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Partnering between the IAEA Collaboration Center for Human Resource and Nuclear Energy Infrastructure Development & Gulf Nuclear Energy Infrastructure Institute (GNEII)

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Over the course of its operational history, the Gulf Nuclear Energy Infrastructure Institute (GNEII) has aimed to develop a responsible nuclear energy culture and institutionalize key nuclear energy safety, safeguards, and security ('3S') norms in the future decision-makers of the Gulf-region nuclear power programs. Similarly, the International Atomic Energy Agency's (IAEA) Collaboration Center for Human Resource and Nuclear Energy Infrastructure Development—established in 2017—seeks to enhance Member States' capabilities in building and assessing the infrastructure required for a nuclear power programme, as well as developing critical competences required for infrastructure development. The similarities in mission between the two entities provide a fertile ground for a partnership that can enhance the goals of each in a mutually beneficial manner.

Though this partnership is still maturing, there are several areas in which the two entities—GNEII and the Collaboration Center—can leverage the expertise, capabilities, and experiences of the other to enhance the knowledge transfer from the UAE in building its nuclear power infrastructure to other embarking IAEA Member States. Options for partnering range from developing and implementing specific short courses to hosting best practices/lessons learned workshops to designing advanced versions of IAEA Nuclear Energy Management and Nuclear Infrastructure Development Schools. Each of the options within this spectrum are intended to train professionals from Member States in critical areas of nuclear power infrastructure development, such as nuclear safety, security, safeguards, stakeholder involvement, legal and regulatory framework and others.

This paper will briefly introduce the background for both GNEII and the Collaboration Center, as well as introduce how a partnership will support their respective missions for supporting responsible nuclear energy program development. Next, this paper will discuss specific options for how this partnership will manifest. Lastly, this paper will summarize the results of the current state of the partnership, identify implications for upcoming events within the partnership, and discuss the future of the partnership for serving as a regional resource supporting the development and operations of responsible nuclear energy programs.

INTRODUCTION

The late 2000s and early 2010s saw an increased global interest in nuclear energy, primarily driven by a desire for improved living and social standards, energy security, and climate change mitigation. Many of the regions expressing a strong interest in nuclear energy programs—such as the Gulf region—could benefit from improvements in human infrastructure to support such programs. Here, human infrastructure incorporates two key aspects. First, it includes building *national*

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infrastructure development with adequate numbers of individuals available to work in nuclear-energy-related government and industry positions. This population of nuclear professional must be sufficient to ensure that these are *responsible* nuclear energy programs—aligned with international best practices in nuclear energy safety, security, and safeguards. Second, it also includes growing *human resource development* to ensure such individuals have the appropriate level of education, training, experience, and knowledge across a range of topics within nuclear power programs—including safety, security, and safeguards responsibilities.

GNEII: Origins, Objectives, and Operations[1]

The new nuclear energy program in the United Arab Emirates (UAE) demonstrated a need to address the lack of *indigenous* human infrastructure capabilities available to support growing regional interest in nuclear energy.[2] Addressing this gap in nuclear energy human infrastructure development poses two unique challenges. The first is related to limited knowledge and experience in nuclear energy programs existing in Gulf-region states. The second is related to the breadth of safety, security and non-proliferation (or, safeguards) concerns unique to nuclear energy programs. In response, a focus arose to synchronize both technical and non-technical aspects of nuclear energy safety, security and safeguards that balances academic programs with the applied, practical knowledge of hands-on training courses.

The result was the Gulf Nuclear Energy Infrastructure Institute (GNEII—pronounced "*genie*"), housed at Khalifa University of Science and Technology (KU) located in the United Arab Emirates (UAE). From its inception, GNEII aimed to help generate expertise among future leaders of Gulf-region nuclear power programs in global standards, norms and best practices in safety, security and safeguards. GNEII was based on three key design features that have been consistently reiterated throughout the institute's development and implementation:

- ***Regional***, physically located in the Gulf region, hosted by a regional state, and sustained by demand-driven interest from regional professionals interested in nuclear energy;

- ***Educational***, providing a more comprehensive forum to prepare regional nuclear professionals to think, to lead, and to impact their nuclear energy programs[2]; and,

- ***Strategic***, with sustainability through regional financial and operational ownership and acting as a long-term investment for developing responsible nuclear energy programs.

