engineering
v. Fellow of the Institution of Engineers
vi. President of Indian Institute of Industrial Engineers, Pune Chapter

Profile of Shri P. P. Yadav

Executive Director, Nuclear Business Group, BHEL

Mr. P P Yadav heads the Nuclear Business Group in BHEL and is on the Board (as Part-time Director) of NBPPL (NTPC BHEL Power Projects Private Limited)- A Joint venture of NTPC and BHEL.

Nuclear Business Group is a separate Business vertical in Power Sector, BHEL created during 2016, on a Single window concept, to harness the emerging opportunities of the ambitious Indigenous Nuclear Power Programme of India and to enhance responsiveness of BHEL to the needs of the Customers.

He is an Electrical Engineering graduate of 1983 batch from Delhi College of Engineering. Previously held positions in BHEL. Mr Yadav has diversified, versatile and varied experience through working in major segments of the organization:

Head- International Operations Division (Oct'15 –July'16) In various capacities in CMD's Secretariat including Head- CMD's Secretariat (2010-2015)For about 2 years (2014 - 2016) he has been on the Board (as Part-time Director) of BGGTS (BHEL GE Gas Turbines Services Pvt. Limited)- A Joint venture of BHEL and General Electric Head – Planning & Management Services- Industry Business Sector (2007-2010) For more than two decades Mr. Yadav had been in marketing of Captive Power Equipment to various Industries, offering most suitable configurations with highly optimized and energy efficient power equipment solutions to various industrial Customers.

Profile of S.C.Chetal

Former Director, IGCAR & Mission Director, AUSC Project

S.C.Chetal, 1970 graduate in mechanical engineering from Delhi College of Engineering is from the 14th batch of BARC training school. Hehas made immense contributions to the Indian fast reactor programme. His career in Department of Atomic Energy spanning over 41 years had been associated with fast reactors at Indira Gandhi Centre for Atomic Research from where he superannuated as Director in January 2013.He has unique expertise in design, materials and manufacturing of mechanical components for elevated temperature applications. He enhanced the capabilities of Indian industries to manufacture nuclear reactor components to challenging requirements. Apart from his contributions towards fast reactors, he had contributed towards design and manufacturing of high temperature reduction retorts for commercial zirconium and titanium sponge plants, and design and manufacturing of large size cryostat for ITER. He is a fellow of Indian National Academy of Engineering. He is presently Mission Director of Advanced Ultra Supercritical R&D Project of 800MW thermal plant.

Profile of Shri Guntur Nageswara Rao

Chairman, AERB

Shri G. NageswaraRao, an Electrical Engineering Graduate of 1975 from the Jawaharlal Nehru Technological University, Andhra Pradesh. took over as Chairman, Atomic Energy Regulatory Board w.e.f. January 4, 2019.

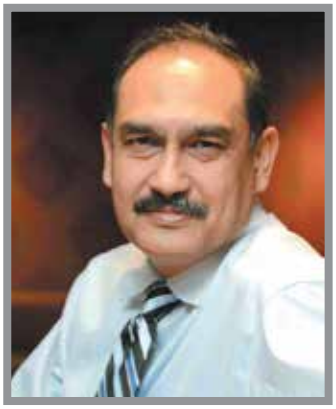
He joined Department of Atomic Energy in 19th batch of the BARC Training School, and received the HomiBhabha Award for obtaining the first rank in his group. Since then, he has made valuable contributions to indigenous nuclear power program in different managerial positions over the last four decades

He made noteworthy contributions in commissioning and managing the first indigenous PHWR on power fuel handling systems at Madras Atomic Power Station. In 2002, he was appointed as the Station Director of Kaiga Generating Station-1&2 (KGS-1&2) . He established excellent safety culture at Kaiga units, which laid foundation for consistent excellent performance in subsequent years. Considerable credit is given for his contribution for 962 days of continuous operation of Kaiga Unit-1 establishing a new world record.

