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

ANS Webinars

GAIN
Gateway for Accelerated Innovation in Nuclear

GAIN WEBINAR SERIES

GAIN Gateway for Accelerated Innovation in Nuclear

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**.

ANS Webinars

@www.ans.org
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americannuclear

Shannon M. Bragg-Sitton, PhD

Lead, Integrated Energy Systems
Idaho National Laboratory

Objective of the Clean Nuclear Energy for Industry Webinar Series

- **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.

GAIN
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EPRI | ELECTRIC POWER RESEARCH INSTITUTE

NEI
NUCLEAR ENERGY INSTITUTE

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 for slides, webinar recordings and Q&A.

GAIN
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DESIGNING FUTURE ENERGY SYSTEMS

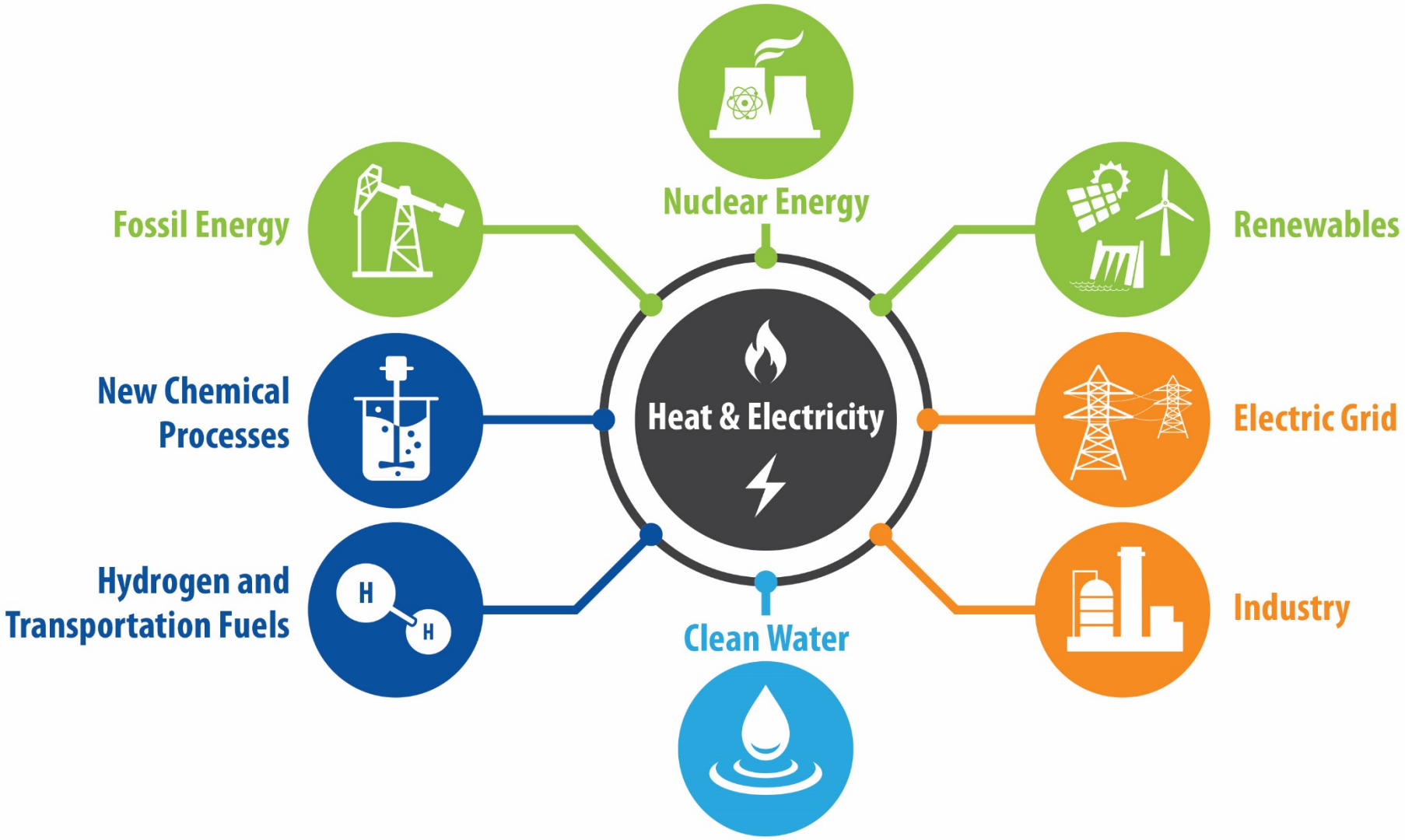
What goals are we trying to achieve?

How will energy be used?

What role(s) can each energy source fill?