In this manner, GNEII is able to better address the complexity in operating responsible nuclear energy programs as a multidisciplinary human capacity development institute offering education, research and technical services to support responsible nuclear energy programs in the Gulf and Middle East regions.[3]

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[1] This section is a summary of the more in-depth description in the forthcoming [1].
[2] It is important to note that GNEII is not a nuclear engineering degree granting entity. GNEII does, however, plan to develop a way to support the Nuclear Engineering Masters of Science program offered by Khalifa University.
[3] In order to manifest these design principles, GNEII's creation emerged from a strategic partnership of no less than 10 government, non-governmental, and academic entities—including (but not limited to) KU, Emirates Nuclear Energy Corporation, Federal Authority for Nuclear Regulation, Critical Infrastructure and Coastal Protection Authority, Nawah,

To reach these goals, GNEII established a *mission* to "develop a responsible nuclear energy culture and institutionalize key safety, security and nonproliferation norms in the future decision-makers of Gulf-region nuclear energy programs through professional development and training." Similarly, GNEII orients its strategic decision-making toward is *vision* to "provide the Gulf, and surrounding region, with a continual source of indigenous nuclear energy professionals with whom the global community can effectively partner and collaborate to achieve broader nuclear energy security and safety priorities." In support of GNEII's vision and mission, the institute consists of three foundational pillars: education, research and technical services, as shown in Figure 1. These pillars are not intended to be independent, but rather were designed with the intent for frequent interaction. Development and evolution of each pillar has progressed at different rates, but the interdependencies between the three are regularly leveraged to enhance the experience of Fellows at the institute. Taken together, GNEII's primary functional elements – education, research, and technical capability – support the institute's key design features; reflect the institute's mission and vision; and serve the institute's regional relevance and sustainability.

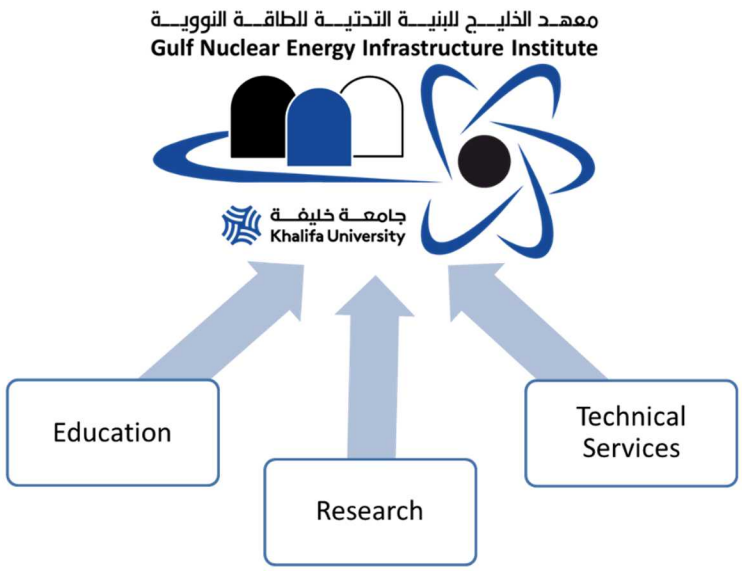

Figure 1. Graphical illustration of GNEII's operational pillars

GNEII's operational history is divided into two phases. Phase I officially began with the signing of the Memorandum of Understanding (MOU) titled *Developing and Operating the Gulf Nuclear Energy Infrastructure Institute* on February 21, 2011. As previously described (e.g., [3][4]), this first phase focused on initiating operations and continual improvement to:

- Expand the strategic operational partnership, regional outreach, and Fellow participation;
- Refine curriculum supporting a novel, integrated 3S framework
- Establish the institute's research framework
- Initiate technical services
- Mature GNEII's Fundamentals Course

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Phase II officially began on April 12, 2016 with the signing of a second MOU entitled *Establishing a Framework for Continuing Collaboration with the Gulf Nuclear Energy Infrastructure Institute*. This new phase focuses GNEII's developmental partners toward collaborating together to achieve the institute's vision and mission.[5] Current efforts supported by this MOU include joint KU/GNEII and SNL research projects (e.g., [6]), aligning operations with IAEA best practices and implementing a multi-faceted sustainability plan.

