AMERICAN NUCLEAR SOCIETY

2011 MISSION TO INDIA

10/30/2011

Dear ANS Members:

The ANS Mission trip was formed as follow-on to President Harold McFarlane's 2007 trip and to continue India-U.S. nuclear cooperation. This ANS Delegation toured three nuclear facilities on Tuesday, September 27; Wednesday, September 28; and Saturday, October 1; and had numerous press engagements throughout the trip.

What follows in this report are the details, teachings, and contacts made during our journey, so that you, as fellow ANS members, are informed and can use this as a guide if you choose to perform collaborative technical work in the near term. The report is relatively short, only four pages; however, the pages refer the reader to specific appendices for the details.

This report highlights the findings and conclusions while the appendices articulate recommendations of the Mission team. ANS's role in supporting this nuclear collaboration is key. The Obama Administration's continued support of this Bush initiative shows bipartisan support rare in America, especially with respect to nuclear projects. I see enormous opportunity for the great democracies of the world (oldest and largest) to open up their nuclear markets, to each other.

The Mission team was made up of a diverse cross section of our Society's membership and are detailed in Appendix A of this report. I thank them all for supporting this Mission. An extra "thank you" goes to Dr. Corey McDaniel, a U.S. expatriate living in Mumbai who organized the trip and has a firm grasp on the issues regarding U.S. companies doing work in the emerging market of India.

I would also like to especially thank Ben Holtzman for his efforts in drafting and coordinating input on this report.

Sincerely,

Eric P. Loewen, Ph.D.
President
American Nuclear Society

Why go to India?
Why go to India? It's a fair question. We went to India because the ANS believes that the U.S. has a stake in India's success and nuclear energy is a key to that success. Why did we take our members who came from academia, the government, and industry to the other side of the world? They were invited with so that they too could experience first-hand how India develops nuclear energy to not only provide safe, clean, and affordable electricity to a population and economy; not only to see how nuclear technology is being utilized for everything from water desalination to medical isotope production; but to meet the people leading these programs. During our time in India we were able to gain access to a broad cross section of leaders in the Indian nuclear field and made numerous new professional friends as we exchanged ideas and developed contacts for the future.

This was the second ANS mission to India. The first occurred in 2007 and was led by then ANS President Harold McFarlane. That mission as well as this one were supported by the U.S. embassy, in Delhi, and the consulate, in Mumbai. The delegation toured research facilities at Indira Gandhi Centre for Atomic Research (IGCAR) and Bhabha Atomic Research Centre (BARC), manufacturing facilities at Larsen & Toubro (L&T), and had discussions with many of the senior nuclear leaders. The delegation was able to evaluate various aspects of Indian nuclear technology, strengthen the connection between the Indian Nuclear Society and American Nuclear Society, and improve the opportunities for U.S. businesses.

Overview of Mission Itinerary
The mission began with a press conference on Monday, September 26, in Mumbai where we held a press conference announcing that the American Nuclear Society had brought a delegation to India and that the ANS as well as many American companies would be attending the Nuclear Energy Safety Summit and Expo later in the week at the Bombay Exhibition Centre. The news of the conference and 'Framework on Nuclear Education Co-operation' even made the Times of India, the world's largest English-language circulated newspaper in the world! The article and additional press is attached along with other press contacts in Appendix F.

Tuesday, we boarded a plane and flew across the country to Chennai where we then drove 80 kilometers south to Kalpakkam so that we could tour IGCAR. On site, we were able to tour the operating Fast Breeder Test Reactor (FBTR). The FBTR has been operating safety without incident for over 20 years. FBTR uses a unique mixed plutonium-uranium carbide fuel that has safely reached a burnup of 155 GWD/MTU (165 GWD/MTU in a sub-assembly) without fuel failure (See Appendix C for additional information on IGCAR). After being wowed at IGCAR, we had dinner with the leading IGCAR scientists back at our hotel.

Wednesday, was another early morning flight across India. This time we headed back to Mumbai to tour the manufacturing facilities at Larsen & Toubro (L&T) where we learned the nuclear capabilities of India. This was one of the many highlights of the trip as we were able to tour not only the L&T campus but also their manufacturing shop that produces the sodium-water steam generators being supplied for the Prototype Fast

Breeder Reactor. The attendees could see, feel, and understand not only L&T's but India's deep commitment to the advancement of nuclear science and technology (See Appendix D for more information on L&T). After which, it was back to the hotel for a dinner with the delegation members and key Indian personnel.

Thursday, was the Department of Atomic Energy (DAE) Summit with a keynote address by Dr. Srikumar Banerjee, the Chairman of the DAE (See Appendix C for more information on the DAE). The message from the all the presenters was that we are all in this together as technologists, let's work together to make a brighter future for tomorrow. In fact, ANS President Eric Loewen was quoted as saying, "The global platforms provided by the Summit, the Expo, and related events provide a wonderful forum for sharing perspectives on deploying nuclear technologies to benefit our respective countries and our shared world." The day also consisted of a lunch with the U.S. Ambassador Peter Burleigh in the U.S. Pavilion and many interviews with the Indian press. The day concluded at the summit with an exhibitor's dinner at the expo.

Friday, began with the ANS India Section Annual Meeting at the U.S. Pavilion before the start of the Indo-U.S. Nuclear Energy Safety Summit, where American companies touted their impressive reactor designs and special guest Dr. R.K. Sinha, Director of the Bhabha Atomic Research Centre, gave a presentation on India's own water cooled reactor, the Advanced Heavy Water Reactor (AHWR). The conference agenda is attached in Appendix D with details on all the presenters and their presentation titles. In the evening, we departed the exhibition center for dinner with the U.S. Ambassador and Consulate General at the U.S. Consulate in downtown Mumbai (See Appendix G for invitation and U.S. government contacts). At the dinner, ANS President Eric Loewen conferred the ANS Presidential Citation to Dr. Anil Kakodkar, former Chairman of the Atomic Energy Commission and Secretary of the Department of Atomic Energy, for his critical leadership role in successfully negotiating the Indo-U.S. civil nuclear agreement.

Saturday, commenced at the Indian Institute of Technology, Bombay, where the ANS India Section hosted a Framework for Indo-U.S. Nuclear Education Cooperation at the Victor Menezes Convention Centre. Numerous talks were given to students and professors from more than a dozen Indian and American universities consisting of how the nuclear engineering academic and research programs in India and the U.S. operated as well as possible ways for collaboration. While existing avenues for collaboration already exist through presenting research at ANS national meetings using the current infrastructure, these talks focused on how collaboration between the universities themselves could be improved. Ideas ranged from summer study abroad programs to get students across the ocean and having them do research outside of their non-nuclear class to formal programs where a student would do two years of their program at a university in America and two years at a university in India (See Appendix E for additional information on research collaboration). Immediately after, we headed over the Bhabha Atomic Research Centre (BARC) where we met with the heads of the center and received another impressive tour that included hot cells and a demonstration of how they vitrify waste – using a surrogate material (More information on BARC and contact information can be found in Appendix C). An interesting side note is that the mangos that were

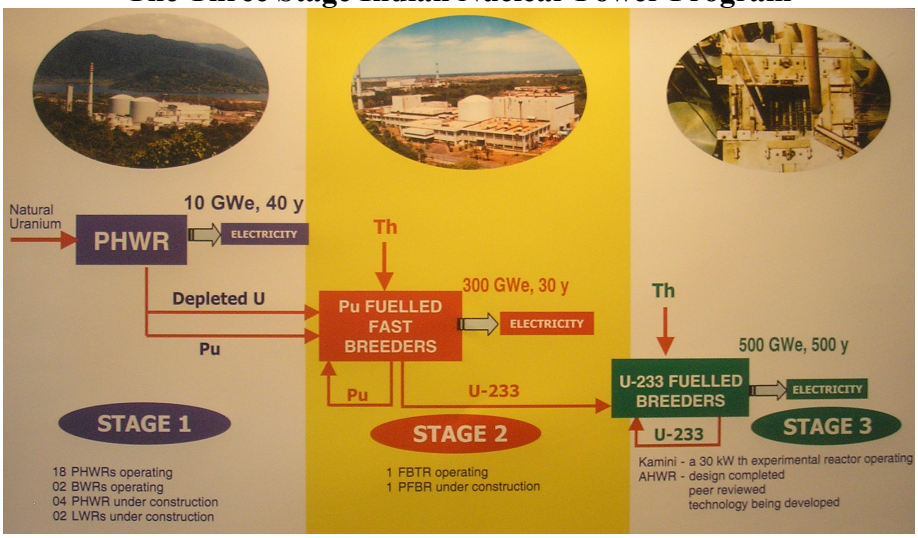
discussed by then President George W. Bush when he visited India were irradiated at BARC. Finally, we concluded the day and the mission with a dinner at the McDaniel residence before flying home.

Basics of the Indian Nuclear Energy Plan

The most impressive aspect of the Indian domestic nuclear program is that it has remained true to the vision first laid out over 50 years ago by Dr. Homi Bhabha, considered the father of atomic energy in India. Such consistency in implementation would be unheard of in America, and yet in India the political leadership has supported the plan over five decades regardless of political affiliation! While it is unfortunate that our democracy cannot follow our plans, it is a testimony to India's determination that they have stuck to their plan for so long.

Dr. Bhabha's plan consists of three stages and will result in India being self sufficient in the fields of nuclear science and technology, and engineering. This self reliance and energy independence will allow India to grow its economy and raise the standard of living for its people. The plan believes in adopting a closed fuel cycle in order to extract the maximum energy from the limited uranium resources and to provide long-term energy security by utilizing the country's vast resources of thorium. Each successive stage of the Indian three stage plan will only be attained after building a strong foundation in the previous stage.

The Three Stage Indian Nuclear Power Program



The first stage of the plan is to use natural uranium in Pressurized Heavy Water Reactors (PHWR) to generate electricity, depleted uranium, and plutonium. The latter two being used as fuel material along with thorium for the fast breeder reactors that will generate electricity, more plutonium, and U-233 in the plutonium fueled fast breeder reactors of the second stage as well as develop associated recycling technologies. The plutonium would be refabricated into fuel for other second stage fast reactors, while the U-233 will be used in the third stage of reactors. The third stage uses U-233 and thorium to power U-233 fueled breeder reactors. These reactors generate additional U-233 for further use in

third stage reactors as well as electricity. The plan is for all reactor stages, fuel fabrication, pyroprocessing, and waste treatment to be located at the same site to limit the amount of transport required.

The largest consequence of the Indian isolation is that the world probably underestimates their determination and dismisses their plans as fool-hardy or overly ambitious, however, India should not be underestimated. India has a great long-term vision for their nuclear program and the Indian nuclear industry can confidently look many years into the future.