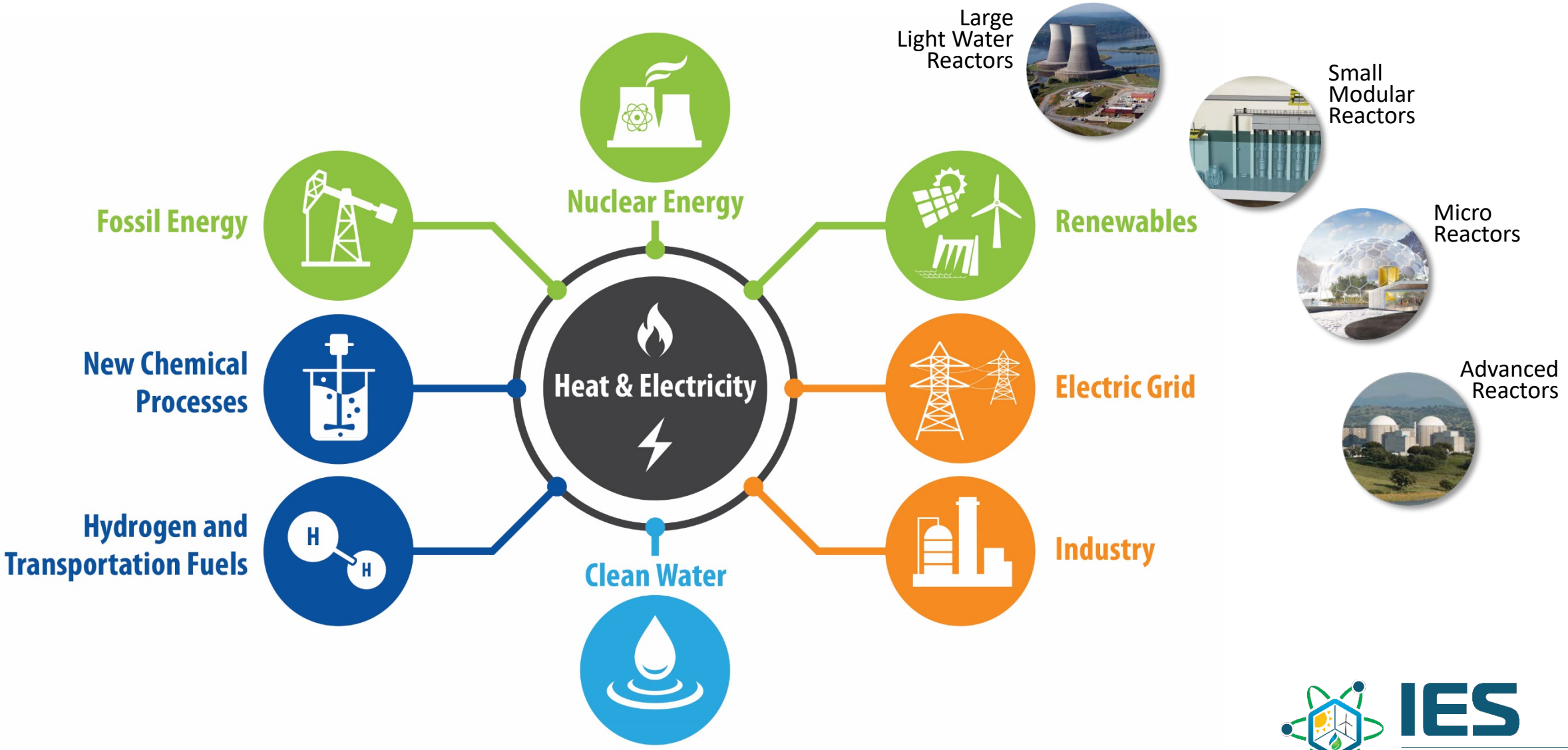
IES
Integrated Energy Systems

IES: Using Energy Effectively and Efficiently



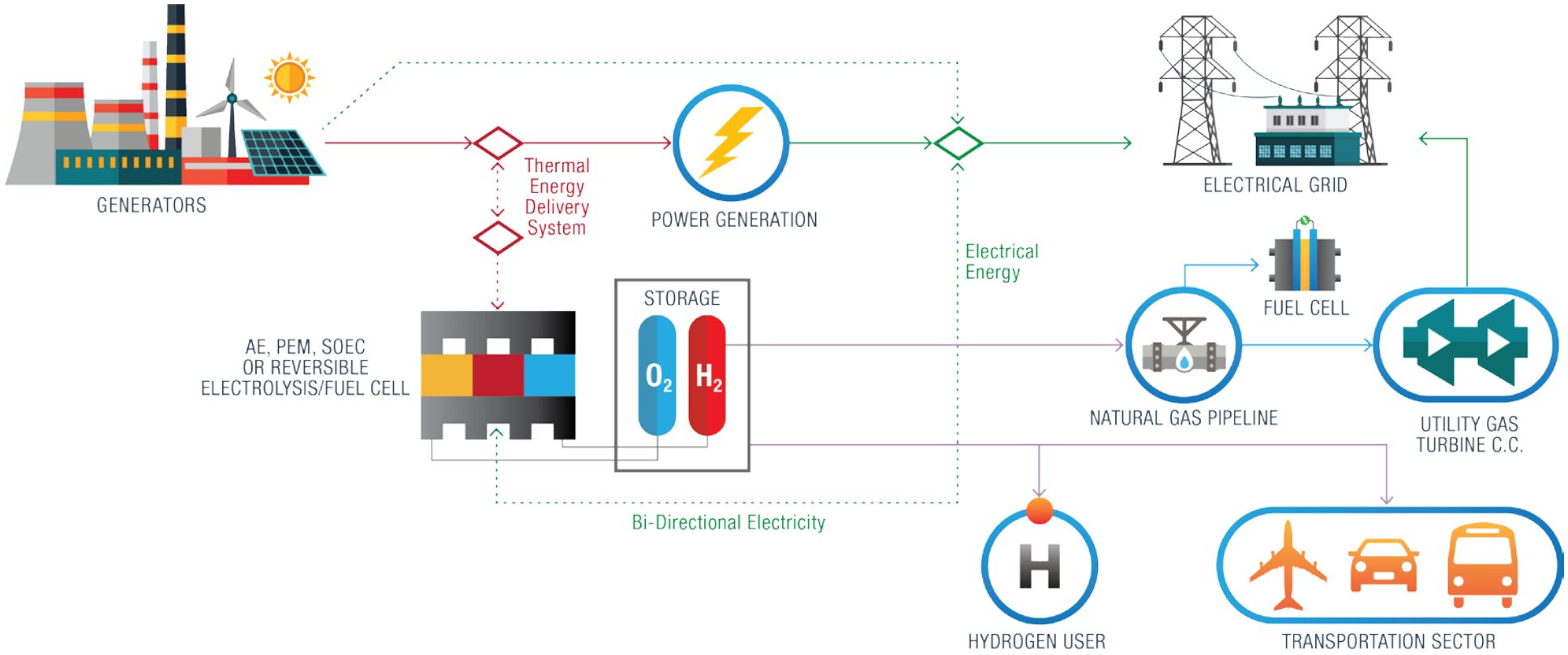
IES
Integrated Energy Systems

IES: Using Energy Effectively and Efficiently



IES
Integrated Energy Systems

Example: Hydrogen Production via Electrolysis



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

IES
Integrated Energy Systems

Nuclear Innovation: Clean Energy Future (NICE Future)
— an initiative of the Clean Energy Ministerial

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.

Lead Countries


Canada


Japan


USA

Participant Countries


Argentina


Poland


Romania


Kenya


Russia


UAE


UK


Jordan

More information on the NICE Future initiative is available at www.nice-future.org.

External Partners

International Energy Agency
OECD Nuclear Energy Agency
International Atomic Energy Agency
International Framework for Nuclear Energy Cooperation
Generation IV International Forum
ClearPath
Third Way
Energy for Humanity
Energy Options Network
Women in Nuclear Global
International Youth Nuclear Congress
Nuclear Industry Council
Nuclear Energy Institute
World Nuclear Association
American Nuclear Society
Electricite de France

Nuclear Innovation: Clean Energy Future (NICE Future) — an initiative of the Clean Energy Ministerial

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.

Researching innovative solutions (photo: research lab)

Leveraging diversity of talent (photo: research scientist)

Focus Areas

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.

