

Expanding into Research Opportunities: Gulf Nuclear Energy Infrastructure Institute (GNEII) in Year 5*

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ABSTRACT

Abu Dhabi's Khalifa University of Science Technology and Research is partnering with United Arab Emirates and United States nuclear stakeholders to develop and operate a regionally located institute that couples nuclear infrastructure development and regional intellectual capacity building with education in nuclear energy safety, safeguards, and security (3S). Since its inception in 2011, the Gulf Nuclear Energy Infrastructure Institute's (GNEII) mission has been to develop a responsible nuclear energy culture and institutionalize key 3S and nonproliferation norms in the future decision-makers of the Gulf-region nuclear power programs through professional development and education. Khalifa University's implementation is endorsed by the key UAE nuclear stakeholders (the Emirates Nuclear Energy Corporation [ENEC], Federal Authority for Nuclear Regulation [FANR] and Critical Infrastructure and Coastal Protection Authority [CICPA]). U.S. implementers, Sandia National Laboratories and Texas A&M University's Nuclear Security Science and Policy Institute (NSSPI), help develop curricula and provide course instructors. They are supported by two U.S. sponsors, the U.S. Department of Energy's National Nuclear Security Administration Office of Nonproliferation and International Security and the U.S. Department of State's Partnership for Nuclear Security. Together these organizations make up a strategic partnership that has produced 78 graduates over five years and resulted in high-quality education and research opportunities for the Gulf region in nuclear energy infrastructure development and 3S. GNEII's education opportunities provide a more comprehensive understanding of (and novel curriculum for) the interacting technical, operational and political aspects of responsible nuclear energy programs. Similarly, GNEII research opportunities explore such topics as radiation background measurements in urban environments, Monte Carlo detector modeling, integrated 3S methodologies, nuclear infrastructure development, and Gulf/Middle East regional nuclear interactions. The institute's growing research efforts are represented by Fundamentals Course capstone projects, culminating research projects on GNEII-relevant topics and by a professional visiting research scholar. As GNEII grows in size and prestige, its aim is to become a leading institute through which GCC and Middle East voices can be introduced into global nuclear discourse and become a fully self-supporting regional institute by 2017.

INTRODUCTION

Since 2011, the Gulf Nuclear Energy Infrastructure Institute (GNEII) provides a regional mechanism for developing human resources in responsible nuclear energy programs. Combining education and research, GNEII helps increase understanding of nuclear energy infrastructure, including safety, safeguards, and security (3S), among professionals in regional nuclear energy programs. GNEII is affiliated with the Nuclear Engineering Department at Khalifa University of Science, Technology and Research in Abu Dhabi, United Arab Emirates (UAE). [1]

BACKGROUND

GNEII's mission is, through professional development and education of decision makers from Gulf-region nuclear-energy programs, to develop a responsible nuclear-energy culture and institutionalize safety, security and safeguards norms.[1] GNEII constitutes a strategic partnership among several UAE and USA entities. In the UAE, these are the Federal Authority for Nuclear Regulation (FANR), the Emirates Nuclear Energy Corporation (ENEC), the Critical Infrastructure and Coastal Protection Authority (CICPA), and Khalifa University. The partnership also includes support from the US Department of Energy's National Nuclear Security Administration Office of Nonproliferation and International Security and the US Department of State's Partnership for Nuclear Security. Sandia National Laboratories (Sandia) and Texas A&M University's Nuclear Security Science and Policy Institute (NSSPI) are the US implementers working with Khalifa University. By design, as the U.S. financial commitment has decreased over the life of the project, GNEII's UAE partners have shouldered a growing portion of the work. They will assume full responsibility for GNEII operations by 2017 – transitioning the institute from a primarily US-supported initiative, to a UAE-hosted and supported institute.[2,3]

FOUNDATIONAL PILLARS OF GNEII

GNEII is predicated on three “pillars” that describe how the institute will fulfil its mission and reach its vision. These pillars are not intended to be independent, but rather they were designed with the intent for frequent interaction to occur between them. One pillar – **education** – seeks to move beyond traditional, more narrowly focused training and provide a comprehensive understanding of the interacting technical, operational and political aspects of responsible nuclear energy programs.[1,6] The core of this pillar is a novel curriculum designed to identify the independent need for, overarching goal of and benefits of interaction between nuclear energy safety, security and safeguards (3S). Reframing these individual areas of expertise as part of a responsible nuclear energy program, the systems and critical thinking based curriculum emphasizes the need for all aspects of nuclear energy programs to work toward the goal of producing low cost electricity without detriment to people, infrastructure or the environment.