India is expected to invest $100 billion in its nuclear energy sector over the next 20 years. The India perspective was best stated by Dr. Bhabha himself when he remarked that, "No power is costlier than no power." Dr. Bhabha realized that a lack of electricity would cost India far more in the long-term than any development program would ever cost up front – especially when complete energy independence lay at the end. It is important to note that India will move forward with their three stage plan regardless of any U.S. concerns about proliferation risks. It is very important to the Indians that they continue with closing the fuel cycle to fully utilize their resources, provide nuclear sustainability, and credible waste management.

In spite of many decades of isolation, the Indian scientists and engineers have gained an impressive amount of experience in their indigenous technology as well as confidence in themselves. The program is considered to be part of the pride of India by everyone that we talked to and the Indians will continue to press forward (See Appendix B for more on the Indian Nuclear Future).

Points to Consider

Overall, the ANS mission to India was beneficial and enlightening. India is definitely a place where ANS members can and should be pursing nuclear science and technology activities as there remains great potential for two great democracies to work together. That is not to say that there are not barriers remaining for U.S. companies; however, these need to be worked out on a government level and are beyond the scope of this report.

At the birth of the Indian nuclear industry, the Indians only had enthusiasm and the will to press forward. Today, the will and enthusiasm remains, and they are joined by pride and experience. The Indian nuclear program is something worth having pride over, not only for the technology but for the fact that they did almost all of it through training their own people and developing the some very impressive technology.

U.S. Secretary of Energy, Dr. Steven Chu said it best, "our choice is clear…develop these technologies today or import them tomorrow." India is fast on its way to become the world leader in nuclear technology. They are going to move forward in accomplishing their goals; they are not going to wait. Will we?

APPENDIX A: Delegate Roster

Dr. Eric Loewen
American Nuclear Society (ANS), President
GE-Hitachi Nuclear Energy (GEH), Chief Consulting Engineer

Dr. Loewen supports GEH's Advanced Reactor and Advanced Recycling Center, which couples electrometallurgical processing and the PRISM sodium cooled reactor. His current work involves leading GEH's efforts to deploy the integral fast reactor (PRISM - a small modular reactor [SMR]) that will recycle spent nuclear fuel from their current fleet of light water reactors and also eliminate weapon grade material. Dr. Loewen received both his masters and Ph.D in Nuclear Engineering and Engineering Physics, respectively, from the University of Wisconsin-Madison after completing several years of service in the United States Navy. He also received his two BA degrees in Chemistry and Math from Western State College. Dr. Loewen also served as a Consulting Engineer for the Idaho National Laboratory and served as an advisor to a U.S. Senator as the 2006 ANS Congressional Fellow.

Prof. Sukesh Aghara
Prairie View A&M University (PVAMU), Chemical Engineering (Nuclear), Associate Professor
NSF Center for Energy and Environmental Sustainability, Director

Dr. Sukesh Aghara is in the Department of Chemical Engineering (Nuclear) at PVAMU, a member of the Texas A&M University System. He is the PI/Director of the $1 million per year, 5 year, NSF CREST Center for Energy and Environmental Sustainability. In addition he is the leader for radiation transport group with NASA Center for Radiation Engineering and Science for Space Exploration (CRESSE). He served as a NASA Administrator's Fellow for 1 year at NASA Langley Research Center (LaRC). Previously he has been a visiting scientist with Nuclear Science and Technology Division at Oak Ridge National Laboratory. His expertise includes radiation shielding analysis and experimental design, applications of nuclear analytical techniques, nuclear energy and nuclear security. Dr. Aghara earned a Masters in Environmental Engineering from Vanderbilt University. He received his Masters and Ph.D. in Nuclear Engineering from the University of Texas at Austin (UT). He serves on the board of the Nuclear Power Institute (NPI), a multi-agency (university/industry/utilities) consortium focused on the development of the nuclear workforce of the future.

Prof. Sama Bilbao y León
American Nuclear Society, Board of Directors, International Committe
Virginia Commonwealth University (VCU), Nuclear Engineering Programs, Director

Sama became an Associate Professor in the Department of Mechanical and Nuclear Engineering at VCU in January 2011. She was one of the key individuals involved in the creation of the Dominion-sponsored Master in Nuclear Engineering offered by VCU from the fall of 2007. Until December 2010, Sama was the Technical Head of the International Atomic Energy Agency (IAEA) Water Cooled Reactors Technology Development Unit. From February 2001 until March 2008, Sama was a Nuclear Safety Analysis Engineer at Dominion Generation. Sama earned the ANS Public Communications Award in 2002, and in 2007 she received the NA-YGN Founder Award, the highest award given to an NA-YGN member. Sama holds a bachelor's degree in Mechanical Engineering and a master's degree in Energy Technologies from the Polytechnic University of Madrid; a master's degree and a PhD in Nuclear Engineering and Engineering Physics from the University of Wisconsin – Madison; and an MBA from Averett University.

Thomas Bergman
U.S. Nuclear Regulatory Commission, Division of Engineering, Office of New Reactors, Director

Mr. Bergman has more than 20 years of experience with the U.S. Nuclear Regulatory Commission. He is the NRC's senior management lead for bilateral relations with India. Previously, he was Deputy Director for Licensing Operations in the Division of New Reactor Licensing, a position he held since the Office of New Reactors was formed in 2006. His other NRC experience includes the Office of the Executive Director for Operations, Office of Nuclear Regulatory Research, Region III, and Office of Nuclear Reactor Regulation. Prior to joining the NRC in 1990, Mr. Bergman worked for ARINC Research Corporation, and for the Naval Nuclear Propulsion Directorate in the U.S. Navy. He has a Bachelor of Science Degree in Aerospace Engineering from the University of Michigan and a Master of Business Administration from the University of Maryland.

David Blee
U.S. Nuclear Infrastructure Council (NIC), Executive Director

The U.S. NIC is a national coalition of more than 40 member companies for policy, business and public education issues affecting nuclear materials transporters, suppliers and customers. Mr. Blee's public service includes appointments as Principal Deputy Assistant Secretary of Energy and Director of Public Affairs for the U.S. Department of Energy – and as Chief of Staff to former U.S. Senator Connie Mack, during his service in the U.S. House of Representatives. His private sector experience includes assignments as Executive Vice President for Marketing and Business Development and Group Executive Vice President for Worldwide Consulting for NAC International, an Atlanta-headquartered energy services company. Prior to joining NAC, he served as a principal in several leading strategic communications firms, including Robinson, Lake, Lerer & Montgomery and Franklin, Blee & Burling.

Robert Cleveland
Rosemount Nuclear Instruments, Asia Pacific Manager

Robert Cleveland has 10+ years of experience in the field of nuclear power marketing Rosemount Nuclear safety-related pressure transmitters worldwide. He has managed Rosemount's nuclear business in Asia Pacific since 2003. Rosemount Nuclear Instruments, Inc. is a division of Emerson Process Management which is dedicated to the design, manufacture and distribution of safety related pressure measurement instrumentation for the worldwide nuclear power industry. Robert has a Bachelor of Arts Degree from Lenoir-Rhyne University. He has recently participated in business management courses at St. Thomas University.

Prof. Yousry Y. Azmy
Nuclear Engineering Department Heads Organization (NEDHO), Chairman
North Carolina State University, Department Head, Professor of Nuclear Engineering

Prof. Azmy is lead PI of development activities for the renowned neutral particle transport code TORT, his expertise includes implementation of neutron transport and diffusion methods on multiprocessing computers, and the development of parallel performance models. He previously taught at Penn State University and served as a research scientist at the Oak Ridge National Laboratory. Prof. Azmy received both his masters and Ph.D. in Nuclear Engineering from the University of Illinois, and earned his bachelors of science in Nuclear Engineering from the University of Alexandria, Egypt.

Benjamin Holtzman
Westinghouse Electric Company, Nuclear Fuel Rod Design Engineer

Ben is currently responsible for ensuring the fuel integrity throughout life for all reactor types serviced with Westinghouse. Ben has been a part of the nuclear industry for 5 years and has previously worked at Knolls Atomic Power Laboratory, GE-Hitachi, and Sargent & Lundy. Ben earned his B.S. and M.S. in Nuclear, Plasma, and Radiological Engineering at the University of Illinois. Ben first joined the American Nuclear Society as a student and has had numerous roles ranging from Student Section President to Marketing Chair for the 2009 Young Professionals Congress. Currently, Ben is most prominently serving the ANS as Presidential Executive Assistant to ANS President Dr. Eric Loewen. He is also an executive board member of the ANS Young Members Group, serves on the Professional Development Coordination Committee, is a member of ANS Standard 53.1 and is the Finance Chair for the 2011 Young Professionals Congress.

Mark W. Marano
Areva USA, Senior Vice President, New Plant Build Operations - USA

Mark Marano was appointed to his current position on January 1, 2010. His previous position was Senior Vice President New Plants Business Development for AREVA NP INC. upon his initial hire in March 2009. Marano has also served as Senior Vice President Marketing at GE Hitachi Nuclear Energy. In this position he was responsible for all inorganic and organic growth initiatives for the global nuclear business, including mergers & acquisitions, strategic partnerships, alliances, joint ventures and dispositions. Other positions held include Vice President Uranium Business Unit at (GE) Global Nuclear Fuels, Vice President, Financial Planning at AEP Service Corporation and Vice President of Business Services for both the fossil and nuclear generation fleet at AEP Generation. Prior to joining AEP, Marano worked at Florida Power Corporation, (Crystal River Nuclear Plant), Carolina Power and Light's (Brunswick Nuclear Plant), PSEG's (Hope Creek and Salem Nuclear Stations) and as a Pricing Analyst and Industrial Engineer for several New York state companies, including a large defense contractor (Grumman Aerospace). Marano earned a Bachelor of Science degree in business administration from State University of New York, College of Oswego, and is completing his MBA from the New York Institute of Technology, Old Westbury, New York.

Dr. Corey K. McDaniel
American Nuclear Society, India Local Section, President, International Committee, Chairman
NuScale Power, Country Manager for India
McDaniel Technical Associates Inc., Chairman/Managing Director

Corey McDaniel represents NuScale Power in Mumbai. Dr. McDaniel has over 20 years of experience as a manager and advisor on nuclear technology, business and policy issues. Before moving to India he spent five years as the senior advisor to three United States Senators advising on energy and environmental policies on seven Senate Committees. Corey previously served as a managing director of an energy development company, as the senior technical associate at an energy and environment consulting practice, and as a nuclear safety scientist at the Los Alamos National Laboratory. Corey earned his Ph.D. in Environmental Science and Public Policy from George Mason University, and his M.S. and B.S. degrees in Nuclear Engineering from the University of New Mexico and Purdue University respectively. Corey first joined the American Nuclear Society (ANS) as a student in 1989.

