Clean Nuclear Energy for Industry: The Case for SMRs and Microreactors in Puerto Rico

Presented by:
Shannon Bragg-Sitton
Luis Reyes
Eddie M. Guerra
Ivan Lugo
GAIN Clean Nuclear Energy for Industry Webinar Series highlights the innovations in nuclear energy and associated integrated-energy options that may be beneficial to a wide range of industrial applications.

The intent is to develop connections between the nuclear community and the energy end-use community to communicate the benefits of clean, reliable, and resilient nuclear energy.
Shannon M. Bragg-Sitton, PhD

Lead, Integrated Energy Systems
Idaho National Laboratory
Objective: The GAIN Clean Nuclear Energy for Industry Webinar Series highlights the innovations in nuclear energy and associated integrated-energy options that may be beneficial to a wide range of industrial energy applications.

The intent is to develop connections between the nuclear community and the energy end-use community to communicate the benefits of clean, reliable, and resilient nuclear energy, allowing a discussion on requirements, considerations and concerns for energy system planning at “end use” facilities.
Past Webinars

• **Part 1: Kick-off**  
  April 16, 2020  
  • Introduces innovations in nuclear energy and associated integrated-energy options that may be beneficial to industrial energy applications  
  • Focuses on near-term demonstrations of nuclear integration with hydrogen production at existing nuclear plants – ongoing projects

• **Part 2: Advanced Nuclear Technologies**  
  May 29, 2020  
  • Features high-level presentations on the unique capabilities of advanced reactor technology concepts, highlighting key operational features, options to support industrial users, and potential deployment timelines.

• See [https://gain.inl.gov/SitePages/GAINWebinarSeries.aspx](https://gain.inl.gov/SitePages/GAINWebinarSeries.aspx) for slides, webinar recordings and Q&A.
DESIGNING FUTURE ENERGY SYSTEMS

What goals are we trying to achieve?

How will energy be used?

What role(s) can each energy source fill?
IES: Using Energy Effectively and Efficiently

- Fossil Energy
- Nuclear Energy
- Renewables
- Electric Grid
- Industry
- Heat & Electricity
- New Chemical Processes
- Hydrogen and Transportation Fuels
- Clean Water
IES: Using Energy Effectively and Efficiently

- Nuclear Energy
- Large Light Water Reactors
- Small Modular Reactors
- Micro Reactors
- Advanced Reactors

- Fossil Energy
- New Chemical Processes
- Hydrogen and Transportation Fuels

- Heat & Electricity
- Electric Grid
- Industry
- Renewables
- Clean Water
Why support multiple processes/products beyond electricity?

1) Provides second source of revenue

2) Provides energy storage, for electricity production or hydrogen user (e.g., chemicals and fuels synthesis, steel manufacturing, ammonia-based fertilizers)

3) Provides opportunity for grid services, including reserves and grid regulation
Initiatives under CEM are a country-led and opt-in partnership. The NICE Future initiative explores the potential for nuclear energy uses, innovations, and greater systems integration to accelerate progress toward clean energy goals.

More information on the NICE Future initiative is available at www.nice-future.org.
The CEM NICE Future initiative envisions a world in which nuclear energy innovations and applications advance clean energy goals. The initiative recognizes there is no one-size-fits-all solution to energy and fosters collaboration among clean energy supporters in exploring diverse solutions, including nuclear energy technology solutions, both electric and non-electric, for clean, integrated, and reliable systems of the future.

**Focus Areas**

- **Researching innovative solutions** (photo: research lab)
- **Exploring innovative applications for advanced nuclear systems both electric and non-electric.**
- **Engaging policy makers and stakeholders regarding energy choices for the future.**
- **Pooling experience on economics, including valuation, markets structure, and ability to finance.**
- **Communicating nuclear energy’s role in clean integrated energy systems and developing the nuclear workforce of the future.**

---

**Leveraging diversity of talent** (photo: research scientist)

**Talking with diverse audiences** (photo: stakeholder discussion)

**Sharing the vision with future generations** (photo: student tour of lab)
How do you envision meeting future clean energy needs?

Image courtesy of GAIN and ThirdWay, inspired by Nuclear Energy Reimagined concept led by INL.

Download this and other energy park concept images at: https://www.flickr.com/photos/thirdwaythinktank/sets/72157665372889289/
Luis Reyes
Chair, Technical Advisory Board
Nuclear Alternative Project
Former, Executive Director of Operations
U.S. Nuclear Regulatory Commission
Eddie M. Guerra, P.E.