He played a leading role in commissioning of the first 1000 MWe advanced VVER unit of Kudankulam Nuclear Power Project addressing several technical challenges of first of a kind systems in these units. He served NPCIL as Director (Operations) for nearly eight years from August 2007, being responsible for safe operation and maintenance of all the nuclear power plants of NPCIL.

After his superannuation, he made contributions tonuclear safety having associated with various safety Committees of AERB. Indian Nuclear Society honored him with “INS Outstanding Service Award 2011” for his outstanding contributions.

He served as Member in the Heavy Water Board, Nuclear Fuel Complex, Hyderabad, Atomic Energy Education Society of Department of Atomic Energy. He attended several International Conferences and presented technical papers on Nuclear Power Plants, commissioning, safe and reliable operation Experiences and Strategies.



Profile of Dr. Harsh Mahajan

Founder & Chief Radiologist, Mahajan Imaging

- M.B.B.S. from Maulana Azad Medical College, New Delhi, India (1977-1982)
- M.D. in Radiodiagnosis from Post Graduate Institute of Medical Education and Research, Chandigarh, India (1984-1986)
- Fellowship in MRI from M.D. Anderson Cancer Hospital, Houston, Texas; went on a Rotary Foundation Scholarship (1987-1988) Present Position
- Founder and Chief Radiologist of Mahajan Imaging (1999 – Present): Mahajan Imaging is a chain of highly reputed medical imaging centres in North India, including stand-alone facilities at Defence Colony and Hauz Khas, New Delhi, in Gurgaon, Haryana and in many reputed hospitals of Delhi, namely Sir Ganga Ram Hospital, Safdarjung Hospital (Sports Injuries Centre),Fortis Flt. Lt. RajanDhallHospital,BLK Super Specialty Hospital and PSRI Hospital. Her serves as Chairman of the Department of Radiology at these hospitals.
- Honorary Radiologist to the President of India (1998 – Present)
- Chairman (1999 – Present), Department of Nuclear Medicine & PET-CT,Sir Ganga Ram Hospital, New Delhi
- Consultant, International Atomic Energy Association, Vienna, Austria
- Advisor, Union Public Service Commission Examination (UPSCE)

Previously Held Positions

Chief Radiologist and Director, GMR Institute of Imaging & Research, New Delhi (1992 -2004)
Dr. Ram Manohar Lohia Hospital, New Delhi Fellow, MRI Division, M.D. Anderson Cancer Hospital and Research Institute, Houston, USA , Senior Resident , Department of Radiology, AIIMS, New Delhi
House Surgeon, Maulana Azad Medical College & Associated LNJP and GB Pant Hospitals, New Delhi

Awards

- Padma Shri (2002): Conferred by the Government of India in 2002 for contribution to the field of radiology.
- NationalPresident (2012) of the Indian Radiological and Imaging Association (IRIA), a body comprising of more than 12,000 radiologists from across India.
- President (2009) of the Indian Society of Neuroradiology (ISNR)
- Chairman, Organising Committee(2011), 64th National Conference of the IndianRadiological and Imaging Association
- OISCA Laureate (1999): An award given by the Ambassador of Japan inrecognition of contribution to the field of radiology
- President(2000) of the Indian Radiological and Imaging Association, Delhi Branch
- Vice President(2001) of the Indian Society of Neuroradiology

Profile of Shri Sudeep Gupta

Director ACTREC,Tata Memorial Centre, India

Dr.Sudeep Gupta is a Professor of Medical Oncology at Tata Memorial Hospital in Mumbai, India. Dr. Gupta obtained his MBBS degree from All India Institute of Medical Sciences (AIIMS) in New Delhi in 1992. He completed his Postgraduate (MD degree) in internal medicine in 1994 and his Medical Oncology training in 2000 at the same Institute. Following his Medical Oncology training, Dr. Gupta joined Tata Memorial hospital in Mumbai as an Assistant Professor in Medical Oncology and was promoted to Associate Professor in 2003 and Professor in 2010.