Shikha Prasad
American Nuclear Society, Local Section Committee, Executive Committee
University of Michigan, Department of Nuclear Engineering, Doctoral Candidate

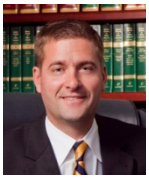
Shikha Prasad is a University of Michigan Barbour Scholar. She is the President of the Teach for India Chapter at the University of Michigan. She has served the American Nuclear Society for over five years in various capacities and is presently a member of the executive committee of the ANS Local Section Committee. In the past she has worked for General Atomics, Hitachi-GE Japan, Bhabha Atomic Research Center, Oak Ridge National Laboratories and ERIN Engineering and Research Inc.

Dr. Atam S. Rao
American Nuclear Society, International Committee
ALTRAN, Principal Consultant Global Nuclear

Dr. Rao is a recognized leader, innovator and effective proponent of complex issues, having traveled to over 40 countries, having many international contacts, and speaking several languages. Most recently he spent 5 years at the International Atomic Energy Agency, Vienna, Austria as the Head Nuclear Power Technology Development. Previously he had a 31-year distinguished career at GE in the Nuclear Power Industry. Atam has organized several very large international projects and activities, and has worked extensively with industry, government regulators and different organizations. Dr. Rao earned his PhD and MS degrees in Mechanical Engineering from the University of California, Berkeley, and his bachelor's degree in mechanical engineering from the Indian Institute of Technology, Kanpur, India. Atam is an ASME Fellow and has received the ASME George Westinghouse Gold Medal and the Distinguished Alumni Award, IIT, Kanpur – West Coast Chapter.

Ed Wolbert
Transco Products, President
U.S. Department of Commerce's Civil Nuclear Trade Advisory Committee (CINTAC), Chairman

Transco Products Inc., is a leading U.S. medium-sized manufacturer and contractor dedicated to nuclear power. Mr. Wolbert has been in the nuclear power industry for over 30 years, has been with Transco for the last 26 years, and has served as its president for the last 14 years. Mr. Wolbert oversees the daily strategic direction and tactical operations of the company, including direct guidance of its foreign activities. Mr. Wolbert is a member of the American Nuclear Society, and is also a member of ASTM (serving on the C16 committee). Mr. Wolbert was also recently appointed to serve on the NIST/MEP National Board of Advisors for a three year term.



Matthew J. Dryden
AREVA USA, Vice President, Business Development – Strategic Initiatives

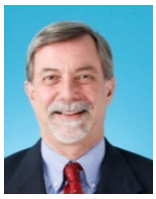
Matt Dryden is responsible for strategically positioning and providing linkage to AREVA's entire North American Operations portfolio offering by actively engaging and aligning interests within both new and exisitng customer bases, governmental policy and financial communities. Previously, Matt served as Vice President of Marketing and Commerical Operations for GE-Hitachi Nuclear Energy and spent the first 16 year of his career at American Electric Power. Matt holds an Associate's Degree in Nuclear Power from Terra Technical University, a Bachelors Degree in Business Administration from Siena Heights University and a Masters Degree in Business Administration from Indiana University.

Dr. Vijay K. Sazawal
USEC, Director of Government Programs

Dr. Sazawal has over 35 years of professional experience in the nuclear industry covering the entire fuel cycle. USEC, Inc., is a leading supplier of enriched uranium fuel for commercial nuclear power plants worldwide. Dr. Sazawal is a member of the U.S. Department of Commerce's Civil Nuclear Trade Advisory Committee (CINTAC). Prior to joining USEC Inc., Dr. Sazawal worked at COGEMA Inc. (now Areva NC) for 7 years where his last position was the Vice President of Engineering and Technology. Dr. Sazawal completed his doctoral degree in structural mechanics in 1975 and immediately joined Westinghouse Electric Corporation in the Advanced Reactors Division, his tenure in Westinghouse lasted 20 years. Dr. Sazawal holds a Bachelor's degree in Mechanical Engineering from the Banaras Hindu University (India), M.Tech. in Materials Engineering from the MA College of Technology, Bhopal (India), and Ph.D. in Structural Mechanics from the Michigan Technological University. Dr. Sazawal played an active role as a subject matter expert (SME) in the U.S.-India civil nuclear agreement.

Shailesh R. Sheth
GE Hitachi Nuclear Energy (GEH), Vice President of India Strategy

Shailesh leads a matrix 30-person GEH team in the execution of commercial negotiations and early project planning activities with NPCIL and has overall responsibility for the planning and implementation of GEH's business strategy in India. From March 2008 and until he assumed his current role in October 2010, Shailesh was the Vice President of Global Marketing for GEH's New Plants business with responsibility for the formulation and execution of GEH's New Plants business and marketing strategy globally in collaboration with the New Plants product line. Shailesh has a B. Tech. in Chemical Engineering (Ch. E.) from The Indian Institute of Technology (IIT), Mumbai, India, Master's (Ch. E.) from the State University of New York in Buffalo and a Ph.D. (Ch. E.) from the University of Illinois at Urbana-Champaign. He is a GE-certified Six Sigma Black Belt. Shailesh was born and raised in Mumbai, India and lives in Wilmington, North Carolina with his wife, Trupti, their 4-year old son, Sohum and his mother, Beena Sheth.



Gary T. Urquhart
Westinghouse Electric, Vice President and MD for the India, SE Asia and Taiwan region

Mr. Urquhart is responsible for all business activities within the region including business development and project delivery. He is located in the Westinghouse Asia Regional headquarters in Tokyo. He started his career in the nuclear power industry nearly 40 years ago with Babcock & Wilcox and moved to Westinghouse in 2002. He has diverse engineering experience in nuclear primary component design and manufacturing, quality assurance, remote inspection and service equipment design and field services. Besides his technical experience he has had business development, sales and project management leadership responsibility for nuclear services and fuel including an assignment at BNFL's Sellafield MOX plant. He relocated to Tokyo in 2007 and assumed his current position in 2010. Mr. Urquhart has a BS in Mechanical Engineering from the State University of New York at Buffalo and an MBA from Lynchburg (Virginia) College. He is a licensed registered engineer in Virginia, USA.

APPENDIX B: The Indian Nuclear Future

India remains firmly committed to its indigenous nuclear program and is planning a major expansion of nuclear installed capacity to 20,000 MWe by 2020, with further planned growth to reach approximately 60,000 MWe during the early 2030s. By 2050, India hopes to attain 25% of their total power demand through nuclear power. India has devised a fully integrated energy policy and realizes that in the long term, only nuclear will be able to meet the country's energy demands.

The Indian installed nuclear power capacity is currently 4,780 MWe from a total of 20 operating reactors (18 PHWRS and 2 BWRs), giving India the sixth most nuclear power reactors in operation. The Indian nuclear power industry has registered over 345 reactor years of safe operation.

The heavy water reactor was primarily chosen because it requires little to no uranium enrichment, maximizing the use of India's limited uranium resources. India drew upon the heavy water experience of the Canadians and of the French for fast reactors. In many ways, they now appear to be the leaders in both of these technologies.

India is entirely self-sufficient in nuclear technology with respect to their PWHRs and fast reactors; however, they have no one to exchange ideas with due to their being a non-signer of the Nuclear Non-Proliferation Treaty. As such, the Indian government, through the DAE, has been forced to support and actively fund the development of India's nuclear technologies and industrial capacities. The result of this has been the creation of many Indian innovations by homegrown scientists, engineers, and technicians who cannot share their progress with the world.

It is true that now India has gained access to the international uranium market, however, they by no means plan on altering from their course rather they view this as an opportunity to diversify their light water reactor holdings. India is very interested in having foreign vendors build light water reactors in the near future to increase their electricity production while their closed fuel cycle matures. There is currently construction being done on two 1,000 MWe VVERs at Kudankulam that are being set up in technical cooperation with Russia; in addition, to the six 700 MWe PWHRs and one 500 MWe PFBR that the Indian are building on their own. Additionally, AREVA is already present in India. Other nations are obviously already positioning themselves to benefit from the growth of the India nuclear complex, the fear that undertoned our visit was the US would not benefit as much.

No matter how many light water reactors are built, the Indians realize that uranium is fundamentally finite and it is only a question of when it runs out. They deem it foolish to use only a small fraction of the available energy when it's possible to extract nearly all the energy, which is only possible using the fast reactors and reprocessing technology in the latter stages of the Indian nuclear plan.

The development of the Advanced Heavy Water Reactor (AHWR) is fundamental to the success of the final stage of India's three stage fuel cycle plan. It will utilize metallic thorium fuel and heavy water for a moderator. The Indians plan to convert from carbide fuel, in their fast reactors, to oxide fuel - to take advantage of the worldwide experience with oxide fuel – before eventually converting to metal fuel for its faster doubling time. The AHWR incorporates the lessons learned and experience from the PWHRs in the first stage while adding passive safety features. It is also being looked at to produce hydrogen and do water desalination in addition to electricity generation. India wants to be the first country to extract electricity from a thorium powered reactor. There could be a possible opportunity for cooperation on fast reactors and thorium reactors.

The closed fuel cycle is considered the best way to handle long-term disposal. The Indians have a separate 3-stage plan for waste disposal: immobilization, interim storage, deep disposal. The PUREX process is currently used for separating the uranium and plutonium before vitrifying the remaining spent fuel; however, the Indians are continuing their research into pyroprocessing and they noted that there would be a transition to it in the future.

APPENDIX C: Government Support

Department of Atomic Energy
The DAE is a government run entity that comprises of research and development institutions (such as BARC and IGCAR), regulatory boards and organizations [such as the Atomic Energy Regulatory Board and the Nuclear Power Corporation of India Limited (NPCIL)], universities (such as the Homi Bhabha National Institute) and numerous other entities. It reports directly under the Prime Minister of India and is responsible for nuclear technology, nuclear power, and research.

Indira Gandhi Centre for Atomic Research (IGCAR)
IGCAR was established in 1971 under the DAE. The center was chartered to pursue a broad based multidisciplinary program aimed at scientific research and advanced reactor engineering with a focus on the development of fast reactor technology. Their vision, "To be a Global Leader in Sodium cooled fast breeder reactors and associated Fuel Cycle Technologies by 2020," seems almost assured.

The current operating fast reactor (FBTR) uses a mixed plutonium-uranium carbide fuel but the plan is to utilize oxide fuel before switching to metallic fuel in commercial fast reactors for the higher rate of plutonium and U-233 production that is required for the latter stages of the Indian Nuclear Plan. The Indians have done extensive research into how to have their fuel achieve higher burnups, it has already reached over 155 GWD/MTU without fuel failure, as part of a directive to reduce the quantity of fuel required. While we were able to tour the FBTR, we were unable to see the nearly complete 500 MWe Prototype Fast Breeder Reactor or the KAMINI reactor. The KAMINI reactor is an advanced test reactor and the only operating reactor in the world that uses U-233, in an Al alloy, as its fuel.