Co-Founder
Nuclear Alternative Project

Senior Engineer
Arup
Ivan Lugo-Montes
Executive Director
INDUNIV
Part 1
Puerto Rico’s Rich History in the Nuclear Field
1946 Atomic Energy Act Establishes the Atomic Energy Commission (AEC)
1957 University of Puerto Rico (UPR) signs contract with AEC
1960 Bonus Reactor Construction Starts
1970 Nuclear Engineering Dept established at UPR Mayaguez Campus
Construction Application to USNRC for a 600 MW Pressurized Water Reactor (NORCO PROJECT)
1980 National Academy of Sciences Study

Interim Report of the Committee on Future Energy Alternatives for Puerto Rico

Ponied indefinitely in 1975. At this stage of its deliberations, the Committee believes that it would be advisable to preserve the nuclear option as a possible component of Puerto Rico’s future electric power system, but for the next major addition to generating capacity, considerations of both scale and timing rule it out. A plant of over 600 megawatts’ capacity (approximately the minimum economic size for a nuclear plant) would be undesirably large in relation to the total capacity of the WRA system. Unless economical small nuclear plants become available, it will be at least two decades before the Puerto Rico system becomes large enough to accommodate a nuclear unit. Furthermore, as a practical matter, it would probably be impossible to complete a nuclear power plant by 1990. In addition, the relevance of the nuclear option to Puerto Rico is likely to depend on the clarification of national policy in several respects, notably the procedures for siting and licensing plants, ensuring safety, and providing for spent fuel management and waste disposal.

For these reasons and those set forth in Section IV, among other

Energy Engineering Board Assembly of Engineering
2006 Grants Provided to UPR for Nuclear Engineering related course development and Instructors training

NRC NEWS
U.S. NUCLEAR REGULATORY COMMISSION
Office of Public Affairs Telephone: 301/415-8200
Washington, D.C. 20555-0001
E-mail: opa@nrc.gov
Site: http://www.nrc.gov

No. 08-141

NRC AWARDS NUCLEAR EDUCATION GRANTS

August 1, 2008

The Nuclear Regulatory Commission has awarded nearly $20 million to 60 different institutions in 28 jurisdictions to boost nuclear education and expand the workforce for nuclear energy. Congress provided NRC with $15 million to supplement NRC’s grant program.

The 88 grants are for faculty development ($7.8 million), education scholarships and graduate fellowships ($6.4 million), university curriculum development ($4.7 million), and trade school scholarships ($7.5 million). Recipients included Minority Serving Institutions and Historically Black Colleges and Universities. They are located in 26 states, the District of Columbia and Puerto Rico.
2015 Puerto Rican Engineers in the U.S. Nuclear Industry Launch The Nuclear Alternative Project
Interest from Leadership in Puerto Rico

2010 Senate Energy Commission
Larry Seilhammer
Senate Resolution 890
Called to study feasibility of large nuclear plants

2016 CIAPR President
Ralph Kreil Rivera (Now Chairman of PREPA Board of Directors)
Proposed SMRs as an option to Puerto Rico’s energy needs

2018 House Speaker
Gabriel Rodriguez-Aguilo
Resolution 1189 to study the feasibility of SMRs and Microreactors
2019 DOE awards The Nuclear Alternative Project funds to study advanced reactors in Puerto Rico

Preliminary Feasibility Study for Small Modular Reactors and Microreactors for Puerto Rico

May 11, 2020
Prepared for the U.S. Department of Energy
under Contract No. 226618

For a Better Puerto Rico

In 2015, The Nuclear Alternative Project (NAP), a non-profit organization comprised of Puerto Rican engineers, embarked on a journey to inform the people of Puerto Rico about the potential of nuclear reactors and their capabilities. In the aftermath of Hurricane Maria, where more than 3,000 deaths were attributed to the lack of electricity and basic services, our educational effort evolved into one of need—to evaluate the potential of advanced nuclear reactors for Puerto Rico.

As nuclear industry engineers and professionals we have labored to maintain the safety of nuclear reactors in the United States. We are using this same passion and knowledge base to assess the feasibility of advanced nuclear reactors to address Puerto Rico’s pressing energy needs.

This document presents the results of a preliminary feasibility study developed with the support of partners and industry advisors. This report delves into the potential advantages of advanced nuclear deployment by exploring market and infrastructure conditions, legal and regulatory aspects, public interest and potential applications.

NAP is grateful for the support from the U.S. Department of Energy Office of Nuclear Energy and the Marine National Laboratory for their sponsorship in developing this study. It is our hope that this report serves as the beginning of a transformative project for the U.S. nuclear power industry, a young generation of engineers, and for the people of Puerto Rico.