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


2019

Ivan Lugo-Montes

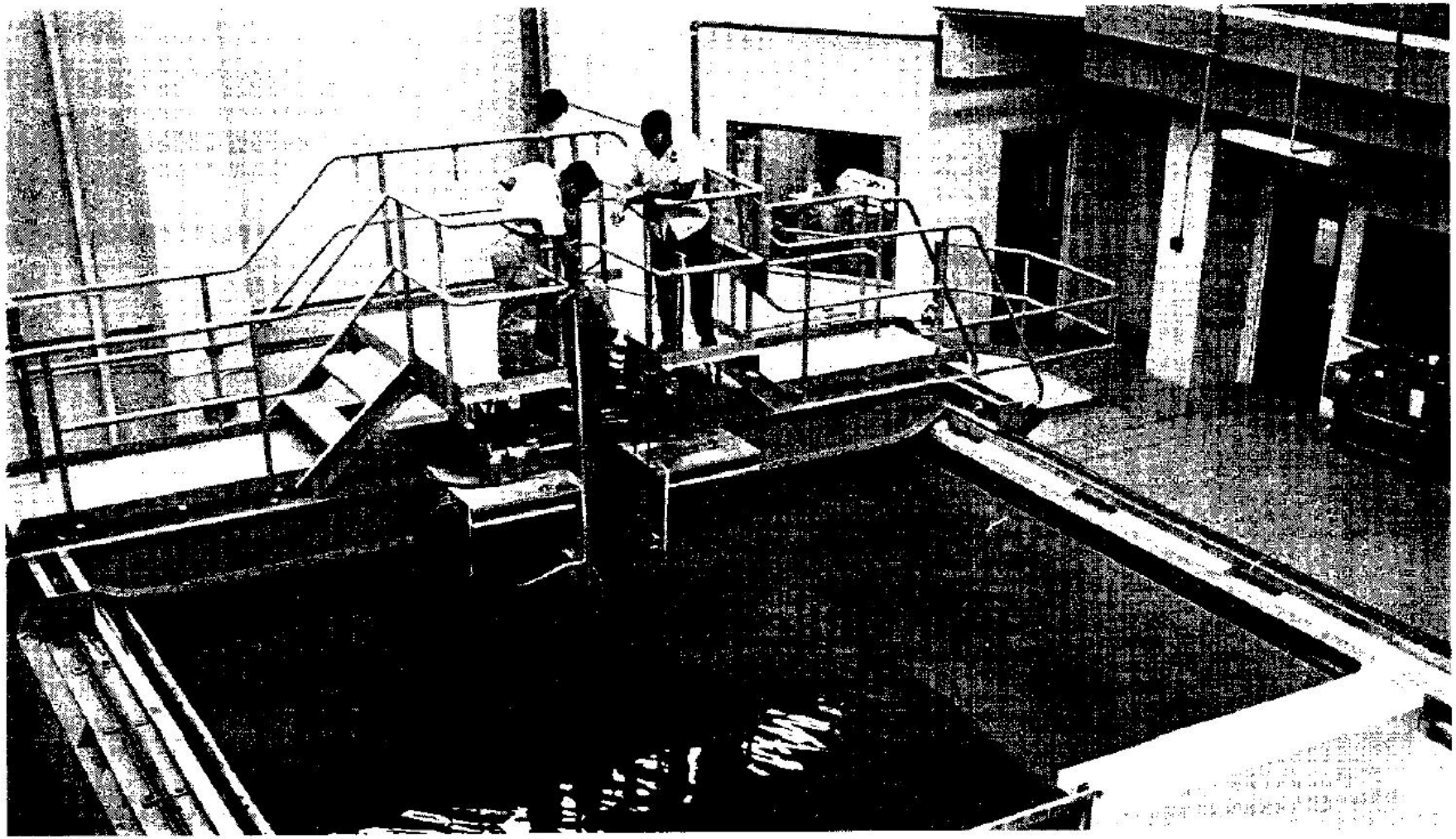
Executive Director
INDUNIV

Part 1

Puerto Rico’s Rich History in the Nuclear Field

1946 Atomic Energy Act Establishes the Atomic Energy Commission (AEC)

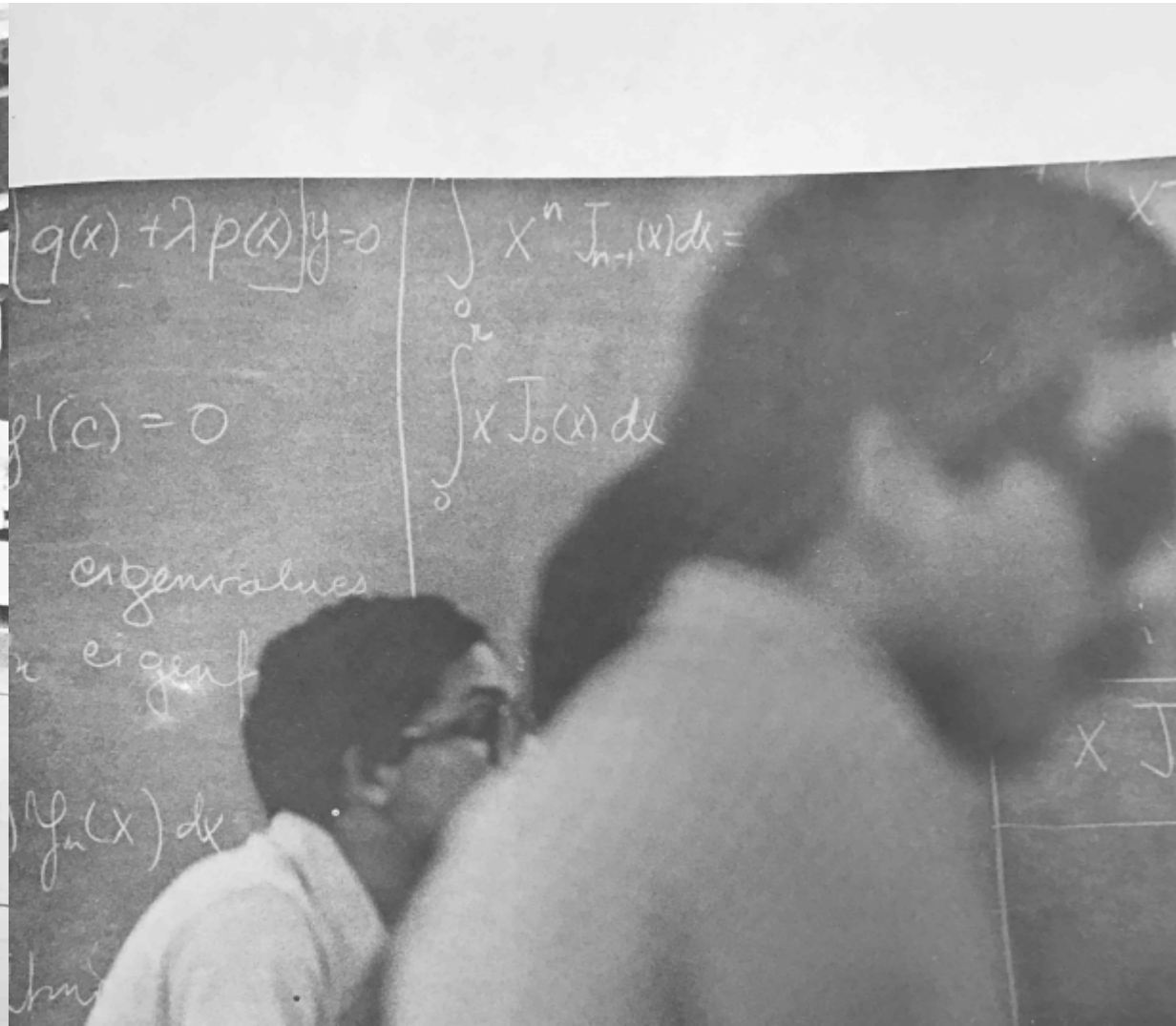
1957 University of Puerto Rico (UPR) signs contract with AEC