India assigns an equal emphasis to non-power applications of nuclear energy. A message that our ANS President took to heart when he had his heart scanned on site via magnetocardiography (MCG), which is a technique to measure the magnetic fields produced by the electrical activity of the heart. IGCAR is researching additional applications in health care as well as applications in agriculture and water desalination. One such example is the nuclear desalination plant at Kalpakkam with a capacity of 6.3 ML per day and is currently the largest nuclear desalination unit in the world.

One opportunity for collaboration with IGCAR would be for the ANS to get the Fukushima radiation dispersal data to their Atmospheric and Ocean Dispersal Modeling group, for them to compare against their model. The group is part of the safety readiness program for India and they help create escape routes in case of accidents so the evacuees can safety move without getting dose.

Bhabha Atomic Research Center (BARC)
BARC does a wide spectrum of scientific and technological research that extend from basic research to full plant level operations covering everything from accelerators, supercomputers, radioisotopes, and lasers. Its core mandate is to provide research and

development support required to sustain nuclear power generation in India covering everything from the conceptual design of the program, the creation of computer models and their validation against simulated reactor conditions, structural and nuclear fuel material selection and testing, and risk analysis.

This mandate has never been changed since BARC's inception in 1945. BARC also works on the development of the storage and disposal of spent nuclear fuel as well as human resource development through partnerships with universities and the BARC Training School (created in 1957). There are 19 groups that cover 94 divisions and employ ~4200 scientists and engineers.

BARC is also home to the DHRUVA reactor, which is a heavy water as moderator and coolant. Its maximum power is 100MWt and it contains unique features such as water turbines, uses light-water as shielding and reflectors. It is used as an experimental neutron physics facility.

Visit of delegation from American Nuclear Society on 27 September, 2011 (Tuesday)

Time (hrs)	Programme	Remarks/ Coordinated by
	Details of arrival awaited	
11.45	Meeting with Director, IGCAR	Director's Room, Entry permit
12.00	Meeting with Group Directors Presentation on "Fast Reactor Programme at IGCAR" by Director, IGCAR	Green Room, High Tea Group Directors & Dr.Sai Baba to join
13.15	Lunch at HBB IV Floor *(Mamalla Catering)*	Group Directors & Dr. Sai Baba to join
	Visits	
14.15	Fast Breeder Test Reactor	Shri G.Srinivasan
14.45	Hot Cells and NDE Lab	Dr. T. Jayakumar
15.15	Fuel Coolant Interaction Studies in Nuclear and Safety Engineering Group	Dr.P.Chellapandi/ Shri B.K. Nashine
16.00	Atmospheric Dispersion and sodium aerosol studies in Reactor Engineering Group	Dr.B.Venkatraman
16.30	Accelerators and Magnetoencephalography programme in Materials Science Group	Dr. C.S. Sundar/ Shri M.C. Valsakumar
17.15	Departure to GRT	
20.00	Dinner at GRT Radisson Temple Bay Hosted by Director, IGCAR	Senior colleagues to join
	Details of departure awaited	

Details of the delegation

1.Dr.Eric Paul Loewen	Chief Nuclear Engineer, GE, Hitachi
2.Prof.Sukesh Aghara	Associate Professor(academia)
3.Prof.Yousry Youssef Azmy	Professor & Head, Department of Nuclear Engineering, North Carolina State University
4.Dr.Thomas Arthur Bergman	Federal Government (US Nuclear Regulatory Commission), Management
5.Prof.Rosa Marina (Sama) Bilbao y Leon	Associate Professor, Director, Nuclear Engineering Programmes, Virginia Commonwealth University
6.Dr.Benjamin Asher Holtzman	Nuclear Fuel Rod Design Engineer, Westinghouse
7.Dr.Atambir Singh Rao	Engineer
8. Ms. Shikha Prasad	Doctoral Student

Department of Atomic Energy
Government of India

Dr. P.R. Vasudeva Rao
Director, Chemistry Group
Indira Gandhi Centre for Atomic Research
Kalpakkam - 603 102, Tamil Nadu, India

Tel 044-2748 0229 / 0222 (O)
044-2748 1279 (R)
Fax 044-2748 0222 / 0065

Email: vasu@igcar.gov.in
dcg@igcar.gov.in
prvasudeva.rao@gmail.com

Dr. T. Jayakumar

Government of India
Department of Atomic Energy

Director, Metallurgy and Materials Group &
Head, Non Destructive Evaluation Division
Indira Gandhi Centre for Atomic Research
Kalpakkam 603 102, Tamil Nadu, India

Phone: +91 44 2748 0107 / 2748 0232
Residence: +91 44 2748 1333 / 2748 7740
Fax: +91 44 2748 0075 / 2748 0356
E-mail: tjk@igcar.gov.in

Govt. of India

Dept. of Atomic Energy

K.K. Rajan
Outstanding Scientist
Director
Fast Reactor Technology Group
Indira Gandhi Centre for Atomic Research
Kalpakkam 603 102 Tamil Nadu India

Phone: 91-44-27480083 (O)
Res: 91-44-27481098/27488002 ®
Fax:91-44-27480311

e-mail: kkrajan@igcar.gov.in
Mobile: 94445 67011

Government of India

Dept. of Atomic Energy

G. SRINIVASAN
Director
Reactor Operation and Maintenance Group
Fast Breeder Test Reactor, IGCAR, Kalpakkam - 603102

Residence :
14, 1st Street, Township,
Kalpakkam, - 603 102.
Ph : 044 - 27487458

Office :
Ph : 044 - 27480358
Fax : 044 - 27480336
Mail : gsv@igcar.gov.in

Department of Atomic Energy
Indira Gandhi Centre for Atomic Research

Kalpakkam - 603 102
Tamilnadu, India

M.C. Valsakumar
Head, Materials Physics Division
Materials Science Group

Phone : (Off) +91-44-27480014
Fax : +91-44-27480081
E-mail : valsa@igcar.gov.in
mc.valsakumar@gmail.com

(Res) : +91-44-27481388/27488279
Mobile : 9445441388
http://msg.igcar.gov.in/mpd

Dr. Ramakrishnan BASKARAN
Scientist - G
Radiological Safety Division
Indira Gandhi Centre for Atomic Research
Kalpakkam -603 102, Tamil Nadu, INDIA

Phone : 3301 (Intercom) **Fax :0091-44-27480235**
0091-44-27480062 **E-mail :** rb@igcar.gov.in

Phone :044 27480090(O)
:044 27480109(O)
:044 27481218(R)

Fax : 044 27480228
Telefax : 044 27480210
E-Mail : *satya@igcar.gov.in*

S.A.V. SATYA MURTY
Outstanding Scientist and Director
Electronics & Instrumentation Group

INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH
Department of Atomic Energy, Government of India
Kalpakkam 603102, T.N, India

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY

Indira Gandhi Centre for Atomic Research Kalpakkam - 603 102.

K.V SURESH KUMAR
HEAD, REACTOR OPERATION DIVISION & REACTOR SUPERINTENDENT
FAST BREEDER TEST REACTOR

Off :
Ph : 044-27480351
Fax : 044-27480336
E-mail : kvsuresh@igcar.gov.in

Res:
17, Bhairavi, Anupuram
Kalpakkam - 603 109
Ph : 044 - 27482201
Cell : 94436 39607

Jojo Joseph
Head, P.I.E. Division

Government of India
Department of Atomic Energy

Metallurgy and Materials Group
Indira Gandhi Centre for Atomic Research
Kalpakkam 603102 Tamil Nadu, India

Phone 91-044-27480500 extn. 26464
Fax 91-44-27480356 / 27480208
E-mail jojo@igcar.gov.in

B.K. NASHINE, M.E.,
SCIENTIFIC OFFICER - G
Head, Electrical Design & Services Section
FAST REACTOR TECHNOLOGY GROUP
Govt. of India, Department of Atomic Energy
Indira Gandhi Centre for Atomic Research
Kalpakkam - 603 102. Tamil Nadu, India.

Phone : 044 - 27480311 (Off), 27488059 (Res)
Fax : 044 - 27480311, e-mail : bknash@igcar.gov.in
Intercom : 21050 (O) 84184 (R)

Government of India

Dept. of Atomic Energy

B. ANANDAPADMANABAN
Indira Gandhi Centre for Atomic Research
Kalpakkam - 603 102.

Head
Reactor Maintenance Division
ROMG

&

Head
Quality Assurance Division
RSEG

Phone : 044-27495133, 27480091
Fax : 044-27480336
Phone (R) : 27487398, E-mail : bap@igcar.gov.in

Phone : 044-27480071
Fax : 044-27480209

Resi. : 9, 3rd Street, Kalpakkam - 603 102. Mobile : 9443881190

Ratan Kumar Sinha, FNAE, D Sc(hc)
Director, BARC &
Member, Atomic Energy Commission

BHABHA ATOMIC RESEARCH CENTRE
Trombay, Mumbai 400 085, India
E-Mail : rksinha@barc.gov.in
director@barc.gov.in
Tel. : (91-22) 2550 5300
: (91-22) 2551 1910
Fax : (91-22) 2550 5151
: (91-22) 2559 2107

Dr. N RAMAMOORTHY
Senior Advisor to Director, BARC

GOVERNMENT OF INDIA
BHABHA ATOMIC RESEARCH CENTRE
Trombay, Mumbai 400 085, India
Tel. : (91-22) 2559 2300
Fax : (91-22) 2550 5151
(91-22) 2551 9613
E-Mail : nrama@barc.gov.in

S.D. MISRA
Director, Nuclear Recycle Group

Government of India
Deptt. of Atomic Energy
BHABHA ATOMIC RESEARCH CENTRE
Trombay, Mumbai 400 085, India.
Tel. Off : +91-22-2550 5185
+91-22-2559 3652
Fax. : +91-22-2550 5185
+91-22-2551 5151
E-Mail : sdm@barc.gov.in

C. A. Kakodkar
Ass. Reactor Superintendent
Dhruva,
Reactor Operation Division
B.A.R.C
2559465

APPENDIX D: Supporting a Nuclear Industry

Summit and Expo

The Indian Nuclear Energy (INE) Summit is India's largest nuclear exposition and ran from September 29 through October 1st at the Bombay Exposition Centre in Goregaon, Mumbai. The INE 2011 Summit provided a common platform to address the nuclear liability issues, the regulatory issues, and safety issues and concerns. U.S. companies showcased their achievements and capabilities. Such chances for so many pivotal figures to meet and learn from each other in a single location are quite rare. Dr. Srikumar Banerjee, Chairman of the Atomic Energy Commission, delivered the keynote address at the summit.

