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ADDRESS BY

GUEST-IN-CHIEF

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Government of India

JADAVPUR UNIVERSITY

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His Excellency Shri Viren J.Shah, the Chancellor, Jadavpur University, Dr.A.N.Basu, Vice-Chancellor, Jadavpur University, Distinguished Members of the Court, Learned Faculty Members, Students graduated at today's Convocation, Ladies & Gentlemen:

It is indeed a matter of great privilege and honour for me to be invited for delivering the 47th Annual Convocation Address at Jadavpur University, a renowned seat of learning in the country. In fact, I am delighted to be amongst you this morning, where a group of our bright young men and women are getting their degree prior to an important decision in respect of either to take up professional careers in the fields of their respective specialisation or to pursue their respective academic excellence. This University can justifiably be proud of its multifaceted contributions it has made to the task of nation building. Many of the faculty members and alumni of this University have played sterling roles not only in shaping the development activities for the country in the post-independence era but also in the freedom movement that have led to our political independence.

We revere the great personalities like Rabindra Nath Tagore and Aurobindo Ghosh who are associated with Bengal National College, the forerunner of this University. Through their outstanding contributions, the towering personalities like Gurudas Banerjee, Acharya Prafulla Chandra Roy, Chittaranjan Das, Nilraton Sarkar, H.L.Roy, Triguna Sen, Amartya Sen and the like whom we all greatly admire have left indelible marks in their respective domains of excellence. Similarly, we must also not forget to remember gratefully all those enlightened philanthropists whose generosity nurtured this University in its formative years.

Before I proceed further, let me congratulate in general all the students who will receive the degree today on the occasion of the 47th Annual Convocation and particularly those who will receive special awards for their meritorious performances. Let me also take this opportunity to compliment all members of the faculty, parents and guardians of students who must have worked equally hard to encourage and empower the students to accomplish their achievements.

Creation of new knowledge and its dissemination through education are undoubtedly the most important responsibility of the University system. In today's world of rapid advances in the knowledge base of scientific and technological development, conversion of new knowledge into wealth for the societal benefits is yet another objective of the University system. Moreover, the

Universities are traditionally acknowledged conscious keepers of the society. In the present environment of explosive growth of data/ information, the responsibilities of the faculty of the University have magnified manifold in terms of their tasks for evaluating and screening the data for extracting useful information, critically analysing the information to create knowledge and share this knowledge for creation of expertise leading to generating wealth for the society, and finally sublimate the expertise into wisdom which may ultimately lead to realisation of truth. If the society can be compared with a human body, the University can be assigned the role of the brain. The contributions that Jadavpur University has made in various areas of our society right from its inception are indeed commendable. In fact, many of the alumni of the University are presently guiding and participating in the scientific, technological and intellectual fields both at national as well as international levels. Perhaps, most of you if not all of you are aware, this great educational institution had started the moto of self-reliance not only in education but also in the development of science, technology and social welfare.

Similarly, right from the days of inception, our founder Dr.Homi Jehangir Bhabha has assigned highest priority on dependence on indigenous resources and self-reliance in indigenous nuclear technologies in our programme on nuclear science and technology. Let me share with you some of our experiences in our journey towards the path of self-reliance in implementing our nuclear energy programme in the country.

Energy, Environment & Education

It has been recognised since our independence that India's national development would have to be driven by science and technology. It has also been recognised that it is not possible to transform the economy of a country on the basis of the modern technology that has been developed elsewhere without establishing at the same time modern science and technology in the country. As Dr.Bhabha said "what developed countries have and the under developed countries lack is modern science and an economy based on modern technology". We are aware, water, energy, environment and education are the essential pillars of the structure that support quality of life in the society in any country, particularly in the developing countries with large population like ours. The linkage between availability of sufficient primary energy in general (and that of electricity in particular) and the economic growth of the country is established beyond doubt. To alleviate the poverty and to improve quality of life of our 1 billion plus population (which accounts for nearly one-sixth of the entire humanity in the world), we need to ensure a sustained economic growth of about 6% which, in turn, calls for growth in generation of electricity by about 8% on a sustainable basis. Our per capita electricity consumption is only about 600kwhr/y (which is less than one-fourth of even the world average value of 2500 kw hr/yr) compared to the target of about 5000-7000 kw hr/y which is the bare minimum required for an acceptable quality of life in a society. Various means of energy production and its consumption pattern in different sectors of the society have a direct bearing on the environment because of their direct linkages with the generation of associated wastes. For sustained development of society, what is important is to strike a balance amongst these life supporting pillars failing which the society will collapse sooner or later depending on the amount of imbalance we allow in the life supporting structure.