VIEW OF P.R.N.C. POOL REACTOR LOOKING TOWARD BRIDGE WITH CONTROL ROOM VISIBLE IN THE REAR

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)

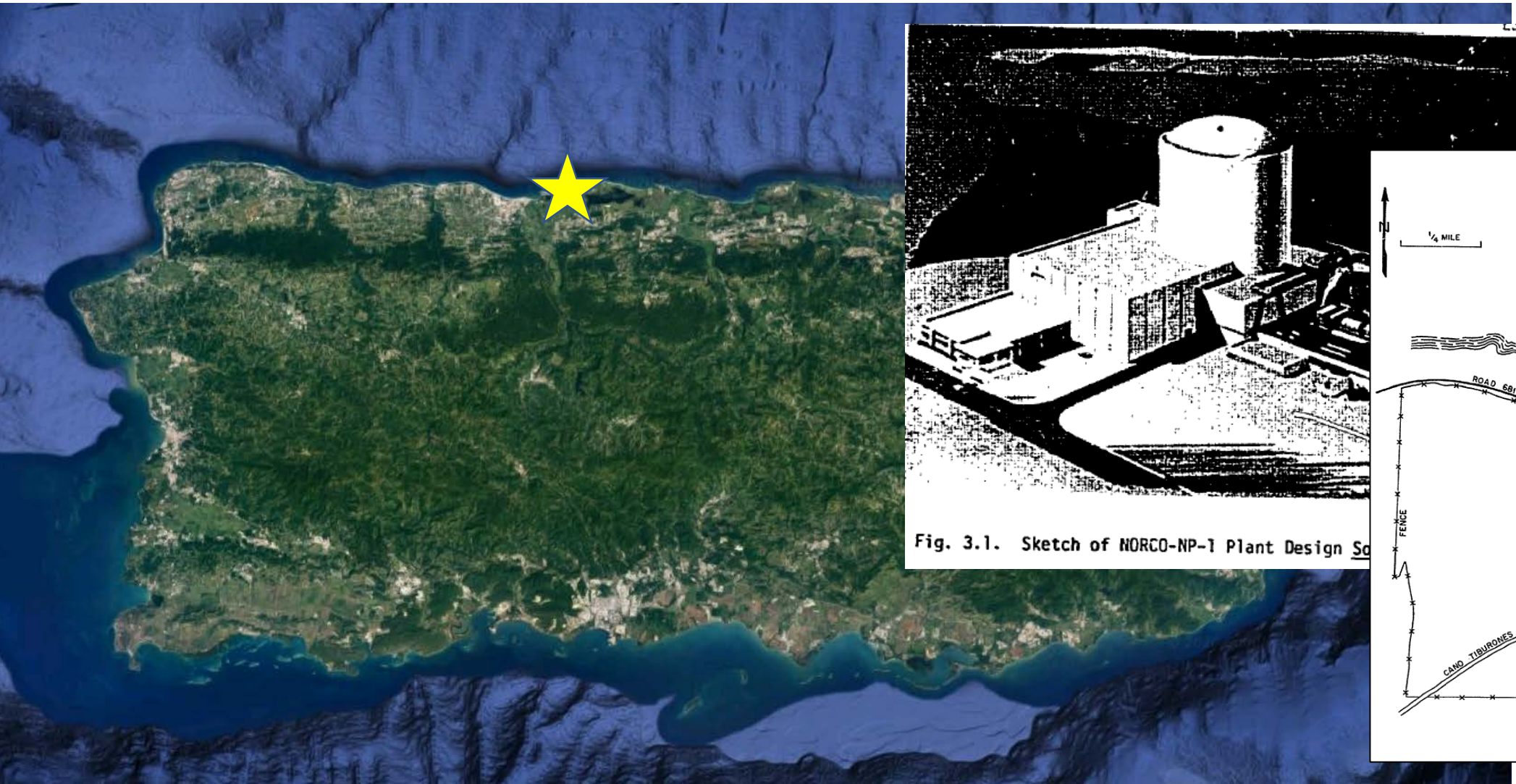


Fig. 3.1. Sketch of NORCO-NP-1 Plant Design So

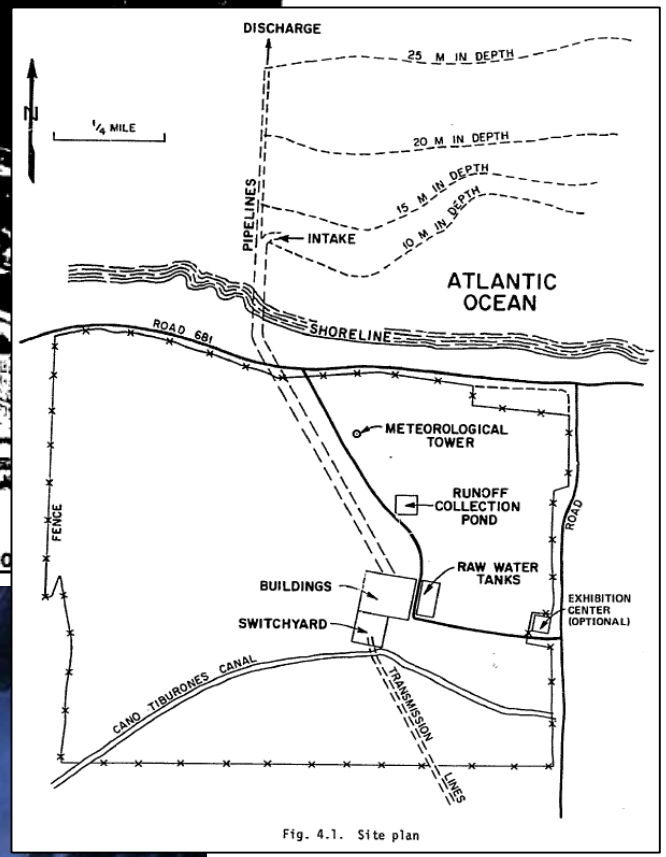


Fig. 4.1. Site plan

1980 National Academy of Sciences Study

Interim Report
of the

Committee on Future Energy Alternatives for Puerto Rico

Energy Engineering Board
Assembly of Engineering

poned 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, we recommend

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 August 1, 2008

NRC AWARDS NUCLEAR EDUCATION GRANTS