The goal of the mission, summit, pavilion, and education outreach activities are to promote cooperation between nuclear professionals of our two countries. These activities even drew the attention of the higher echelons of the U.S. government. The Hindustan Times reported on October 9th that U.S. Secretary of State Hillary Clinton mentioned the summit as an event "where you saw a host of top-tier American companies working to expand our private engagement and investment in the civil nuclear sector."

A U.S. Nuclear Infrastructure Pavilion at the India Nuclear Exposition, certified by the U.S. Department of Commerce, featured many U.S. corporations and the Indo-American Chamber of Commerce. Its purpose at the exposition was to work towards the extension of the U.S. supply chain globally into India. The U.S. has the gold standard in quality and safety, and by assisting the development of India's infrastructure, India can safety continue to grow their economy into the future as well as increase collaboration with American companies.

The ANS participants left the India Nuclear Energy 2011 Exhibition and Conference with the impression that the Indian nuclear industry is potentially a great partner for U.S. organizations serving the nuclear industry.

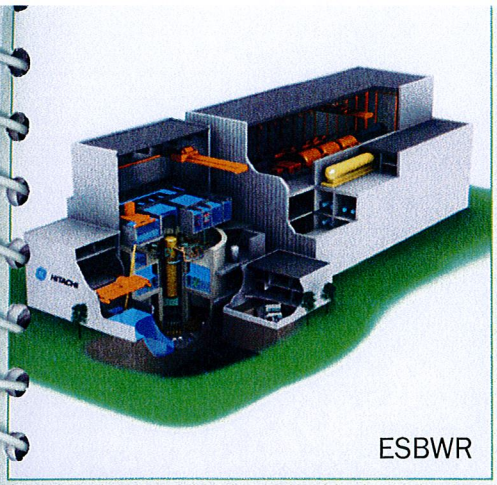
Larsen & Toubro

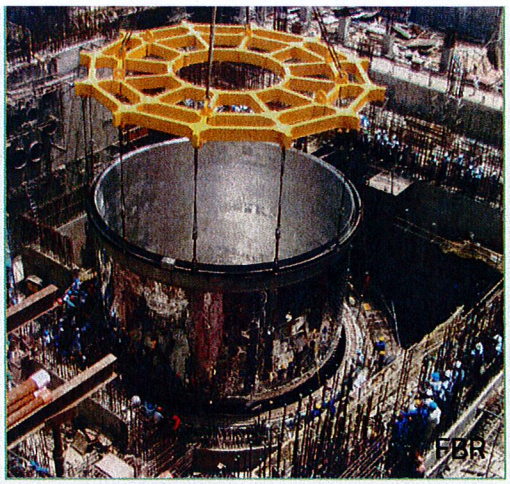
Larsen & Toubro is an $8.5 billion technology, manufacturing, engineering and construction organization who does it all. They are a "One Stop Shop Solution" for nuclear with expertise covering nuclear piping & equipment packaging, reactor services, steam generators, calandria, end shields, heat exchangers, precision machining, and nuclear power plant electronics.

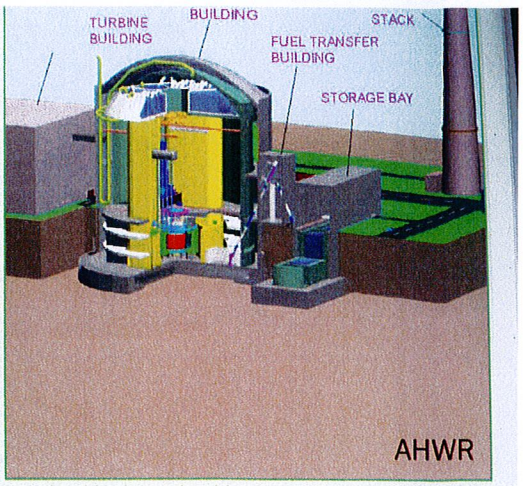
Through its participation in the various projects of the Indian nuclear history, L&T has emerged as a total solution provider with unmatched experience in nuclear infrastructure. They are already exporting into the U.S.

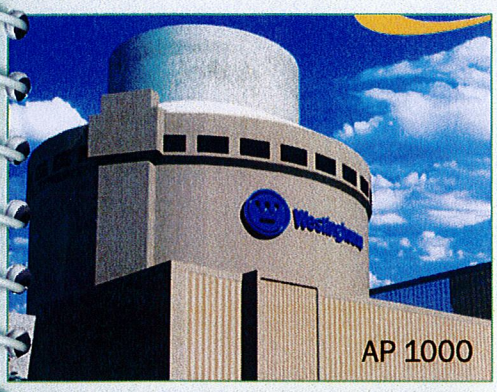
On February 15, 2011, L&T becomes first company in India to ship dry shielded canisters for spent fuel transportation and storage to the U.S. and Europe. The canisters

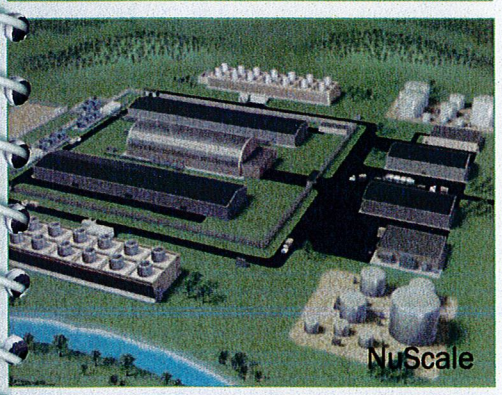
were manufactured in accordance to the U.S. Code of Federal Regulations 10 CFR and nuclear safety class 1 standards.

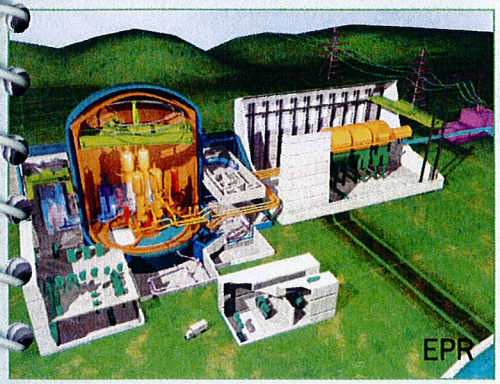


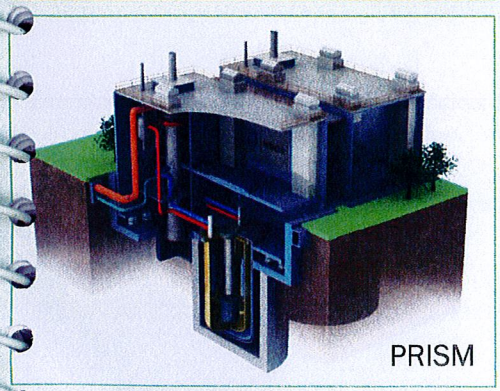












Working Together for a Safer, Cleaner, Affordable Energy Future

INDO-U.S. Nuclear Energy Safety Summit 2011

30 SEPTEMBER 2011, BEC, MUMBAI

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CONFERENCE AGENDA

Working Together for a Safer, Cleaner, Affordable Energy Future

FRIDAY, 30 SEPTEMBER 2011, BOMBAY EXHIBITION CENTRE, GOREGAON, MUMBAI

PRE-PROGRAM

900-930 hrs	Registration of Summit Delegates
	ANS India Section – Annual Meeting (members only – join here: http://local.ans.org/india/joinus.html)

PROGRAM STRUCTURE

0930-1220 hrs – SAFETY ADVANTAGES OF INDIA'S NEXT GENERATION OF NUCLEAR REACTORS

India plans for nuclear power to provide 63 gigawatts of emission-free electricity by 2032, and by 2050 nuclear power could meet as much as 25% of India's growing energy demands. With 20 reactors in operation and 6 under construction, India looks towards the future construction of indigenous and foreign next generation reactors that utilize advanced safety technologies. Leading technical experts will discuss the safety advantages of these Generation III+ reactors and their prospects for India.

Moderated by **Mr. Thomas Bergman**, U.S. Nuclear Regulatory Commission

930-950	Faster Breeder Reactor (FBR)	**Dr. Eric Loewen (confirmed)** President, American Nuclear Society Chief Consulting Engineer, GE-Hitachi Nuclear Energy
950-1020	Address by Chief Guest: Advanced Heavy Water Reactor (AHWR)	**Dr. R.K. Sinha (confirmed)** Vice-President, Indian Nuclear Society Director, Bhabha Atomic Research Centre
1020-1050	AP-1000 Pressurized Light Water Reactor (PWR)	**Mr. Gary T. Urquhart (confirmed)** Westinghouse Electric, Vice President and MD for the India, SE Asia and Taiwan Region
1050-1120	ESBWR Boiling Light Water Reactor (BWR)	**Dr. Shailesh Sheth (confirmed)** Vice-President India Strategy, GE Hitachi Nuclear Energy
1120-1150	NuScale Small Modular Light Water Reactor (SMR)	**Dr. Corey McDaniel (confirmed)** Country Manager for India, NuScale Power
1150-1220	EPR Pressurized Light Water Reactor (PWR)	**Mr. Mark Marano (confirmed)** Senior-Vice President, U.S. New Build Operations, Areva
1220-1250	*Tea and snacks*	

Indo-U.S. Summit Dedication Ceremony - U.S. Nuclear Infrastructure Council Pavilion