To date, the primary mechanism for delivering this education is the GNEII Fundamentals Course.[4] While options for additional mechanisms (including modular, short or part-time courses) are being explored, the Fundamentals Course has experienced a fair measure of success over its five iterations.[5,6] Though specific to the 2015 offering, the list of topics below captures the breadth of knowledge provided to Fellows of the Fundamentals Course:

- Week #1: Need for nuclear; Critical & Systems Thinking; and Introduction to 3S
- Week #2: Nuclear & Reactor Physics
- Week #3: Nuclear Power Plant Operations & Systems
- Week #4: Nuclear Fuel Cycle & Nonproliferation Policy
- Weeks #5-#6: Nuclear Safeguards
- Weeks #8-#9: Nuclear Security
- Weeks #10-#11: Nuclear Safety
- Weeks #7, #12-#14: Capstone Introduction, Preparation & Presentation

Each topic is introduced in the 3S framework underlying the Fundamentals Course curriculum [4,5] and ends with a reiteration of how the main topical concepts support the goals of

responsible nuclear energy programs. The final requirement of the Fundamentals Course is that Capstone Project which serves as an opportunity to apply the novel education and knowledge learned to a real problem in a practical way (please see the **RESEARCH** for more). Upon completion of the Fundamentals Course, Fellows earn KU/Sandia/TAMU certificate of completion, as well as 20 Continuing Education Units from the Texas A&M Engineering Experiment Station, which can be applied towards Fellows' educational and professional-engineering credentials. As indicated in Table 1 below, the Fundamentals Course has a good participation record that includes a growing number of regional Fellows.

Table 1. Summary of GNEII Fundamentals Course Fellows 2011-2015

Year	# UAE Fellows			# Non-UAE Fellows	Yearly Total	Countries Represented
	ENEC	FANR	CICPA			
2011	4	5	1	0	10	UAE
2012	3	9	2	8	18 (22) ⁱ	UAE, Kuwait, Saudi Arabia, Qatar, Jordan
2013	4	6	3	7	20	UAE, Saudi Arabia, Qatar
2014	6	3	3	0	12	UAE
2015	7	4	5	2	18	UAE, Jordan
TOTAL	24	27	14	17	78	5

ⁱDue to modular structure of the course in 2012 not all international participants were able to finish all required modules because of the travel restrictions.

One of the unique aspects of GNEII's educational paradigm is the encouragement of Fellows from different types of organizations (e.g., regulators, utilities, safety, security) and from different countries (to date, GNEII boasts Emirati, Saudi, Qatari and Jordanian Fellows) to collaborate on Capstone Projects that directly serve to further the development of responsible nuclear energy programs in the Gulf region. With 78 graduates from four regional countries, GNEII's novel, system and critical thinking-based curriculum is already shaping the next generation of 3S professionals.[7]

A second institute pillar – **technical capability** – provides GNEII with opportunities to ground new insights into responsible nuclear energy programs into practical tools or demonstrations. This pillar affords GNEII Fellows chances to participate in practical exercises, hands-on instruction and 'real-life' simulations of scenarios potentially encountered in their roles in regional nuclear power programs. Similarly, GNEII's technical capability supports the growing research pillar (please see the **RESEARCH** section for more) by providing additional pathways by which to generate or conduct institute research. Much of the equipment that comprises this pillar are shared with Khalifa University's nuclear engineering department and includes:

- KU Reactor Analysis & Simulation Laboratory
- KU Environmental Radiation Laboratory
- KU Radiation Science and Safeguards Laboratory
- Scale model of APR1400 reactor vessel

As GNEII's technical capability continues to grow, the increased experience with instruments, simulators, computer codes, and related technical tools used in the nuclear industry will further the institute's position to shape future leaders in the regional nuclear power programs.

RESEARCH: ORIGINS & GROWTH

The third and final pillar upon which GNEII is built is **research**.^[3] Developing this pillar will allow for the thoughts, ideas and talents of regional professionals to be shared with the greater nuclear energy community in a consistent and rigorous manner. The intent for this pillar is to allow GNEII Fellows and other collaborators to examine technical, operational, and political aspects of three envisioned areas of the core research competency. The first area of GNEII's core competency is integrated 3S methodologies, which seeks to build on both initial efforts and international emphasis on how to best leverage the interactions between safety, safeguards and security. GNEII is well positioned to take advantage of the fresh perspectives of 3S methodologies associated with the emerging nuclear energy professional force in the region. GNEII's second area of core competency is nuclear infrastructure development, given its proximity to new nuclear builds and novel models of nuclear energy program development. The third and last area of core competency envisioned for GNEII is Gulf/Middle East regional nuclear interactions. This area of research provides a vehicle to encourage multinational collaboration on and discussions regarding intraregional nuclear energy issues.^[7]