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 ($4.7 million), and trade school scholarships ($.75 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.

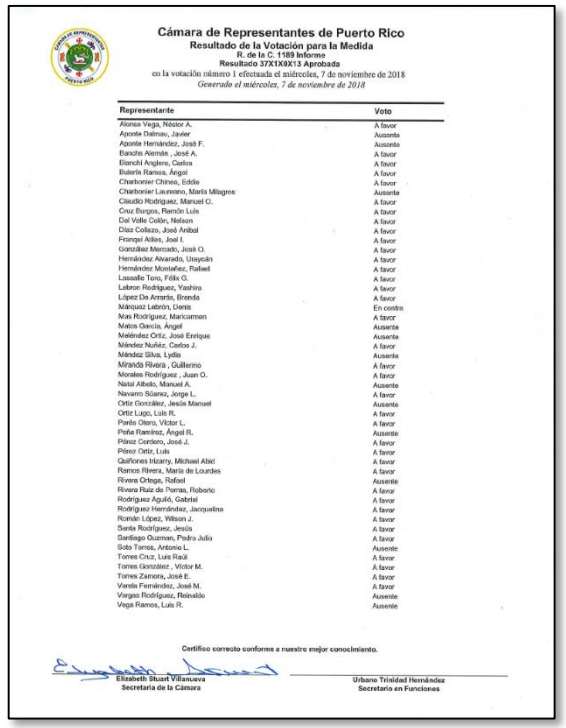
2015 Puerto Rican Engineers in the U.S. Nuclear Industry Launch The Nuclear Alternative Project

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



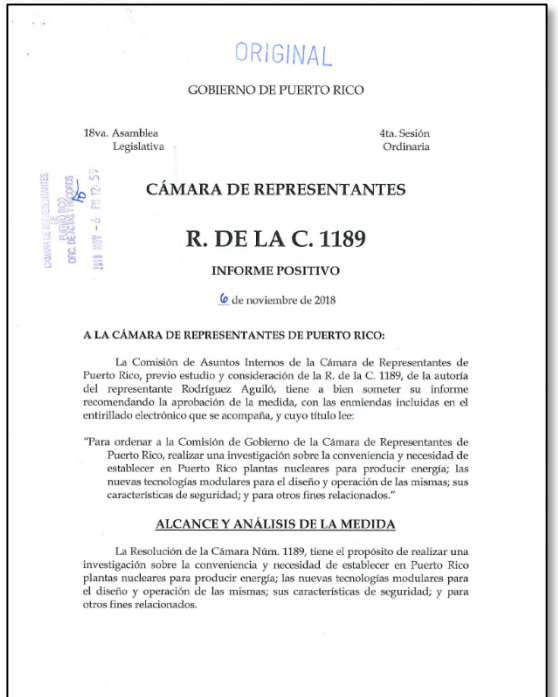
Cámara de Representantes de Puerto Rico
Resultado de la Votación para la Medida
R. de la C. 1189 Informe
Resultado 37X1X0X13 Aprobada
en la votación número 1 efectuada el miércoles, 7 de noviembre de 2018
Generado el miércoles, 7 de noviembre de 2018