1245-1330	**Keynote Session - IMPORTANCE OF INDO-U.S. CIVIL NUCLEAR ENERGY SAFETY COOPERATION**	
Moderated by **Dr. Eric Loewen**, President, American Nuclear Society		
1250-1255	Introduction by Honored Guest	**Ambassador Peter Burleigh (confirmed)** Charge d' Affaires, U.S. Embassy New Delhi
1255-1315	Address by Honored Speaker	**Dr. S.K. Malhotra (confirmed)** Joint Secretary, Indian Nuclear Society Head, Public Awareness, Department of Atomic Energy
1315-1335	Address by Keynote Speaker	**Mr. Geoffrey Pyatt (confirmed)** Principal Deputy Assistant Secretary, South and Central Asian Affairs Bureau, U.S. Department of State
1335-1415	*Lunch*	
Dedication of U.S. Nuclear Infrastructure Council Pavilion		
1415-1645 hrs - INDO-U.S. CIVIL NUCLEAR REGULATORY AND COMMERCIAL OPPORTUNITIES TO COLLABORATE FOR A SAFER NUCLEAR FUTURE		
Moderated by **Mr. David Blee,** Executive Director, U.S. Nuclear Infrastructure Council (confirmed)		
1415-1435	Remarks by Guest of Honour Essentials of an Effective Nuclear Regulatory Infrastructure	**Mr. Thomas Bergman (confirmed)** Director, Division of Engineering, Office of New Reactors, U.S. Nuclear Regulatory Commission
1435-1450	Remarks by Guest of Honour Commercial Opportunities and Challenges for Civil Nuclear Energy Trade and Export with India	**Ms. Judy Reinke (confirmed)** Senior Commercial Officer, U.S. Embassy New Delhi U.S. Department of Commerce
1450-1510	Recommendations of the U.S. Department of Commerce Civil Nuclear Trade Advisory Committee (CINTAC) on Improving Export Control Procedures with India	**Mr. Ed Wolbert (confirmed)** President/CEO, Transco Products Chairman, CINTAC
1510-1525	Assuring Public Safety at the American Centrifuge Plant	**Dr. Vijay K. Sazawal (confirmed)** Director of Govt. Programs, United States Enrichment Corp Member, CINTAC
1525-1540	Nuclear Safety Through Quality Assurance Practices For Manufacturing of Nuclear Components	**Mr. Robert Cleveland (confirmed)** Asia Pacific Manager, Rosemont Nuclear

INDO-U.S. Nuclear Energy Safety Summit 2011

CONFERENCE AGENDA

1540-1555	Nuclear Energy Technologies – Holtec Asia's Solutions for a Safer Emerging World	**Dr. Jyoti Chatterjee (confirmed)** President, Holtec Asia
1555-1610	Framework for Indo-U.S. Nuclear Education Cooperation on Nuclear Safety Research & Development Preview of Symposium at IIT-Bombay 1 Oct 2011 from 10:00-13:00	**Prof. Yousry Azmy (confirmed)** North Carolina State University Chairman, Nuclear Engineering Dept Heads Organization **Prof. Sukesh Aghara (confirmed)** Prairie View A&M University **Ms. Shikha Prasad (confirmed)** Nuclear Engr. Ph.D. Candidate, University of Michigan
1610-1640	Enhancing Global Technical Exchange between India and the U.S. Through INS-ANS Cooperation	**Prof. Sama Bilbao y Leon (confirmed)** Virginia Commonwealth University, formerly IAEA **Dr. Atam Rao (confirmed)** Altran, formerly IAEA
1640-1730	*Tea and snacks*	
Networking at the U.S. Nuclear Infrastructure Council Pavilion		
1900-2200 hrs	**"Commemorating the Third Anniversary of the Indo-U.S. Civil Nuclear Agreement"**	
Invitation-only speakers and sponsors dinner hosted at the U.S. Consulate Mumbai by **Ambassador Peter Burleigh** to witness **Dr. Eric Loewen** presenting the ANS Presidential Citation to **Dr. Anil Kakodkar.**		

**Conference Structure/Topics are subject to changes to best suit the objectives of the Conference*

LARSEN & TOUBRO LIMITED

Anil V. Parab
Vice President
Nuclear Power Plant Equipment Business

Heavy Engineering Division
Powai Campus,
Saki Vihar Road,
Mumbai - 400 072, INDIA.

Tel. : +91-22-6705 2431
Mobile : +91-99209 27718
Fax : +91-22-6705 1611
Email : anil.parab@hed.ltindia.com

L&T Heavy Engineering

Amit Kumar
Manager - Marketing
(International)
Nuclear Power Equipment

Larsen & Toubro Limited
G4 Bldg, 1st Floor, Gate No. 1,
Powai Campus, Saki Vihar Road,
Mumbai - 400 072, INDIA

Tel : +91 22 6705 4922
Fax : +91 22 6705 1611
Mobile : +91 98195 60100
Email : a.kumar@hed.Ltindia.com
Website : www.lnthed.com

L&T Heavy Engineering

Rit DESAI
Manager - Marketing (International)
Nuclear Power Equipment

Larsen & Toubro Limited
G4 Bldg, 1st Floor, Gate No. 1,
Powai Campus, Saki Vihar Road,
Mumbai - 400 072, INDIA

Tel : +91 22 6705 4146
Fax : +91 22 6705 1611
Email : rit.desai@hed.Ltindia.com
Website : www.lnthed.com

NuScale Power

Corey K. McDaniel, PhD PE
Country Manager - India

NuScale Power, Inc.
1000 NE Circle Drive
Building 10, Suite 302
Corvallis, OR 97330
+001 (202) 669-3429
www.nuscalepower.com

201/202 Quantum Park 'A' Wing
Union Park Road, Khar (West)
Bandra, Mumbai 400 052
+91 (98) 2104 9735
cmcdaniel@nuscalepower.com

Mobile: 9820387792

G. D. MITTAL
Treasurer
Indian Nuclear Society

Project Square, Anushaktinagar, Mumbai - 400 094.
E-mail: gdmittal@gmail.com

Westinghouse

Dr. Alok Mishra
Deputy Director
India Regulatory & Licensing Project

Westinghouse Electric Company
Nuclear Power Plants
Unit No. 402, Building Sigma
Hiranandani Gardens,
Powai, Mumbai 400076 India
Phone: +91-22-401-56040
Fax: +91-22-401-56043
Cell: +91-773-836-9765
Email: mishraa@westinghouse.com
www.westinghousenuclear.com

RELTECH Consulting Private Limited

Janaki Devi Kompella
Principal Consultant & Managing Director

714, Raikar Chambers
K.D. Road
Govandi (E)
Mumbai - 400 088, India

Telefax: +91 22 2557 7859 / 6671 9976
Mobile: +91 99309 74622 / 93222 74622
Email: devi.kompella@gmail.com
Web: www.reltechconsulting.co.in

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APPENDIX E: Growing The Future

Framework for Indo-U.S. Nuclear Education Cooperation
The symposium first discussed the status of nuclear engineering education programs in both the U.S. and India as well as their research programs before breaking into small panel discussions focusing primarily on research.

In India, students are jointly selected with the DAE and are guaranteed employment with the DAE upon graduation. Even before graduation, the students are heavily influenced by the DAE as the research areas that universities pursue are based on the problems faced by the Indian nuclear industry, which is essentially run by the DAE.

Academia is a prime area for collaboration between the U.S. and India. Students could be sent back and forth between universities in both countries. India has excellent labs, test reactors, and experience through their indigenous nuclear program specializing in fast reactors, the thorium fuel cycle, and waste isolation. A possibility for the Indians to benefit from American facilities, without traveling to the U.S., could be in Indian universities using the internet research reactor, e-PULSTAR, which is a virtual version of reactor data, control and readout systems. There are existing examples of both international and domestic students already using e-PULSTAR. More information about e-PULSTAR can be found in the slides attached in this appendix.

Existing Collaboration with Fermilab
Throughout this report, we discuss some of the possibilities for future collaboration with our Indian colleagues. Many of you likely have many concerns about the viability of such a partnership. To help ameliorate these worries, we would like to show a case study, with Fermilab. In fact, numerous students have received their doctorates through Indian Institutions and Fermilab collaborations.

Fermilab and Indian Institutions have been collaborating on high energy physics experiments since 1985. While the researchers at Fermilab are most interested in the results pertaining to particle physics, the Indian researchers have been developing technical capabilities for their nuclear energy, physics and material science research programs. Additionally, a memorandum of understanding was signed on January 9, 2006, to further extend this collaboration into accelerator and detector technologies.

AMERICAN NUCLEAR SOCIETY INDIA SECTION

In Association with the

DEPARTMENT OF MECHANICAL ENGINEERING IIT BOMBAY

Presents a Symposium On

"Framework for Indo-US Nuclear Education Cooperation"

Victor Menezes Convention Centre, IIT Bombay

9:00 AM - 01:00 PM, October 01, 2011

As a part of the **Indo-US Nuclear Energy Safety Summit 2011,** a half day symposium on **"Framework for Indo-US Nuclear Education Cooperation"** will be held on **October 1st, 2011** at IIT Bombay. The objectives of the symposium are to address the possibilities of collaborations in the academic and research spheres between the universities in the two countries and to provide a platform to the industrial partners to better engage with the academic counterparts to evolve research programs that will benefit the industrial community.

Programme

09.00 - 09:30	**Registration**	
09:30 - 09:35	**Introduction to the Symposium:** Dr. Alok Mishra	
09:35 - 09:40	**Welcome Address:** Prof. Rangan Banerjee, Dean R&D	
09:40 -10:00	**Current status of Nuclear Engineering Academic Program & Research in India:** Prof. Kannan Iyer	
10:00 - 10:20	**Current status of Nuclear Engineering Academic Program & Research in USA :** Prof. Yousry Y. Azmy	
10:20 - 10:40	**Tea Break**	
10:40 - 11:25	**Panel Discussion-I: Indo-US Academic Exchange: Scopes and Possibilities**	
	India	USA
	Prof. Prabhat Munshi (Co-Chair) Prof. Shriram Paranjape Prof. Amitava Gupta	Prof. Sama Bilbao y Leon (Co-Chair) Prof. Yousry Y. Azmy Prof. Sukesh Aghara
11:25 - 12:10	**Panel Discussion-II: Indo-US Bilateral Academic Research Program: Expanding the Horizon**	
	India	USA
	Prof. Kannan Iyer (Co-Chair) Mr. S.F. Vohra Prof . T. Sundararajan	Prof. Sukesh Aghara (Co-Chair) Ms. Shika Prasad Dr. Eric Loewen, President ANS
12:10 - 12:55	**Panel Discussion-III: Breaking the Barriers Between Education, Research and Technology** Session Chairman: Prof. J.B. Joshi, Homi Bhabha Distinguished Chair Professor and J.C. Bose National Fellow	
	India	USA
	Prof. Manmohan Pandey Prof. Prabhat Munshi Mr. S.F. Vohra	Dr. Eric Loewen, President ANS Prof. Sama Bilbao y Leon Dr. Corey Macdaniel
12:55 - 13:00	**Vote of Thanks:** Dr. Alok Mishra	

Current Status of Nuclear Engineering Academic Programs & Research in USA

Yousry Y. Azmy
Chair of Nuclear Engineering Department Heads Organization (NEDHO), ANS
AND
Professor & Head
Department of Nuclear Engineering
North Carolina State University

0. Outline

1. **Historical Synopsis**
2. **US Nuclear Education System**
3. **Recent Trends**

1. Evolution of Nuclear Engineering Education in the US

1. The Beginnings – 1950 & 60's

- **Nuclear Engineering programs as "focus area" within other engineering disciplines:**
  - Mechanical Engineering
  - Chemical Engineering
  - Physics
- **Oak Ridge's Reactor School:**
  - Broad training & education program for professionals
  - Instructed by many of the *Fathers* of nuclear education in US
- **Birth of several graduate programs in Nuclear Eng (NE)**
- **Nuclear power buildup ⇨ rapidly rising HR demand:**
  - Development of Undergraduate (UG) NE curricula
  - Many NE BS-granting programs/departments open
  - First *generation* of nuclear engineers join workforce
- ***Golden age* of nuclear Power & NE education in US**

1. The Middle Ages – 1970 & 80's

- **Early 1970s:**
  - Continued growth of nuclear power: Oil embargo of 1973
  - NE programs flourish with strong governmental & industrial support
  - UG programs serve essential function as pipeline of Grad students
- **1979 – Three Mile Island accident:**
  - Mishandling of communications following the accident
  - Loss of public trust ⇨ nuclear power reactor orders cancelled
- **1980s:**
  - Nuclear industry self-reforms ⇨ today's exemplary performance
  - Declining enrolments in both UG & Grad NE programs
  - Oil glut in mid 80s ⇨ cheap oil ⇨ interest in nuclear power declines
- **1986 – Chernobyl accident:**
  - Nuclear power all but dead!