We, at the Department of Atomic Energy (DAE) in general and Bhabha Atomic Research Centre (BARC) in particular, are committed to exploit nuclear science and technology for:

(a) improving the quality of life of our 1 billion plus population,

(b) staying at the forefront of nuclear science and technology in order to retain the place of honour and dignity for India amongst the world community; and of course

(c) enhancing the national security.

And for improving the quality of life in the society, our primary mandates are to:

(i) provide energy security by way of generation of nuclear power that are safe, reliable and economical in addition to its eco-friendliness; and,

(ii) use radioisotopes and radiation technology in non-power sector for health care, industry, agriculture & food preservation, isotope hydrology, nuclear desalination, etc.

At present fossil fuels, particularly coal, plays a dominant role which accounts for about 70% of the total electricity generation capacity of about 1,31,000 MWe (which includes about 27,000 MWe generated from captive power plants) followed by hydro sources accounting for about 25% share of generation capacity with a small contribution (of 3%) from nuclear source. But our fossil fuels are dwindling fast and their excessive use has already triggered the alarm bell of the danger of global warming arising out of emission of carbon dioxide. Hydroelectric power sources, which are apparently eco-friendly renewable sources, are linked with undesirable effects of damage to natural environment (by way of inundation and submergence of vast areas of land) in addition to the difficulties associated with their locations in inaccessible areas. Other forms of renewable energy sources, though virtually inexhaustible, are not suitable for electric power generation at their present stage of technological development. We are, therefore, left with no other option but to increase progressively the share of nuclear energy in the overall energy-mix in India.

But harnessing nuclear energy for its utilisation either in nuclear power sector or non-power sector calls for development of a host of technologies which demands high level of excellence in both basic sciences and engineering sciences to address in totality the various issues involved in the complex multi-disciplinary nuclear science and technology. In order to fulfill our commitment to exploit nuclear energy for the societal values, we have created a host of centres of excellence at Bhabha Atomic Research Centre (BARC) where scientists and engineers are pursuing excellence in basic science (in all the relevant areas of physics, chemistry and biology) while pursuing technology development task in mission mode. These pursuits are nurtured in complimentary mode to each other like the twin strands of DNA molecules. Perhaps, you are aware that BARC is the largest research institute in the world where the widest spectrum of activities in nuclear science and technology is being pursued from where the entire nuclear energy programme in India is grown on the basis of RD3 – Research, Development, Demonstration & Deployment. Once the technologies are brought to maturity at demonstration scale, these are subsequently deployed at commercial scale either by the various public sector units/ industrial units under the Department of Atomic Energy (DAE) or by BARC itself (for those technologies that are not advisable to be handed over to other agencies).

To enable the scientists and engineers at BARC to pursue excellence in the areas of nuclear science and nuclear technology, we have built a series of research reactors and developed all the relevant technologies required at the front-end as well as the back-end of nuclear fuel cycle needed to support the research reactors, including the facilities for production of radioisotopes and development of radiation technology. We are one of the very few countries in the world with the widest range of neutron beam research facilities. We have also built various types of accelerators with different energy range. Out of the two Synchrotron Radiation Sources (SRS) planned in CAT, the 450 MeV(e) Indus-1 SRS is operational since 1998 and the 2-GeV Indus-2 SRS is under construction. These two facilities will provide intense synchrotron radiations in wavelengths from Vacuum Ultra-Violet (VUV) to X-rays through several beam lines which would stimulate multidisciplinary R&D in radiation and condensed matter physics (by studying the absorption, fluorescence and photoelectron spectra), material research, biology and industrial applications such as micro-lithography. As a part of our advanced accelerator development work, new generation of accelerators utilizing superconducting (SC) magnet and RF technology are under construction at VECC and at TIFR respectively and these accelerators are expected to become operational in 2-3 years time.