For a better Puerto Rico,
The Members of The Nuclear Alternative Project

Angel A. Reyes, Jessica J. Rivera, Jesus M. Nunez, Valiente Loqui, Eddie M. Guerra

Preliminary Feasibility Study for Small Modular Reactors and Microreactors for Puerto Rico
Prepared for the U.S. Department of Energy
under Contract No. 226618
May 11, 2020
Part 2
Feasibility Study for Advanced Reactors for Puerto Rico
Our Study: What we covered?
Our Study: The Team

Technical Advisory Board (TAB)
- Dr. Jose Reyes - PWR
- Mr. David Siedzik - BWR
- Dr. Abdul Dullao - Micro
- Mr. Jeff Harper - HTR
- Amr Elnashai - Natural Hazards
- Marc Nichols - U.S. Utilities/Government

Mr. Luis Reyes (Chair/NRC regulations)
Technical Advisory Board (TAB)

Mr. Angel Reyes
Management – Project Controls

Ms. Valerie Lugo
Contracts & Corporate Governance

Mrs. Jessabel Rivera
Community Engagement & Industry Outreach

Mr. Jesus Nunez
Technical Support for Community Engagement

Puerto Rico Community
INESI, San Sebastian, Villalba

Puerto Rico Stakeholder
PREPA representative
PRB representative
Fort Buchanan Representative
Dr. Guillermo Aguilo – Hospital Office of House Speaker
Pharma – TEVA

U.S. Reachout
Our Study: The Team

Technical Advisory Board

Luis Reyes
Chair of the Board
(Former Nuclear Regulatory Commission
Executive Director of Operations)

Jeffrey Harper
Vice President Strategy and Business Development

Dr. Jose Reyes
Co-Founder and Chief Technology Officer

Dr. Abdul Dulloo
Director, Plant Technologies & Product Development

David Sledzki
Senior Vice President Sales & Commercial Operations

Marcus Nichols
Director, New Reactor Deployment

Dr. Amr Elnashai
Vice Chancellor Research and Technology Transfer
What we found?
Need for baseload power

• Our study reviewed the June 2019 Version of the PREPA IRP.
• Puerto Rico is in urgent need for new generation, more specifically base load generation.
• 3,600MW planned retirements by 2030
• Current: operational 3,200MW installed capacity with 700MW reserves
• Expecting 3,000MW of peak demand for this summer
• To meet current RPS requirement of 40% renewable, IRP plans to install 1,800MW of PV and 900MW of battery by 2025 at a cost of about $3.6 billion.
What we found?
Need for baseload power

• Puerto Rico’s daily electricity demand peaks at approximately 10% from average and utilization rates (load factors) in the range of 75%.

• Steady high-power demand throughout the year plus the nature of an isolated grid requires a higher than average reserve margin.
Energy and Economic Forecasts used in the IRP to justify PREPAs Plan for the next 20 years
Historical Correlation of Energy Demand and Economic Performance in Puerto Rico
For many years, local leadership thought that people were opposed or afraid of nuclear...that’s not what we found.
For many years, nuclear energy was deemed unfeasible due to the size and reserve margin requirements for an isolated grid like Puerto Rico. We found that SMRs and Microreactors fit Puerto Rico’s planned grid.

Minigrids and microgrids: Proposed temporary (weeks to 1 month) partitioning of the Puerto Rican grid
The IRP calls for 1,800MW of solar PV for the next 5 years. This presents strict flexibility requirements for ANY generation source in Puerto Rico. Our study found that SMRs and Microreactors are designed for such conditions.

Example: Caguas MiniGrid
A common misconception was that nuclear was prohibited due to a 1993 executive order. This is not the case.

In fact, the public service act allows nuclear generation companies to do business in Puerto Rico.
A Variety of Applications Identified in Puerto Rico: Strong Focus on Distributed Generation and Microgrid Integration – Hospitals, military, energy-intensive industries, pharma, medical device and manufacturing, municipality consortia.
Part 3

Puerto Rico’s Pharmaceutical Industry
PUERTO RICO: LEADER IN BIO-SCIENCES
WHY PUERTO RICO