To date, the majority of development on this pillar is associated with the Fundamentals Course Capstone Project. As introduced above, the Capstone Project is the culminating requirement for the GNEII Fundamentals Course in which Fellows conduct a practical research project firmly based on one of the institute's three core competencies.^[3] In addition to serving as a metric for evaluating the ability of Fellows to learn and synthesize the Fundamentals Course curriculum, the Capstone Project serves two objectives. First, it provides Fellows the opportunity to present their research in front of an audience filled with colleagues, managers and experts from regional nuclear energy organizations. Second (and perhaps, more importantly) this project provides each Fellow with an academic accomplishment – something to 'hang their hat on.' Since these projects are often generated by issues or problems faced by their host organizations, Fellows are able to return to their workplaces with potential solutions in hand. Preparation for the Capstone Project includes lectures on research problem framing, analysis methods and organizing thoughts in slides, poster and written form. As indicated above, Fellows were provided several weeks of 'class-time' to complete the synthesis and analysis for their Capstone Projects without direct instruction – and most Fellows put in work outside of normal business hours to ensure successful projects. Up until this year, Fellows produced a research paper and a 30-minute presentation. The GNEII Steering Committee suggested adding a poster requirement for this year's Capstone Project – an addition that was very well received and implemented at the 2015 Symposium.

Table 2. below lists all Capstone Project completed by GNEII Fellows from 2011 to 2015, and the host organizations for the individuals or group members who participated in a given project.

Table 2. List of GNEII Fundamentals Capstone Project Topics, 2011-2015

2011	Integration of Nuclear Safety, Security & Safeguards	CNIA/FANR/ENEC
	Effects of the Environmental on Nuclear Power Plant Operations	FANR/ENEC
2012	SBO Roles and Mitigation Plan	ENEC
	The UAE Export Control Laws	ENEC
	Project Control of NPP Construction	ENEC
	Impact of NPP/Desalination on Gulf	SEC/KISR
	MIMIS on APR1400 Reactor	FANR
	APR1400 Liquid Source Terms	FANR
	UAE Strategy for HLW Management	FANR/CICPA
	Transportation of Fresh Nuclear Fuel	FANR/CICPA
	Radioactive Dose Pathway Modeling	MOD/FANR
	Transparency in Nuclear Security	FANR
	Emergency Preparedness for NPP	FANR
2013	Pyrochemical Reprocessing	ENEC
	A Qualitative Assessment of Fuel Fabrication Options in the UAE	FANR
	The Suitable Mobile Lab for the UAE Condition	FANR
	Emergency Preparedness Plan for Radioactive Material	MOD
	Safety, Security, and Safeguards Challenges for Building a Final Repository for Spent Fuel in the UAE	FANR
	Use of Microfinned Steam Generator Tubes in NPP	MOEW
	The Role of Management Systems in Protecting the Environment from RNEP	ENEC
	Filling the Gaps Between Safety and Security	ENEC/CICPA
	Emergency Preparedness Plan	CICPA/MOE
2014	Survey of the Current Spent Nuclear Fuel Storage Technologies & Assessing Safety Approaches of Existing Systems for Barakah Nuclear Power Plant (BNPP)	ENEC
	Development of Recommendations for the Nuclear Security Culture in the UAE	FANR
	Evaluation of Security and Safeguards Measures for the Transportation Security in the UAE	CICPA
	Evaluation of Safeguards and Security Options for the Dry Cask Storage in the UAE	CICPA/FANR
	Synergy between Safeguards and Security at an NPP	ENEC
	An Initial Radiation Baseline Study of Urban Environment in Abu Dhabi	ENEC
	Effective Enhancements for Integrated Safety and Security Control Systems in BNPP	ENEC
2015	Thermal-hydraulic Studies on Design Extension Condition of Prolong Station Black Out with Additional Failures	EMRC
	Overview of Molten Core – Concrete Interaction (MCCI) and Mitigation Actions	ENEC
	Needs of Atmospheric Dispersion Models in Emergency Situations	CICPA
	Investigation on the Sensitivity of UAE Domestic Agricultural Production to Radiological Contamination Following a Hypothetical Severe Nuclear Accident at Barakah NPP	CICPA/ENEC
	Evaluation of Threats by Drones to a Nuclear Power Plant	CICPA
	Evaluation UAE Security Culture – Insider Threat	FANR
	Operational Security and Information Protection in the Areas of 3S	ENEC
	Analysis of the Safeguards Measures for the Nuclear Fuel Cycle Back-End Options in the UAE	FANR/ENEC
<p>ENEC = Emirates Nuclear Energy Corporation (UAE); FANR = Federal Authority for Nuclear Regulation (UAE); CICPA (formerly CNIA) = Critical Infrastructure & Coastal Protection Authority (UAE); EMRC = Energy & Minerals Regulatory Commission (Jordan); JAEC = Jordan Atomic Energy Agency (Jordan); KISR = Kuwait Institute for Scientific Research (Kuwait); MOE = Ministry of Environment (Qatar); NCPW = National Committee for the Prohibition of Weapons (Qatar); MOD = Ministry of Defense (Saudi Arabia); MOEW = Ministry of Electricity & Water (Saudi Arabia); MOP = Ministry of Petroleum (Saudi Arabia); SEC = Saudi Electric Company (Saudi Arabia)</p> <p style="text-align: right;">*Indicates a successfully presented at a professional conference</p>		