1. The Dark Ages – 1990s

- **Nuclear power growth halted: HR needs sharply decrease**
- **Declining governmental support of NE education:**
  - End of the Cold War
  - Rising nuclear proliferation concerns
- **The *sufferings* of NE programs:**
  - Enrolments sharply decline especially among US students
  - NE graduates redirect career into non-nuclear employment
  - Several NE Departments shutdown or absorbed into other Engineering Departments: Deconstruction!
  - Many university research reactors shutdown & decommissioned
- **Doom & gloom prevails at NE academia in spite of:**
  - Exemplary performance record of nuclear power industry
  - Vastly improved economics of nuclear power
  - Recognized risk of US' heavy reliance on oil's geopolitics

1. Rising from the Ashes – 2000s

- **Starting in late 90s: Environmental concerns**
  - Acid rain from coal burning: costly treatment of emissions
  - Greenhouse effect: search for non-carbon-emitting energy sources
- **Agents of change in US:**
  - Nuclear power as baseload: 70% of all non-carbon-emitting energy sources @ 20% of total US energy production
  - Growing nuclear power global markets: rapidly growing economies in Far East ⇨ rising demand for cheap energy
  - Oil dependency & rising instabilities in the Middle East
  - 9/11 attacks ⇨ new concerns about nuclear terrorism
- **Turning the tide: A new *Golden Age*?**
  - US government support of NE education reinvigorated: $
  - Opening of several new NE Programs/Departments
- **2011 Fukushima: global repercussions but no immediate effect on enrolments**

2. Overview of US NE Education System

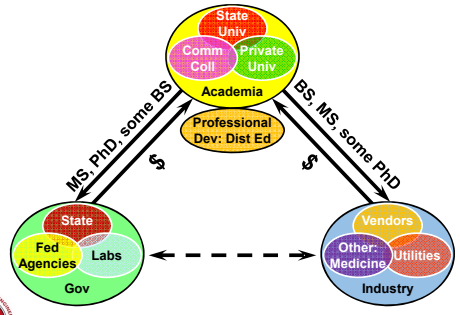
2. General Description

- **Lack of central planning/controlling authority:**
  - True job-market demand drives resource allocations at local level
  - Generally characteristic of American approach intended to:
    - Encourage creativity & innovation
    - Drive competition for improved results
    - Seek non-conforming, diversely-based *wisdom*
- **Government exerts influence via:**
  - Funding incentives: competitive awards or grants
  - Implementing policies & programs to dis/encourage certain results
  - Creating jobs in governmental agencies or industry
- **Cherished characteristics:**
  - Vigorous protection of academic freedom
  - Autonomy: decisions driven by local vision & aspirations
  - Openness: inclusive/welcoming of non-US faculty & Grad students

2. NE Educational Institutions

- **State universities:**
  - UG &/or Grad degrees
  - Typically large universities even if small NE
  - Inexpensive UG education
- **Private universities:**
  - UG &/or Grad degrees
  - Typically smaller universities
  - Typically expensive UG education
- **Community Colleges:**
  - Technical training ⇨ nuclear workforce
  - Feeder of selected students into NE-BS programs

2. Constituencies of Nuclear Enterprise



2. Constituencies Interrelationships

- **State Gov funds Community Colleges & State Universities:**
  - Economic development of populace
  - Attract business & industry to locate within state ⇨ jobs & tax $
- **Federal Government funds Research Universities:**
  - Agencies implement federal initiatives & programs
  - National labs collaborate on mission-oriented research
- **Recent Federal university support:**
  - Nuclear Energy University Program (NEUP):
    - ~$50M/yr: competitive proposals ⇨ DOE's mission & nuclear infrastructure
    - $5M/yr: Scholarships & Fellowships (S&F)
  - Integrated University Program (IUP):
    - DOE, NNSA & NRC $5M/yr each: Scholarships & Fellowships (S&F)
    - NNSA & NRC $10M/yr each: curriculum & faculty development; Comm Col
- **Industry support: S&F, internships, research, grants & equip**

2. Typical Degree Requirements

- **ABET-accredited BS in NE:**
  - ~2 yrs of basic science & math + general engineering courses
  - ~2 yrs NE specific & supportive courses
  - Many electives to broaden experience: humanities, …
  - Senior Design Project: team work, multidisciplinary, communication
  - NE as minor for other engineering disciplines
- **Masters degrees:**
  - Admitted students hold BS in science, math, engineering
  - 6-8 courses at graduate level
  - Time to complete degree in 1.5 to 2.5 years
  - Thesis option – research oriented often precursor to PhD
    - Document research in theses, usually defend to committee
  - Non-thesis option – terminal professional degree
    - Project-based, research not necessary ⇨ predictable timeframe

2. Typical Degree Requirements *(cont)*

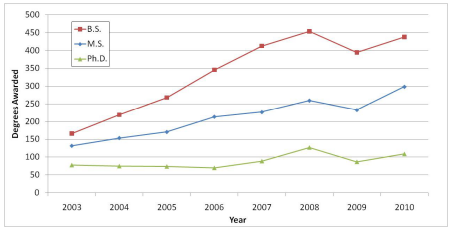
- **Doctorate:**
  - Admitted students hold BS or MS in science, math, engineering
  - MS not required but usually attained by student along the way
  - PhD Qualifying Exam: verify adequacy of student's NE core competency
  - Some programs require additional 6-8 advanced graduate courses
  - Intensive innovative-research oriented degree
    - Research proposal presented to PhD committee for advice & approval
    - Dissertation composed & defended to committee to graduate
  - Time to complete degree: 3-5 years with large variance

3. Recent Trends

3. NE Departments in the US

- ***Source Book*: compilation on NE programs data**
  - Visit https://inlportal.inl.gov/portal/server.pt/community/neup_home/600/press_releases
  - Lists 32 NE programs/departments: UG/Grad/both
  - Lists 438 Faculty (includes adjunct & emeritus)
  - Lists 25 Research Training Reactors
- **Nuclear Engineering Department Heads Organization (NEDHO):**
  - Visit http://www-ners.engin.umich.edu/NEDHO/index.html
  - Coordinate & unify voice of NE academia in addressing US government
  - Factsheets on some US NE programs

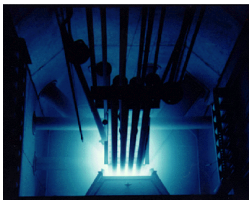
3. NE Degrees Awarder



Indo-US Academic Exchange: Scopes & Possibilities

Yousry Y. Azmy
Chair of Nuclear Engineering Department Heads Organization (NEDHO), ANS
AND
Professor & Head
Department of Nuclear Engineering
North Carolina State University

1. Reactor Labs on the Web



1. University Research Reactors

- **Typical mission of a University Research Reactor:**
  - Teaching: Reactor labs for Undergrad & Grad courses
  - Research: Resource to strengthen proposals & "seed" new ideas
  - Service: Industrial applications for pay
- **~20 remaining in the US with power from few KW to MW**
- **Example: NC State's 1 MW PULSTAR since 1973**
  - Sample teaching experiment: measure moderator temperature & power reactivity coefficients including Doppler feedback
  - Research/Service tools & facilities:
    - Neutron Imaging Facility
    - Neutron Powder Diffractometer
    - Intense Slow Positron Beam
    - Ultra Cold Neutron Source
    - Neutron Activation Laboratory
  - 2010 DOE Infrastructure Award ($1.4 M) to raise power to 2 MW

1. e-PULSTAR: Internet Research Reactor

- **Initial stage:**
  - Virtual version of reactor data: control & readout systems
  - Provide access to virtual data online
  - Students at US NE programs without Research Reactor take classes (reactor labs) over internet
  - Examples: University Tennessee, Georgia Tech
- **Nov 1, 2010, e-PULSTAR goes international:**
  - NE Program, Jordan University of Science and Technology (JUST) connects to PULSTAR
  - Full audiovisual & data communication via internet
  - JUST students remotely use PULSTAR in reactor lab senior-course
  - First use of nuclear reactor in remote instruction across borders
  - Project supported by IAEA & US Department of Energy
  - Arrangement *blessed* by US Nuclear Regulatory Commission & US National Nuclear Security Administration

1. PULSTAR Details

- **Mission:**
  - Enhance, promote, & utilize PULSTAR & facilities in exemplary manner, leading to national recognition
  - Dedicated to research, teaching, and extension
  - Used by UNC faculty & staff, other academics institutions, government & industries in North Carolina & US
- **PULSTAR specs:**
  - H_2O pool type
  - 4% pin-type fuel: UO_2 pellets in zircaloy cladding
  - High fuel : moderator ratio
    - ⇨ high fast leakage at core boundary
    - ⇨ large thermal hump in reflector
    - ⇨ intense thermal neutron beams

1. More on e-PULSTAR

- **Remote participants able to:**
  - Interact with PULSTAR personnel: audiovisual links
  - Direct remote control cameras in the reactor control room
  - View real-time reactor operating data to collect experimental data
- **Examples of laboratories that may be provided include:**
  - Reactor Startup
  - Control Rod Calibration
  - Moderator Temperature Coefficient
  - Power Defect Coefficient
  - Axial Power Density Measurement
- **For more visit** http://www.ne.ncsu.edu/nrp/index.html

2. 2+2 Undergraduate Program

2. Typical 2+2 Arrangement

- **Feeder program concept:**
  - Students complete first 2 years of engineering curriculum at feeder program
  - Transfer to specialty engineering program: earn target degree in 2 years
- **Motivation:**
  - Inexpensive to student & sponsor
  - Reduce relocation "pains" to student: improved retention
    - Smaller classes at typically UG-oriented feeder programs
    - Remain near home (support system) in transition from high-school
  - Diminish admission risk to student: pre-established requirements to qualify for transfer
  - Specialty program focus resources on advanced & grad instruction