In order to extend the opportunity to our scientific community to get access to the still higher energy synchrotron sources/particle accelerators that are needed for carrying out pioneering high energy physics experiments at the frontier level, we collaborate with almost all major international accelerator facilities in Europe (to use Large Hadron Collider at CERN, Geneva), USA (for DO-experiments at Fermilab; PHENIX experiment and STAR experiment at BNL) and Japan (for Radioactive Ion Beam Experiments at RIKEN) on "equal partner basis" and not any longer on a "donor-recipient" basis. Our scientists and engineers are well known for their scientific excellence and for their in-kind contributions in these mega-projects by way of complex software development, detector fabrication, etc. To establish the high credibility of our scientists in the frontier science, special mention may be made of the design and development of the totally indigenous VLSI chip MANAS for use in the ALICE project of the Large Hadron Collider at CERN in Geneva. The front-end design of this mixed signal VLSI chip has been done at Saha Institute of Nuclear Physics, Kolkata, and back end design in the SCL, Chandigarh. Being a very low noise mixed signal VLSI chip, it has its own design intricacies. The analog part in particular had to meet very stringent specifications. Functionally it has outperformed its foreign predecessors. Because of a large number eof similar high end contributions both in terms of software as well as hardware developments, I am happy to inform that India has been given "Observer" status in this prestigious international mega-project at CERN, Geneva where most advanced basic sciences being pursued on facilities built on the most advanced technologies in the world.

Similarly, after decades of dedicated R&D efforts, we have succeeded to establish our indigenous PHWR technology on a firm footing. Our 12 units of PHWRs are operating at world class level both in terms of capacity factor (~90%) as well as safety record. We are amongst a very few countries in the world who have succeeded to achieve the comparative level of excellence in all the technologies involved in the nuclear fuel cycle including the technology for "vitrification of high level nuclear wastes" - (which is needed to allay the apprehensions of common people on management of nuclear wastes). Because of the remarkable progress in our most compressive programmes both in nuclear power generation sector as well as non-power sector (which I intend to cover later), India is acknowledged as advanced country as far as nuclear science and technology is concerned. We are planning to increase the share of nuclear power from present level of 3% to about 5% by the year 2008 and to about 10% by the year 2020.

Some of the important pillars behind our success story in nuclear science and technology are:

(i) Persistent policy of pursuing excellence in basic sciences while we pursue excellence in engineering science for technology development with a definite yardstick to assess their merits.

(ii) Our priority for strong HRD programme with strong linkages with academia and research institutions in the country.

(iii) Our extensive programme on health, safety and environmental science; and

(iv) The premium we pay for development of high performance parallel processing computers which can be claimed to be the best in the country. ANUPAM Parallel Processing Supercomputer using 64 nods (Pentium-4) has attained 42 Gigaflops of computing power and our 128 nods (Pentium-4) supercomputer is expected to touch 100 Gigaflops in next 6 months time. BARC Parallel Processing Supercomputers are now working at 25 different organisations outside DAE. Our supercomputer is running the operational weather codes faster at the National Centre for Monsoon Research and Weather Forecasting of IMD, New Delhi at almost one-tenth of the cost of the Cray-XMP supercomputer. We have target to reach 1 Teraflops capacity by 2006 using about 1000 nodes of PCs available at that time.

But we have no room for complacency. We have a long way to go to fulfill our commitment to provide energy security to our country on sustainable basis. Because of our modest uranium reserves on the one hand and vast thorium resources (accounting for one-third of a total thorium reserves in the world) on the other hand, the road map for generation of electricity from nuclear sources in India is based on three stages of power generation programme - the only path that can provide energy security for the country like India by adopting a closed fuel cycle which ensures production of more and more fissile plutonium-239 (or uranium-233), which are recycled back to the next generation reactors for multiplying the growth of nuclear power generation.