To date, GNEII has provided a high-performing, well-prepared cadre of early and mid-career professional to support regional nuclear energy programs; increased the quality and sophistication of its research efforts; and, grown into a Gulf and Middle East regional hub for addressing nuclear infrastructure and human capacity development needs.[7] To best summarize GNEII's positive impact on regional nuclear infrastructure and human resource development, consider the Fellow Keynote Address at the 2016 GNEII Symposium offered a comprehensive description of the impact the institute can have on emerging leaders in regional nuclear energy programs, where:

> *GNEII is not just a training course that you add to your CV…It is a very powerful educational tool that changes your perspective from being narrowly…to broadly adopt the sense where all of us are parts of something bigger…It's not you as an operator or me as a regulator or them as a defense force, it is us together, working hand by hand to establish a responsible nuclear energy program that effectively integrate the 3S.*

IAEA Collaboration Center(s)

The IAEA, along similar lines, seeks to improve Member State capabilities to initiate, implement, and sustain responsible nuclear energy programs. One such mechanism are IAEA "collaborating centers," which are any

> IAEA Member State institution, department or laboratory within an institution, designated by the relevant IAEA Deputy Director General (DDG), that on the basis of the IAEA Collaborating Centre Agreement designating such institution, department or laboratory within an institution as an IAEA Collaborating Centre, supports the IAEA's programmatic activities through the implementation of a Work Plan that is agreed with the relevant IAEA Division(s), and included as an annex to the IAEA Collaborating Centre Agreement.

Going above and beyond more traditional training events, collaborating centers are more intensive and comprehensive partnerships between Member States and the IAEA to address specific issue supporting all peaceful uses of nuclear energy and technologies. As legally binding agreements between the IAEA and Member State organizations, collaborating centers are given both great authority and responsibility for enhancing capabilities—and reducing risks—in the agreed upon topical areas. This is reflected in the process for becoming a collaborating center, which includes formal written expression of interest by a Member State, a positive assessment by the IAEA, endorsement of the Member State's IAEA permanent representative, and signature by both the IAEA (usually the Director General for the relevant topical area) and the Member State organizations.

According to the IAEA's Collaborating Center Reference Guide [8], collaborating center activities can included (but are not limited to):

- development and application of technology related to any of the IAEA's Programmes;
- provision of analytical services, such as reference products;
- conduct of research, including the planning, monitoring and evaluation of the conducted research, and promotion of the application of the results of such research;
- standardization of terminology, nomenclature of technology, procedures and protocols, and promotion of relevant quality control and quality assurance standards;
- support, organization and/or implementation of conferences and training activities, including research training courses, or the development of training or other educational materials, such as web-based tools, e-learning modules, etc.;
- collection, collation and dissemination of information; and/or
- coordination of activities carried out by several institutions where the IAEA is involved under one of its Programmes (e.g. through networks).

Here, such engagements also include collaborating centers assisting the IAEA with maintaining—and *improving*—their own research, development, and training in the relevant nuclear energy/technology topical area. One notable benefit is the "efficient cooperative mechanism that encourages centres to share resources, knowledge, and expertise [8]." Examples of currently operating collaborating centers is summarized in Table 1.

Table 1. Summary of currently operating IAEA collaborating centres (an update to the list in [9]).