The continual improvement of Fundamentals Course capstone over the years is explained by improvements and clarification in the structure of the Capstone Project itself, as well as increasing standards of quality and GNEII stakeholder expectations. Topics covered in these projects have included both an expanded set of applications and a deeper level of intellectual rigor. These projects are increasingly likely to be accepted into major nuclear energy program-related professional conferences [e.g., 8] – and Fellows will be encouraged to do so to further build up the institute’s research publication library. Further, the Capstone Projects results in good representation across, and intersections between, each of core research competencies established in GNEII’s research framework. Table 3 below illustrates this phenomenon.

Table 3. Categorization of GNEII Capstone Projects by Core Research Competencies

Core Competency Research Area	2011	2012	2013	2014	2015
Integrated 3S methodologies	1	1	4	4	2
Nuclear infrastructure development	0	6	4	4	4
Gulf/Middle East regional nuclear interactions	1	4	3	1	4

iven this strong start to the institute’s research pillar, there are several mechanisms to fuel growth. First, the increasing rigor and novel topics of the Fundamentals Course Capstone Projects will continue to plant seeds for future, more in-depth research supported by the institute. Second, another iteration of the institute Research Fellow position has recently been filled. This individual has the sole responsibility to nurture GNEII’s nascent research endeavors. This work includes preparing ideas identified in Capstone Projects for further research development, generating new ideas for institute research and completing at least one refereed journal and one professional conference paper submission. Third, plans are in place to grow the annual GNEII Symposium in terms of prominence and attendance. Given that the symposium is currently the primarily vehicle for publicizing the ideas, research and conclusions emerging from the institute, expanding its reach and influence is crucial to establishing the research pillar. Growing GNEII into a regional leader in research related to responsible nuclear energy programs will only further establish the value of the institute and is integral to its sustainability plan.

TRANSITION & SUSTAINABILITY

That the three pillars of GNEII are all expanding and growing is part of the strategic plan originated in the February 2011 Memorandum of Understanding signed by Khalifa University, the Nuclear Security Science & Policy Institute/Texas A&M University and Sandia National Laboratories that established 2017 as the year in which operational ownership is transferred from U.S. to UAE stakeholders. Discussions have also commenced regarding extending the cooperation built on the strong relationships between GNEII stakeholder and implementers. These initial talks have centered on the concept of a second Memorandum of Understanding, with activities set to begin in 2017 and hopefully signed in conjunction with the ownership transition ceremony. Whereas the original MOU focused on a structural agreement allowing for US implementers to assist in establishing GNEII [1,2], the emphasis of a second MOU would be framed as peer to peer collaboration between original GNEII implementers. One easily identified area of such collaboration is expanding currently planned joint research projects, pursuant to one of the institutes’ pillars and its mission. Discussions are ongoing to determine

mutually agreeable projects to demonstrate successful research collaboration (in the short term), as well as to serve as the foundation of the follow-up MOU (in the long term).

SUMMARY

Continuing to establish a strong research capability puts GNEII on a firm foundation for future success and sustainability. Building on the growing success and popularity of the Fundamentals Course and developing institute research capabilities in three unique core competencies positions GNEII and its Fellows well to become regional leaders and voices in the ongoing global discourse related to integrated 3S methodologies, nuclear infrastructure development, and Gulf/Middle East regional nuclear interactions. Research will also serve as the backbone for follow-on collaboration efforts between GNEII stakeholders and implementers, illustrating how well the original collaboration was able to help generate a cadre of professionals with whom to join in analysis of timely, complex and stimulating topics. For updates on ongoing GNEII research activities and for contacting the institute for possible research collaboration, please see [9]. As GNEII prepares to become a fully indigenous, self-supporting regional institute by 2017, the institute's various research paths are crucial to developing it into a leading entity through which Gulf and Middle East voices can be introduced into global nuclear discourse.

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