The first stage of our nuclear power generation programme, based on our modest Uranium resources, can support generation of about 15,000 MW(e) electricity through our present generation Pressurised Heavy Water Reactors (PHWRs). Recycling the Pu-239 along with the depleted uranium from the first stage to the next stage Fast Breeder Reactor (FBR) will enable us to get access to about 150 times more energy potential from our limited Uranium (along with Pu-239) resources because FBR technology allows repeated recycling of Uranium with the added inherent advantage of breeding more of Pu-239 in the U-238 blanket material than what is consumed in its MOX fuel (Pu-239 $O_2 - UO_2$) at the core. However, keeping in mind that we will have to fall back on our vast Thorium resource for the energy security of our country, we will start inducting Thorium (as ThO_2) in place of UO_2 in the blanket zone of FBRs at an appropriate growth level of installed nuclear power capacity in the second stage. This would enable us to start building the inventory of yet another fissile material U-233, which will be utilised in the 3rd stage of our nuclear power programme based on yet another type of FBR using MOX fuel (U-233O_2 - ThO_2) in the core with ThO_2 as the blanket material for meeting the national need of electricity on a sustainable basis.

Today, we in the Department of Atomic Energy (DAE), are at the threshold of various transitions. The first and foremost pertains to the consolidation and multiplication of our present PHWRs for substantially increasing the share of nuclear power in the overall electricity generation. The second transition involves the setting up of fast breeder reactor for commercial power production, (the first 500 MW(e) FBR unit is to start in Xth Plan at Kalpakkam, Chennai) based on the year of experience gained through our technology demonstration unit, the Fast Breeder Test Reactor (FBTR).

In addition to providing R&D inputs, which includes (i) technology development for life extension of existing PHWRs, (ii) providing fuel cycle facilities needed to support the expanding PHWR programme at world class level, (iii) development of technologies for fuel and (iv) fuel handling systems for FBR etc., BARC has also the responsibility to develop the technologies for the future by way of implementation of our 300 MW(e) Vertical Pressure Tube type Advanced Heavy Water Reactor (AHWR) which is our future generation reactor system based on thorium based fuel using D_2O as moderator and boiling H_2O as coolant. About 65% of the total power generated in AHWR would be derived from thorium fuel. This reactor system has the most attractive feature of heat removal by natural circulation only and it also incorporates hosts of other passive safety features that are in line with the approach world over for development of inherently safe reactor system – safety features that do not call for any human intervention or any active control devices for reactor safety. Construction of this novel reactor (which will be initially fuelled with ThO_2/Pu-239 O_2 but will subsequently operate on ThO_2/U-233 O_2 fuel), first of its kind in the world, is expected to start within two years time after all the passive safety features are subjected to detailed peer review during which some of the pending experimental verification jobs of AHWR systems are planned to be completed in parallel.

We have also long term plan to induct nuclear energy as primary energy source viz., source of heat for variety of applications like desalination of water, production of cheap H2 as an environmentally friendly alternative to hydrocarbon fuels for our transportation sector etc. We have, therefore, taken the initiative to develop a low power (~100 KW(th) Compact High Temperature (CHTR) for (i) catering to the needs of remote inaccessible areas; and (ii) also for providing high temperature heat source (700-900°C) to produce fluid fuels (e.g. H2 from H2O using thermo-chemical means) for transportation applications. Thermo-chemical method uses an inorganic intermediate compounds (e.g., Iodine-Sulphur Process) to dissociate water such that the inorganic compound gets regenerated during the reaction to make the process a closed cycle one. CHTR (lmd x lmH) is a vertical natural circulation type totally passive reactor based on U-233 carbide fuel (TRISO type coated particle where UC_2 kernel is encased by multi-layers of pyrolytic carbon and silicon carbide) with liquid metal (molten Pb or Pb/Bi eutectic, etc.) as coolant.