PUERTO RICO SPARKS INNOVATION

8 TOP 15
BIOPHARMACEUTICAL PRODUCTS MANUFACTURED

OVER 50 YEARS OF EXPERIENCE
BIO-PHARMACEUTICAL AND MEDICAL DEVICE MANUFACTURING

10 TOP OF THE 20
GLOBAL BIOPHARMACEUTICAL COMPANIES

- 70 MEDICAL DEVICES PLANTS
- 46 BIOPHARMA PLANTS
- 10 AGGIO STATIONS

6 TOP OF THE 10
PRINCIPAL MEDICAL DEVICE
WHY PUERTO RICO

PUERTO RICO
BIOSCIENCE DESTINATION

TOP 7 USA EMPLOYMENT CONCENTRATION AND SPECIALIZED HUMAN CAPITAL

HIGHLY SPECIALIZED

BIOPHARMA
MEDICAL RESEARCH

AOBIO
SUPPLY CHAIN
MEDICAL DEVICES

USA Jurisdiction with Access to Global Markets

68% EXPORTS TO OVER 85 COUNTRIES

63% GDP REPRESENTED BY LIFE SCIENCES

45% OF INDUSTRIAL JOBS REPRESENTED BY BIOTECHNOLOGY SECTOR

AUDITED BY
- U.S. Food and Drug Administration
- Global Regulatory Agencies
Energy needs of industry in Puerto Rico

• **Cost:** Attracting manufacturing to Puerto Rico will depend on competitive cost of electricity for energy-intensive industries.

• **Reliability:** risk of disrupting supply of fuel imports and exposure to extreme natural events
Current Alternatives Being Considered within the Industry
Puerto Rico Reshoring Pharmaceutical Manufacturing From Asia In Support of U.S. National Security

Puerto Rico's Resident Commissioner leads bipartisan legislation that would secure the National Supply Chain

Peter Navarro calls on Congress to 'bring home' manufacturing to Puerto Rico

by Katherine Doyle, White House Correspondent | ☀ | May 28, 2020 12:00 AM
Reliable Power is One of the Key Enablers in Support of The U.S. National Pharmaceutical Manufacturing Strategy
What’s next?
Proposal to be submitted to U.S. DOE
Site Suitability per U.S. NRC Reg Guide 4.7 for Various Regions in Puerto Rico
A fully integrated approach to site suitability

Community + Industry + Government + Technology
Figure 9-1: Timeline for Earliest Case Scenario Deployment in Puerto Rico

**Work in Puerto Rico**

- 2020
  - Community educational campaign for advanced reactors
  - Private sector, biopharma and manufacturing industry engagement
- 2021
  - Economic impact analysis
  - General site suitability assessment per Reg Guide 4.7
- 2022
  - Grid analysis
  - University of Puerto Rico reinstitutes courses in nuclear engineering
  - Establishment of vocational training courses
  - Participate IRP review process
  - Support public hearings for House Resolution 1189
- 2023
  - Site Characterization & Environmental Impact Assessment
  - IRP revision process
  - Revision of key statutes and energy law
- 2024
  - NRC ESP or COL application
  - UAMPS COL Application for INL Site
- 2025
  - UAMPS start construction at INL Site

**Projections for U.S. Advanced Reactor Deployment in the U.S.**

- NRC issues first SMR design certification
- US DOE selection for demonstration projects
- Microreactor NRC COL application
Figure 9-1: Timeline for Earliest Case Scenario Deployment in Puerto Rico

**Work in Puerto Rico**

- **2020**
  - Community educational campaign for advanced reactors
  - Private sector, biopharma and manufacturing industry engagement

- **2021**
  - Economic impact analysis
  - General site suitability assessment per Reg Guide 4.7
  - Grid analysis
  - Participate IRP review process
  - Support public hearings for House Resolution 1189

- **2022**
  - Characterization & Environmental Impact Assessment
  - University of Puerto Rico reinnstitutes courses in nuclear engineering
  - Establishment of vocational training courses
  - Revision process
  - Revision of key statutes and energy law

- **2023**
  - NRC ESP or COL application
  - UAMPS COL Application for INL Site

- **2024**
  - UAMPS start construction at INL Site

**Projections for U.S. Advanced Reactor Deployment in the U.S.**

- NRC issues first SMR design certification
- UAMPS COL Application for INL Site
- US DOE selection for demonstration projects
- Microreactor NRC COL application
¡Gracias!

Follow us:
@ProjectoNAP
The Nuclear Alternative Project
www.NuclearAlternativeProject.org

Knowledge Is Power. Conocimiento Es Poder.
Questions?
ANS Young Members Group upcoming events:

- July 1: Spotlight on National Labs: Pacific Northwest National Lab
- July 2: Virtual Happy Hour Networking
- July 15: Spotlight on National Labs: Lawrence Livermore National Lab
- July 21: Virtual Trivia
- July 28: Spotlight on National Labs: Oak Ridge National Lab

Learn more and register at ans.org.