Country	Centre Name	Topic
Argentina	Comision Nacional de Energia Atomica (CNEA)	Human resources development in the area of nuclear science, technology and their applications
Australia	Australian Nuclear Science and Technology Organisation (ANSTO)	Multi-analytical techniques for materials research, environmental studies and industrial applications
Brazil	Animal Biotechnology Laboratory, Sao Paulo University (LBBMA)	Animal genomics and bioinformatics
Brazil	Moscamed Brasil	Operational programmes against Aedes mosquitoes with a Sterile Insect Technique component
Brazil	Companhia de Pesquisa de Recursos Minerias (CPRM), Geological Survey of Brazil	Water resources assessment and management
Burkina Faso	Centre International de Recherche et Developpement sur l'Elevage en Zone Subhumide (CIRDES)	Use of the Sterile Insect Technique for area-wide integrated management of Tsetse fly populations
Costa Rica	Centro de Investigacion en Contaminacion Ambiental (CICA)	E-learning and accelerated capacity building for food and environmental protection (EACB)
France	Aerial	Multidisciplinary applications of electron beam and x-ray technologies and related dosimetry, especially for food irradiation
France	National Institute for Nuclear Science and Technology	Education and training in nuclear technologies industrial and radiopharmaceutical applications
Hungary	National Food Chain Safety Office FFSD RRL	Production and characterization of reference materials
India	St. John's Research Institute, St. John's National Academy of Health Sciences	Nuclear techniques in nutrition
Indonesia	National Nuclear Energy Agency of Indonesia (BATAN)	Plant mutation breeding for climate smart agriculture (PMBCSA)
Indonesia	National Nuclear Energy Agency of Indonesia (BATAN)	Research and development and capacity building in non-destructive diagnostics, testing and inspection technologies
Italy	Centro Agricoultura e Ambiente "Giorgio Nicoli (CAA)"	Development and implementation of a SIT package for Aedes mosquitoes suppression
Japan	Hiroshima International Council for Health Care of the Radiation-exposed (HICARE)	Healthcare of the radiation-exposed for cooperation in the medical field
Japan	Nat.l Institutes for Quantum & Radiological Science & Technology (QST)	Biology of risk reduction of radiotherapy; nuclear medicine and diagnostics imaging; charged particle
Malaysia	Malaysian Nuclear Agency (MNA)	Radiation processing of polymer and natural polymer and nanomaterials
Malaysia	Malaysian Nuclear Agency	Non-destructive testing
Mexico	Programa Moscas de la Fruta DGSV-SENASICA-SAGARPA	Development and application of the SIT for fruit fly area-wide control
Mexico	National Institute of Nuclear Research (ININ)	Safe operation, maintenance and upgradation of gamma irradiation facilities
Morocco	National Centre for Nuclear Energy, Science and Techniques (CNESTEN)	Water resources assessment and management
Netherlands	Reactor Institute Delft (RID)	Neutron-activation based methodologies of research reactors
Philippines	Philippine Nuclear Research Institute (PNRI)	Harmful algal bloom studies in the context of environmental and global changes
Poland	Institute of Nuclear Chemistry and Technology (INCT)	Radiation dosimetry and industrial radiation processing
Republic of Korea	Korea Institute of Nuclear Safety (KINS)	Enhancing reliability and comparability of environmental radioactivity measurement results
Republic of Korea	Advanced Radiation Technology Institute (ARTI); Korean Atomic Energy Research Institute (KAERI)	Radiation application research for environmental remediation, advanced materials, foods and biotechnology
Saudi Arabia	King Faisal Specialist Hospital and Research Centre	Quality assurance in radiation medicine
Spain	Centro Nacional de Acceleradores (CAN)	Accelarator-based analytical techniques for the study of radionuclides in marine samples
Spain	Hungarian Academy of Sciences; Centre for Energy Research (MTA EK)	Selected nuclear security activities
Switzerland	Ecole Polytechnique Federale de Lausanne (EPFL)	Reactor experiments and high-fidelity multi-physics nuclear simulation techniques for open-source code development and validation
Switzerland	Spiez Laboratory	Sampling and analytical techniques for the study of radionuclides in environmental samples applying ISO/EN/17025 accreditation standards, with a focus on capaciting building within the ALMERA network
United Arab Emirates	Khalifa University of Science and Technology (KU)	Nuclear energy infrastructure and human resources
USA	National Center for Electron Beam Research (NCEBR) at Texas A&M AgriLife Research	Electron beam technology for food, health and environmental applications
Vietnam	VINATOM	Water and environment

GNEII & THE IAEA COLLABORATION CENTER FOR HUMAN RESOURCE AND NUCLEAR ENERGY INFRASTRUCTURE DEVELOPMENT

In late 2017, Khalifa University of Science and Technology and the IAEA embarked on a four-year period of cooperation to implement activities in the field(s) of nuclear power nuclear energy infrastructure and human resource development. As the IAEA *Collaborating Center for Nuclear Energy Infrastructure and Human Resource Development*, KU will support—and advance—IAEA activities to enhance Member State capabilities for building, assessing, and maintaining the legislative, organizational, and personnel infrastructure required for responsible nuclear energy programs.