We have also initiated a programme to develop Accelerator Driven Sub-critical System (ADSS) – yet another reactor concept for future – that could be used for (a) power generation from Thorium, or (b) production of U-233 for our third phase FBR based on ThO2/ U233 O2 fuel; or (c) incineration of long lived minor actinides [like Neptunium (Np), Americium (Am), Cesium (Cm), etc.] and transmutation of long lived fission products (like Cs-137, Tc-99, Zr-93, Pd-107, etc.) of present generation PHWRs to shortlived products with about few 100 years of half life, which will drastically reduce the long term activity burden of nuclear wastes and make their disposal in geological repository at much reduced technological complexities.

Non-Power Sector

Parallel to the world class performances of our indigenous PHWR system, the growth of applications of radioisotopes and radiation technology in non-power sectors in India has been remarkable, covering a wide spectrum starting from nuclear agriculture and preservation of food on one end, to health care and industrial applications on the other end. This appreciable growth has been achieved through decades of R&D efforts at BARC which have subsequently been strengthened by establishing our industrial interfacing unit – Board of Radiation & Isotope Technology (BRIT) at Navi Mumbai.

We produce (i) large quantities of 10-15 types of regularly used neutron-rich radioisotopes in research reactors and nuclear power plants; (ii) radioisotopes like Cs-137, Sr-90 by separating them from FPS; (iii) we have very recently added medical cyclotron (16.5 MeV proton beam) with PET facility at the Radiation Medicine Centre (RMC), at Mumbai for production of neutron-deficient radioisotopes such as F-18 that will provide Fluoro Deoxy Glucose (FDG) for the patients. We have also planned to add a large medical cyclotron (30 MeV proton beam) with PET facility at Kolkata in the 10^{th} Plan period to produce larger quantities of PET group of radiopharmaceuticals along with radionuclides like Thallium-201, Galium-67, Indium-111 and Iodine-123 (which are otherwise not possible to produce with 16.5 MeV medical cyclotron facility at RMC) that would provide opportunities to develop other radiopharmaceuticals.

(i) Nuclear Agriculture

In the areas of nuclear agriculture, we have released 23 varieties of various crops for commercial cultivation by developing radiation induced mutants and their cross breeds. These mutants include 10 of pulses (4 - black gram, 4 - green gram and 2- pigeonpea), 9 of groundnuts (the latest entry of which – TG-41 - a special mutant of large seeded variety for confectionery purpose); 2 of mastard and 1 each of jute and rice. Most of these mutants are of high yielding variety while quite a few of them are disease resistant also. At all India level, our 4-black gram varieties account for about 50 percent of the total national breeder seeds indent for all the existing black gram varieties taken together, while our 9 groundnut varieties account for about 30 percent of national indent. In fact, this year's indent for TAG-24 variety has made it to occupy the first rank among the 33 groundnut varieties.

(ii) **Health Care**

Major emphasis on the application of radioisotopes and radiation technology has been assigned for diagnosis and prognosis in a variety of diseases as well as for providing relief by both curative and palliative treatment. In the field of medical diagnosis, we have strong base of Radio-Immuno-Assay (RIA), Immuno-Radio-Metric Assay (IRMA), dynamics imaging techniques based on SCINTIGRAPHY and SPECT (Single Photon Emission Computer Tomograpy); our Mo-99 – Tc (99m) generation is the workhorse of nuclear medicine in the country.

In the area of therapeutic uses, our programme covers Cobalt based therapy (250 units), Linear Accelerators (35 units), Cs-137/Ir-192 based brachy therapy centres and the country's largest thyroid clinic at RMC. We have also advances in palliation of metastatic bone pains of terminal cancer patients using Sr-89/P-32/Sm-153/Re-186 complexes, development of radiation synovectomy for palliation of joints pain due to rheumatoid arthritis using hydroxy apatite (HA) particles labeled with Ho-166/Sm-153 and radiation sterilization of medical products (Co-60 source) and blood irradiator (Cs-137 source), etc.