Dr. Gupta is an outstanding researcher and has special interests in breast cancer and gynecological malignancies and early drug development. In breast cancer Dr. Gupta's areas of research include adjuvant therapy and management approach of metastasis from breast cancer. His other areas of research are cervical cancer, ovarian cancer, multiple myeloma and lymphoma.

Profile of Ms Kritika Kaur

Technical Manager and Radiological Safety Officer NUVIA India

Kritika Kaur is a Nuclear engineer and works as Technical Manager and Radiological Safety Officer at Nuvia India, the nuclear engineering, services and Products specialists which is part of the Nuvia Group. She has over 7 years of experience in design, calibration of radiation monitoring instruments, R&D, Consultancy and Trainings. She has extensively worked in India and abroad on various projects.

She did her integrated MS and M.Tech in Nuclear Science and Technology from University of Paris Sud XI and University of Delhi.

She has spearheaded consultancy and trainings for various clients like Unilever, Lupin Pharmaceuticals, Larsen and Toubro, Century Pulp and Paper, GAIL, BHEL, Petromasila Yemen, NDRF etc.

Profile of Shri Arun Kumar Bhaduri

President of The Indian Institute of Welding

Dr. Arun Kumar Bhaduri after obtaining his B.Tech. (Honours) degree in Metallurgical Engineering from the Indian Institute of Technology Kharagpur in 1983, joined the Bhabha Atomic Research Centre's Training School at Trombay, and was awarded the Homi Bhabha Medal for being the Overall Topper of its 27th Batch. In 1984, he joined the Indira Gandhi Centre for Atomic Research (IGCAR) at Kalpakkam, where he is presently Distinguished Scientist & Director, and also Senior Professor of Homi Bhabha National Institute. While at IGCAR, he obtained his PhD in Metallurgical Engineering in 1992 from Indian Institute of Technology Kharagpur. He received Humboldt Research Fellowship from Alexander von Humboldt Foundation, Germany in 1994 and carried out 2-year post-doctoral research at the Materialprüfungsanstalt (MPA), University of Stuttgart, Germany and worked on "Assessment of creep behaviour and creep-rupture strength of weld joints".

He pilots the design and technology development of sodium-cooled fast reactors and its associated fuel cycle for the second stage of India's nuclear power programme, and anchors the development of materials and their fabrication technologies for Indian programmes on sodium-cooled fast reactors, fusion reactors and advanced ultra supercritical thermal power.

For his significant and outstanding contributions to science and technology of welding and hardfacing, he has been awarded with many prestigious accolades,

He was elected Fellow of Indian National Academy of Engineering (FNAE) in 2007. He is also Fellow of Indian Institute of Welding (FIIW) and Indian Institute of Metals (FIIM), and a Life Member of the Indian Society for Non-Destructive Testing (ISNT) and Materials Research Society of India (MRSI). At the International Institute of Welding, he is presently Vice-Chairman, Commission–II on "Arc Welding and Filler Metals" (2014–); Member, Editorial Board, Welding in the World (2008 –), and has been Member, Board of Directors (2016–2019); Member, Technical Management Board (2007-2010). He is presently President of The Indian Institute of Welding (2017–2019)

Profile of Dr. A.K. Nayak,

Reactor Engineering Division Bhabha Atomic Research Centre

Dr. A.K. Nayak, a nuclear reactor designer and thermal hydraulic specialist in Bhabha Atomic Research Centre, Mumbai and Professor, HomiBhabha National Institute, Mumbai, has nearly 30 years of experience and is well known for advanced nuclear reactor designs with passive safety systems and severe accidents in light water reactors and PHWRs. Advanced Heavy Water Reactor design is one of his significant contributions. He received his PhD from Tokyo Institute of Technology, Japan in 2000 in Nuclear Engineering and has received multiple awards and prizes throughout his career, published more than 350 peer reviewed articles in highly reputed journals and conference proceedings, edited 3 books, and served editor/guest editor of several international journals. Currently, he is Outstanding Scientist in Bhabha Atomic Research Centre and Head, Thermal Hydraulics Section

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