2. Variations on the Theme

- **South Carolina State University's BS in NE:**
  - Students finish 7 semesters including basic NE courses at SCSU
  - Last semester at NCSU for advanced NE courses + Design Project
  - NCSU courses transfer back to SCSU that confers BS-NE degree
- **Extension to Graduate Degree:**
  - Newly minted MOU between NCSU & Vidya Pratishthan's COE
  - Negotiated basis for NCSU's Master of Nuclear Engineering (MNE) degree to Indian students ⇨ template for other Indian universities
  - 9 Credit hours (CH) in VP-COE courses: 2 Advanced Engineering & 1 Engineering Math courses
  - 9 CH in NCSU NE courses possibly via Distance Ed: NE Fundamentals; Rad Safety & Shielding; Reactor Systems
  - 9 CH at NCSU: N Materials; Fuel Cycles; Waste Management
  - 3 CH MNE project under supervision by NCSU faculty

INDIAN INSTITUTE OF TECHNOLOGY KANPUR

Dr. Prabhat Munshi
Professor of Mechanical Engineering

Nuclear Engineering and Technology Programme
Indian Institute of Technology
Kanpur -208016INDIA

Tel.: +91-512-2597243, 2597902 (Off) **Fax** :+91-512-2597408
+91-512-2598573 (Res) **e-mail** : pmunshi@iitk.ac.in

Kamran Iqbal
Dept. of Mech. Engg.
IIT Bombay
kiyer@iitb.ac.in

Bhalchandra Puranik
Assistant Professor

भालचंद्र पुराणिक
सहायक प्राध्यापक

Department of Mechanical Engineering
Indian Institute of Technology Bombay
Powai, Mumbai 400 076, India.
Tel :(+91-22) 2576 7536 (O)
2576 8536 (R)
Epabx :(+91-22) 2572 2545,
Extn.: 7536 (O) 8536 (R)
Fax :(+91-22) 2572 6875, 2572 3480
email :puranik@me.iitb.ac.in

यांत्रिकी अभियांत्रिकी विभाग
भारतीय प्रौद्योगिकी संस्थान मुंबई
पवई, मुंबई 400076, भारत

IIT Bombay

Dr. S. R. Bhonsle
+919762636569
drsrbhonsle@gmail.com
Professor – Mech. Eng.
Ex MichTech
LawrenceTech

Prof. S.B. Deosarkar
M.E. (Electronics), Ph.D
Principal

Vidya Pratishthan's
COLLEGE OF ENGINEERING
Vidyanagari, Bhigwan Road,
Baramati - 413 133, Dist. Pune,
Maharashtra, India
Tel. : 02112-239500
Res. : 02112-239292
Fax : 02112-239514

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APPENDIX F: Getting the Word Out

CITY
THE TIMES OF INDIA, MUMBAI
TUESDAY, SEPTEMBER 27, 2011

N-experts to discuss safety

Srinivas Laxman | TNN

Mumbai: The city will play host to one of the largest gatherings of nuclear experts from around the world between September 29 and October 1 at the Bombay Exhibition Centre in Goregaon (E).

Though it is third in the series, it is the first conference to be held after the Fukushima mishap that took place in March this year. The spokesperson of the department of atomic energy, Swapnesh Malhotra, highlighted during a media interaction on Monday, that for the first time, the American Nuclear Society (ANS) will be present at the conference. "We are here to listen and learn," Eric Loewen, president of the ANS said.

This three-day meet will provide a major platform to discuss enhanced safety measures in the international nuclear sector. Speakers from the American state department, the US Embassy in New Delhi, the US Department of Commerce and the US Nuclear Regulatory Commission will be addressing the summit on the mutual benefits of the Indo-US civil nuclear agreement signed on October 8, 2008.

Loewen, who is leading a mission of 20 US N-experts, said that his high powered delegation comprises the academia, the government, and the industry. The team will visit Bhabha Atomic Research Centre in Trombay and the Indira Gandhi Atomic Research Centre in Indore.

THREE-DAY MEET AT GOREGAON

The conference holds relevance for Mumbai because on October 1, IIT-Mumbai and the Indian leg of the ANS will host 'Framework on Nuclear Education Co-operation', where students and professors from more than a dozen Indian and American universities will participate.

The French Trade Commission to India is also participating in the conference.

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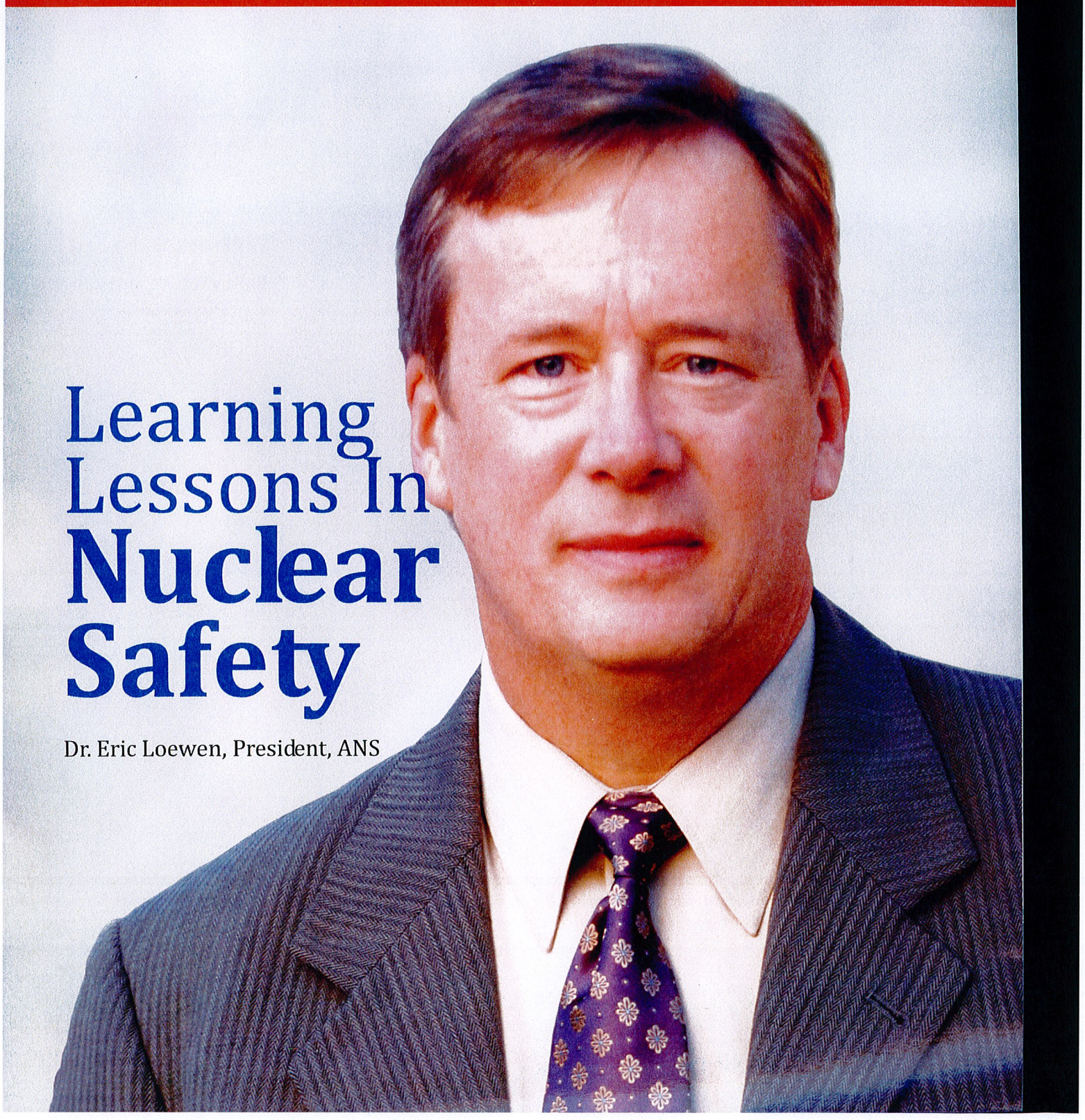

Learning Lessons In Nuclear Safety

Dr. Eric Loewen, President, ANS

APPENDIX G: U.S. Government Support

The Consul General of the United States of America

Peter D. Haas

Requests the pleasure of your company

at a Private Dinner

on Friday, September 30, 2011 at 7 p.m.

To celebrate three years of Civil Nuclear Cooperation between United States of America and India
Dr. Eric Loewen will be conferring the American Nuclear Society Presidential Citation on Dr. Anil Kakodkar

r.s.v.p.
mumbaiprotocol@state.gov
2363-3611 Ext. 4376

Dress: Business
Lincoln House
Bhulabhai Desai Road
Mumbai 400 026

(Please present this card at the gate)

Consulate of the United States of America

Peter D. Haas
Consul General

Lincoln House
78, Bhulabhai Desai Road
Mumbai - 400 026, India

Tel : +91-22-2363-3611
Cell: +91-98-2162-4555
Email: HaasPD@state.gov

Ambassador (Ret.)
A. Peter Burleigh
Chargé d'Affaires a.i.
Embassy of the United States of America

Shantipath
Chanakyapuri, New Delhi 110021

Tel. : 24198000
Fax : 24190017
Email: BurleighAP@State.gov

P Srinivas
Sr. Commercial Specialist

U.S. COMMERCIAL SERVICE
United States of America Department of Commerce

Consulate General of the United States of America
American Center
4 New Marine Lines
Mumbai 400 020, India

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Minister-Counselor for Commercial Affairs

U.S. COMMERCIAL SERVICE
United States of America Department of Commerce

Embassy of the United States of America
The American Center
24 Kasturba Gandhi Marg
New Delhi-110001, India

T 91-11-2347 2000 F 91-11-2331 5172
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Marsha McDaniel
Commercial Officer

U.S. COMMERCIAL SERVICE
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American Center
4 New Marine Lines
Mumbai 400 020, India

T 91 22 2265 2511-2 F 91 22 2262 3850
Marsha.McDaniel@trade.gov

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Anthony S. Ridgeway
Science & Technology Officer
Embassy of the United States of America

Shanti Path
Chanakyapuri
New Delhi-110 021
India

Tel. : (91) 11-2419-8000
Fax : (91) 11-2419-0018
http://newdelhi.usembassy.gov

---

d'Ambrosio EH@state.gov

Eva d'Ambrosio
Vice Consul for Economic Affairs

American Consulate General
78, Bhulabhai Desai Road, Mumbai - 400 026
Tel : 2363-3611 Ext : 4310 Fax : 2363-3437