Addressing the problem of providing of drinking water supply at an affordable cost to water scarce areas in the country, we have set up a desalination plant (1800 m3/d) based on reverse osmosis technology at Kalpakkam, Chennai which will soon be coupled with another plant (4500 m3/d) based on the multistage flash evaporation technology, making this nuclear coupled desalination facility a unique one to have hybrid technology.

(iii) **Industry**

India is the lead country in industrial applications of radioisotopes in Asia & Pacific Region because of our excellence in all three areas of applications – (i) use of sealed sources (g - radiography, computer aided tomography, g-scanning & nucleonic gauging); (ii) use of Radio Tracers, (RTD measurements for process optimisation in chemical, petroleum and petrochemical industry; tracer technology for FCCU of petroleum refinery done for the first time in India; detection of leakages in long and buried pipelines, silt movement in ports and harbours;) (iii) radiation processing (using Electron Beam Accelerator, 2 MeV-20 KW-DC-type) for radiation crosslinked polymers/co-polymers for electrical cables/wires with improved electrical and mechanical properties which are not possible to achieve otherwise; heat shrinkable polymers and polythene 'O' rings for sealing drums at high temperature (220°C); degradation of teflon scraps for high temperature lubricants and non-stick kitchen wares). Very soon, we are going to add the entire range of EB-accelerators (500 KeV – 10 KW DC; 3 MeV-30 KW DC; 10 MeV-10 KW RF) to cover the entire need of the industries.

(iv) **Food Processing**

Another important component for ensuring food security of the country is the effective preservation of food. Radiation processing is fast emerging as an important technology for the preservation of agricultural commodities, hygienisation of food and sterilization of medical products. It also provides a method for overcoming the "quarantine barrier" in the international trade of food products. Radiation processing, therefore, plays a major role in strengthening the food security of the country and in meeting the statutory requirements for international trade in food products. Starting with a Spice Irradiator (250 KciCO-60), we have also added very recently a POTON facility (10 Te/hr) for preservation of onions by low dose irradiation (Co-60).

Human Resource Development Programme

Pursuit of excellence in the areas of nuclear science and technology calls for world class facilities to be provided to the scientists and engineers. The various centres of excellence created within BARC need continuous replenishment of high quality human resource not only for preservation of existing knowledge base but also for their upgradation for development of future technologies. Presently, the growth of knowledge is so fast that in the field of science and technology, the half life of knowledge base of a scientist or an engineer is about 5 years, unless it is updated regularly in order to stay at the forefront of science and technology. We are fully aware that the University system or the research centres or the industries cannot afford to have the luxury of staying in isolations. Research Institutions and industries must provide the frontline of science and technology to the University system and the faculty members/students community should update their knowledge base as per needs of research institutes/industries. In this connection, I must add that inspite of the general downward trend in pursuit of high level research in the country, the scientists and engineers at BARC continues to excel, probably because of our philosophy of assigning equal opportunities to both basic science and engineering science to grow in parallel.

We, in the Department of Atomic Energy, have been very conscious of our needs in terms of human resource. To meet these needs we have devised a variety of programmes for training, some at the entry level and some during the service period to tackle obsolescence. At the entry level, our programme is based on the principle of "hire and train" and this has been very successful in providing trained manpower for the expanding programmes of the Department. Under the first such scheme, which is ongoing since late fifties, we select graduates in engineering and post-graduates in science disciplines and train them in nuclear science and engineering for a period of one year before assigning them to different Units in the Department. Earlier, such training was imparted only at Bhabha Atomic Research Centre (BARC) but now we have opened additional centres at Centre for Advanced Technology (CAT), Indore, Nuclear Fuel Complex (NFC), Hyderabad and at Nuclear Power Corporation of India Ltd., to cope with the need for our growing nuclear energy programme. In the beginning of nineties, we started another programme, under which we select engineers with post-graduate qualifications and train them for four to five months before their placement in different units. The idea of initiating the scheme was to benefit from the already mature Master's Degree Programmes in engineering at our academia. In one of the notable initiative taken since 1999-2000, we devised yet another scheme in which we have made an arrangement with IIT Kanpur for the Masters Programme in nuclear engineering. This scheme has been quite successful and we have expanded it this year to other disciplines and to other IITs/IISc under "DAE Graduate Fellowship Scheme" under which selected M.Tech students in various IITs/IISc will be adopted by DAE during M.Tech course, if they agree to join the department later. We have plans to extend this programme to other leading Universities in the near future.