During the signing ceremony—and enshrined on the official IAEA plaque commemorating this collaborating center—the important role of GNEII in showcasing KU's capacity in nuclear energy infrastructure and human resource development was acknowledged. More specifically, (then) interim President Tod A. Laursen stated that

> We are honoured by the IAEA designation as an IAEA Collaborating Centre. Since I signed our first Practical Arrangement with the IAEA in 2010, we have engaged with the IAEA on human resource development through our Gulf Nuclear Energy Infrastructure Institute (GNEII) programme and by hosting the joint UAE-IAEA Nuclear Energy Management Schools. We look forward to enhancing our offerings in this area, both within the UAE and to support other IAEA Member States

As of one of the world's newest nuclear power states, the UAE has a tremendous wealth of experience and (growing) expertise in nuclear infrastructure development. This collaborating centre provides a robust mechanism by which to do so, including through implementing specific training courses in collaboration with IAEA, and dispatching experts to support IAEA activities. To date, the majority of collaborative efforts have been focused on *planning* and *preparing* various engagement opportunities. In addition to KU's relevant topical experience with GNEII, the university has also hosted several other IAEA engagements, including being a three-time host of the Nuclear Energy Management school in 2013, 2015, and 2017.

Potential Engagement Opportunities

Several novel and innovative engagement options exist in order to most effectively and efficiently leverage the growing relationship between GNEII and this collaborating centre. For example, each partner could significantly contribute to—and benefit from—further development and implementation of the proposed GNEII modularized academic program in "integrated nuclear safety." The goal for this academic program is to build off the strong foundation established from 2011 to 2016 with GNEII's Fundamentals Course by offering a range of potential academic options to meet the range of stakeholder needs with responsible nuclear energy programs. The program content itself includes an overview of the nuclear industrial complex and a model visualizing the interactions with the three pillars of *integrated nuclear safety*: nuclear reactor safety, the physical security of the nuclear plant, and nuclear material accounting and safeguarding. The ultimate goal is create an academic program that provides opportunities for participants to earn credentials ranging from professional course completion certificates to Applied Graduate Diplomas to Applied Masters

degrees.[4] Here, GNEII's professional development experience related to the interactions related to "integrated nuclear safety" coupled with the IAEA's expertise as the global standard for each of the individual subcomponents increase the ability of this proposed to academic program to meet its goal of producing highly competent and appropriately knowledgeable personnel to staff responsible nuclear energy programs.

In similar manner, GNEII could continue to support this collaborating center as it seeks to train professionals recommended by the IAEA in the field of nuclear power infrastructure and human resource development. This could also include hosting additional offerings of—as well as enhancing and improving—the IAEA's Nuclear Energy Management or Nuclear Infrastructure Development School programs. GNEII and this collaborating center could also partner to elicit lessons learned in these topical areas to develop and implement training courses, workshops, or other engagements designed to meet more advanced, specific, or unique needs of Member States embarking on nuclear power programs. GNEII could also continue to develop staff at KU (and other relevant stakeholders) as subject matter experts in nuclear energy infrastructure and human resource development capable of supporting various IAEA workshops, meeting, and expert missions worldwide. In addition, GNEII can work with the world-class resources at KU to create standardized training mechanisms—including both in-person and e-learning platforms—as portable tools for capacity building in the collaborating center's topical areas. Given the growing expertise in both nuclear energy infrastructure and human resource development observed in both entities, this partnership is well positioned to organize and conduct advanced engagements, including the first Nuclear Infrastructure Development Conference (expected to be hosted in Abu Dhabi in 2021).

CONCLUSIONS & IMPLICATIONS

Though this partnership is still maturing, there are several specific areas in which the two entities—GNEII and the Collaboration Center—can leverage the expertise, capabilities, and experiences of the other to enhance the knowledge transfer from the UAE in building its nuclear power infrastructure to other embarking IAEA Member States. As discussed above, these options range from bolstering *already* existing engagements (e.g., the IAEA's Nuclear Energy Management School) to creating *new* engagements (e.g., GNEII's modularized academic program) to improve nuclear infrastructure and human resource development for responsible nuclear energy programs. Ultimately, this burgeoning relationships has the potential to train professionals from Member States in critical areas of nuclear power infrastructure development, such as nuclear safety, security, safeguards, stakeholder involvement, legal and regulatory framework and others.

[4] According to national Emirati education legislation, the learning outcomes for an *Applied Graduate Diploma* are advanced specialized knowledge and critical understanding in a specialized field of work or discipline and at the interface between fields as well as a comprehensive understanding of critical approaches to creating a systematic and coherent body of knowledge and concepts gained from a range of sources. Similarly, the learning outcomes for an *Applied Masters* are self-directed, comprehensive, highly specialized knowledge and practical learning, some of which is at the forefront of knowledge in a specialized field that provides a basis for originality and advanced knowledge and skills in research, analysis, evaluation and/or innovation encompassing complex ideas, information, concepts and/or activities and developing and/or applying ideas, often within a research context.

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