In the year 1999, on the occasion of the birth centenary of Dr.K.S. Krishnan, a programme of Dr. K.S.Krishnan Research Associateship was started. Under this scheme, research associates are inducted every year for a two-year Associateship with the possibility of getting them absorbed, depending on their performance, in one of the R&D organisations of the Department.

In parallel with the induction programmes, we also place considerable emphasis on further upgradation of qualifications of our scientists and engineers. We encourage them to pursue Masters Programme in engineering as well as register for research degrees. Research centres of DAE are recognised as centres of research leading to postgraduate degrees by the universities of the neighbouring regions. A number of our scientists and engineers are recognised as postgraduate teachers and research supervisors by these universities. We do encourage our scientists and engineers to register for advanced degrees based on the work done in our research centres. Quite often, such research projects are jointly supervised by members of university faculty and our senior scientists. This provides yet another avenue for collaborative research. The

Department of Atomic Energy is also setting up advanced centres, dedicated to DAE programmes in Universities. These centres not only enable DAE programmes to benefit from the expertise available with the university faculty but also provide a very valuable training ground to the university students in the areas which are of interest to DAE.

DAE-Academia Interaction

Realising the ground reality that the success or otherwise of our multidisciplinary programmes for taking the benefits of nuclear science and technology to the Indian society depends mainly on the availability of sufficient number of high quality trained manpower, we have assigned top priority for expanding DAE-Academia linkages (in addition to the in-house HRD programme cited earlier) through ultimately a national network for providing access to our knowledge base on nuclear science and technology for the entire academia in the nation. This also includes imparting vigorous training programmes for the people in almost all these specialised activities in the field of nuclear science and technology. Accordingly, we do take advantage of the pool of high quality young talent and wisdom of the faculty members available in our University system such as this University through collaborative programmes. In fact, such interaction is also yet another way by which our scientists and engineers could upgrade and enhance their knowledge base in a win-win situation. I am aware of the fact that Jadavpur University organises not only many refresher courses but also advanced courses in several emerging areas of multidisciplinary nature, which are of direct relevance to our programme. We have benefited considerably from these activities and look forward to their continued expansion.

We also strengthen the synergy between DAE and Academia by providing grant-in-aids to institutions of national eminence in basic and applied research. We have opened up many of our research facilities for utilisation by students and faculties from the University system, for example, through the DAE Inter-University consortium paving the way for utilisation of some major facilities such as nuclear reactor, accelerator and synchrotron radiation sources for this purpose. Further, the wings of our Board of Research in Nuclear Sciences (BRNS), is another major carrier through which we constantly pursue various collaborative research programmes with Universities and institutions (for example, we have a number of successful research projects with Jadavpur University and several such projects are going on at the Structural Engineering Research Centre (SERC), Chennai, University of Pune, etc.).

DAE-Industry Interaction

There is a strong interaction between DAE with the industries in the country whom we consider as our valuable partners for the growth of nuclear industries. Without help from the Indian industries, it would have never been possible to make the progress we have achieved in our nuclear energy programme. In a win-win mode, our cooperation with the industries have lead to general upgradation of not only the quality of our industrial products but has also enabled the industries to execute mega-projects of world class in a highly competitive way.

Concluding Remarks

Friends, I have tried to place a sketch of our programme that we are committed to pursue over the next couple of decades to improve the quality of life of our society through progressively more and more induction of nuclear science and technology both in the areas of power generation as well as non-power generation sectors. The fact that nuclear energy is inevitable for India can be easily realised, if we have a hard look at the various options of energy resources available in the country. I take this opportunity to inform that the growth of nuclear power in the western world was apparently showing signs of slowing down primarily due to (i) their prevailing saturation level of per capita electricity consumption; and (ii) quite understandably their priority for extension of life of the existing nuclear power plants through exploitation of their advances in the fields of non-destructive inspection tools and material science. But the scenario is visibly changing in favour of more and more nuclear power even at the western world because of its inherent advantages for the society in the long run. For developing countries with large population like China, India, South Korea etc., where there is a wide gap between the prevailing per capita electricity consumption (e.g., 600 kWhr/y in India) and the certain minimum level of 5000 – 7000 kWhr/y needed for an acceptable quality of life in the society, the growth of nuclear energy is very high. No doubt, these programmes are scientifically and technically quite complex which are to be solved in a multi-disciplinary approach. But these are the programmes that can provide the necessary challenges to trigger the young minds to face them for the benefit of our own people and for taking India into a position of super power through the road of vibrant economy based on sustained energy security, food security and health care.

I do recognise that at the time of graduation, when a person is in transition from the student life to a professional life, his mind is flooded with several questions such as:

(i) Can he contribute through his present level of education to any activity of societal/national importance?

(ii) which is the best place to join that would provide intellectually stimulating and encouraging ambience for his innovative ideas and design capabilities to grow?

(iii) how to make the education he has received during his student days more relevant to his professional career?

(iv) Is the question of "professional satisfaction" really important at the end of one's career in the present day materialistic world?

(v) When does the process of his learning finally come to an end?

A student generally attempts to select his professional career on the basis of his perception of satisfactory answers to these questions. Of course, a graduating student who is sensitive to his obligations to the society and his profession may not remain a mere job seeker. With his ideas and enterprising initiative, he may strive to be a source person who can help in the creation of many more jobs. Let me share with you some of my personal experiences in this regard.

As a student of chemical engineering, I was intrigued, for example, by the versatality of Maxwell's equations, by the role of Gibbs equation in determining the feasibility of a spontaneous process, by the power of thermodynamics and kinetics in predicting the directions and rates of chemical processes and by the intricate relationship between the microstructure of materials and their macroscopic properties. At the time of my graduation, I was not sure whether I would find a place of work where I could further develop my understanding in these areas and could finally utilize some of the knowledge that I had acquired during the academic career for practical usage. I was fortunate to join the Department of Atomic Energy (DAE) where I could not only apply most of the concepts that I have learned as a student but also could upgrade my level of understanding. I have personally experienced the intricate interplay of entropy and enthalpy in dictating a variety of chemical processes in the nuclear industry. Even in the most challenging task, I had so far faced in my professional career, namely, development of gas centrifuge technology from grass root level that was much needed to deliver enriched uranium for some strategic applications, I had to fall back quite often on my knowledge of classical electrodynamics based on Maxwell's equations. No doubt, my prevailing knowledge base had to be upgraded much above the level normally available in University systems or in normal industries but that is not an impossible task as long as you get the opportunity to pursue such challenges with your highly motivated multidisciplinary team in an exciting environment which is possible only at a world class R&D centre like BARC.

Coming to my advice to you, I would say that the decision is primarily yours. You are welcome to join us straightaway through any of the systems I have cited earlier to get the added advantage of working in the most enviable ambience in the country with guaranteed "professional satisfaction" or you can pursue to enhance your academic excellence and still participate in our programme in a collaborative mode. In case none of these approaches are exciting enough, you are welcome to take the path that assures you much more materialistic satisfaction straightaway. Whichever is the avenue you finally choose to follow, I would personally be extremely happy, if each one of you, during the pursuit of the career of your choice, always allow your mind to be bothered at least sometimes by some concerns about your country's needs and do that with full sense of national pride.

Before I end my address, let me once again congratulate the graduating students and award winners on the occasion of the 47th Annual Conference of Jadavpur University. I wish you all success in your professional careers and sincerely hope you will keep the flag of your Alma Mater flying high wherever you go.

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