Representante	Voto
Alonso Vega, Néstor A.	A favor
Aponte Dalmau, Javier	Ausente
Aponte Hernández, José F.	Ausente
Bianchi Alembik , José A.	A favor
Bianchi Angleró, Carlos	A favor
Bulerín Ramos, Ángel	A favor
Charbonier Chinea, Eddie	A favor
Charbonier Laureano, María Milagros	Ausente
Claudio Rodríguez, Manuel O.	A favor
Cruz Burgos, Ramón Luis	A favor
Del Valle Colón, Nelson	A favor
Díaz Collazo, José Aníbal	A favor
Franqui Atiles, José L.	A favor
González Mercado, José O.	A favor
Hernández Alvarado, Urayoán	A favor
Hernández Montañez, Rafael	A favor
Lassalle Toro, Félix O.	A favor
Lebrón Rodríguez, Yashira	A favor
López De Arrarte, Brenda	A favor
Márquez Lebrón, Dania	En contra
Mas Rodríguez, Maricarmen	A favor
Matos García, Angel	Ausente
Meléndez Ortiz, José Enrique	Ausente
Méndez Nuñez, Carlos J.	A favor
Méndez Silva, Lydia	Ausente
Miranda Rivera , Guillermo	A favor
Morales Rodríguez , Juan O.	A favor
Natal Albelo, Manuel A.	Ausente
Navarro Suárez, Jorge L.	A favor
Ortiz González, Jesús Manuel	Ausente
Ortiz Lugo, Luis R.	A favor
Parés Otero, Víctor L.	A favor
Peña Ramírez, Ángel R.	Ausente
Pérez Cordero, José J.	A favor
Pérez Ortiz, Luis	A favor
Quiñones Irizarry, Michael Aliel	A favor
Ramos Rivera, María de Lourdes	A favor
Rivera Ortega, Rafael	Ausente
Rivera Ruiz de Porras, Roberto	A favor
Rodríguez Aguiló, Gabriel	A favor
Rodríguez Hernández, Jacqueline	A favor
Román López, Wilson J.	A favor
Santa Rodríguez, Jesús	A favor
Santiago Guzmán, Pedro Julio	A favor
Soto Torres, Antonio L.	Ausente
Torres Cruz, Luis Raúl	A favor
Torres González , Víctor M.	A favor
Torres Zamora, José E.	A favor
Varela Fernández, José M.	A favor
Vargas Rodríguez, Reinaldo	Ausente
Vega Ramos, Luis R.	Ausente

Certifico correcto conforme a nuestro mejor conocimiento.

Elizabeth Stuart Villanueva
Secretaria de la Cámara

Urbano Trinidad Hernández
Secretario en Funciones



ORIGINAL

GOBIERNO DE PUERTO RICO

18va. Asamblea Legislativa — 4ta. Sesión Ordinaria

CÁMARA DE REPRESENTANTES

R. DE LA C. 1189

INFORME POSITIVO

6 de noviembre de 2018

A LA CÁMARA DE REPRESENTANTES DE PUERTO RICO:

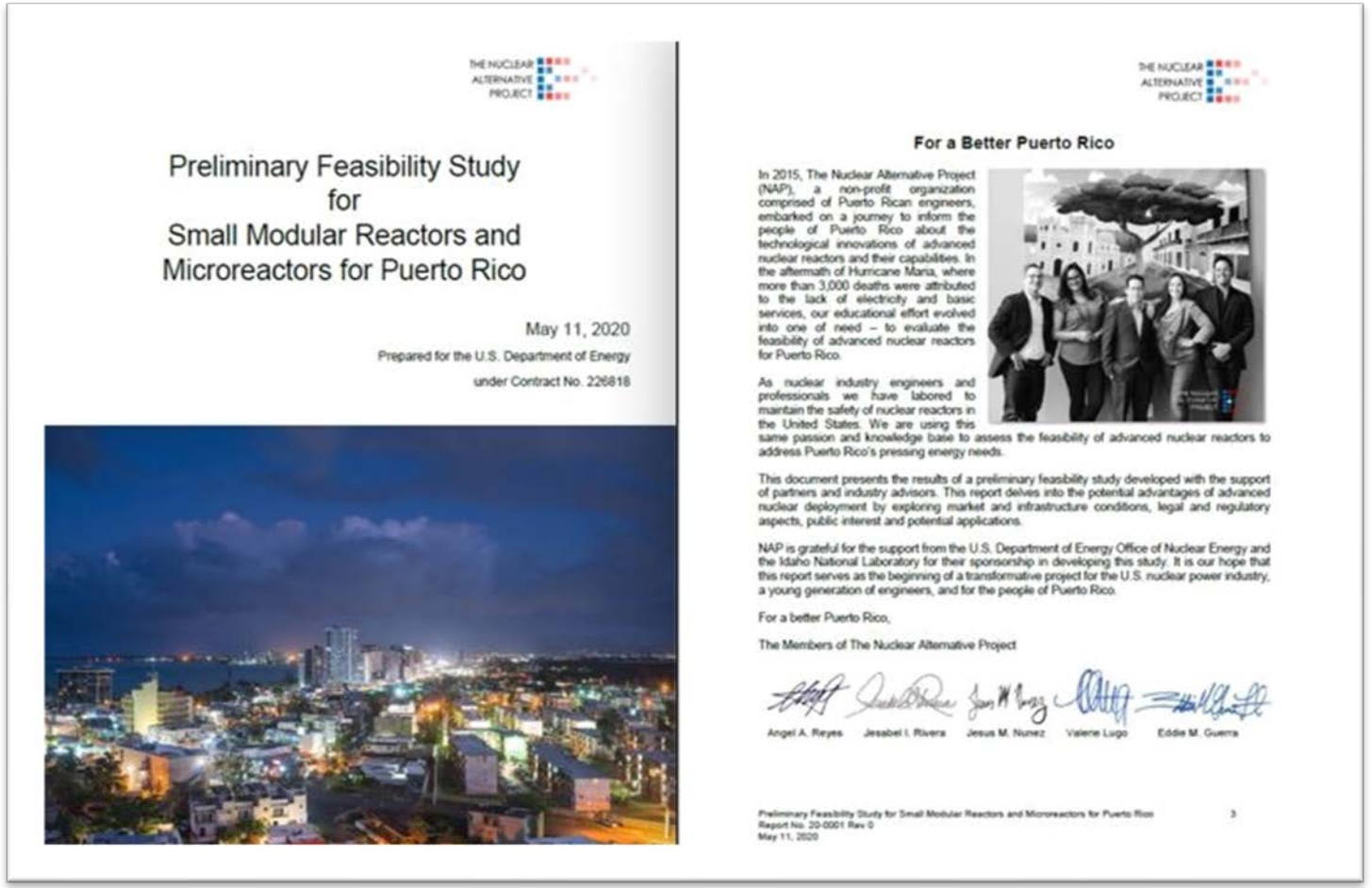
La Comisión de Asuntos Internos de la Cámara de Representantes de Puerto Rico, previo estudio y consideración de la R. de la C. 1189, de la autoría del representante Rodríguez Aguiló, tiene a bien someter su informe recomendando la aprobación de la medida, con las enmiendas incluidas en el entirillado electrónico que se acompaña, y cuyo título lee:

"Para ordenar a la Comisión de Gobierno de la Cámara de Representantes de Puerto Rico, realizar una investigación sobre la conveniencia y necesidad de establecer en Puerto Rico plantas nucleares para producir energía; las nuevas tecnologías modulares para el diseño y operación de las mismas; sus características de seguridad; y para otros fines relacionados."

ALCANCE Y ANÁLISIS DE LA MEDIDA

La Resolución de la Cámara Núm. 1189, tiene el propósito de realizar una investigación sobre la conveniencia y necesidad de establecer en Puerto Rico plantas nucleares para producir energía; las nuevas tecnologías modulares para el diseño y operación de las mismas; sus características de seguridad; y para otros fines relacionados.

2019 DOE awards The Nuclear Alternative Project funds to study advanced reactors in Puerto Rico



THE NUCLEAR ALTERNATIVE PROJECT

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. 226818

THE NUCLEAR ALTERNATIVE PROJECT

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 technological innovations of advanced 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 feasibility 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 Idaho 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 Jesabel I. Rivera Jesus M. Nunez Valerie Lugo Eddie M. Guerra

Part 2

Feasibility Study for Advanced Reactors for Puerto Rico

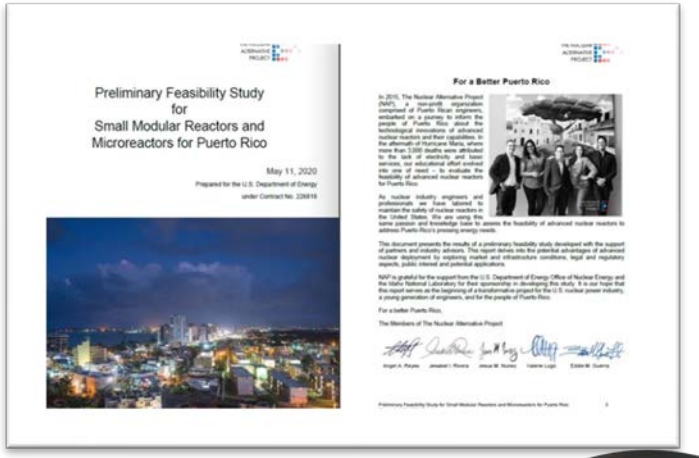
Our Study:
What we covered?

Technology

Grid

Community

Market



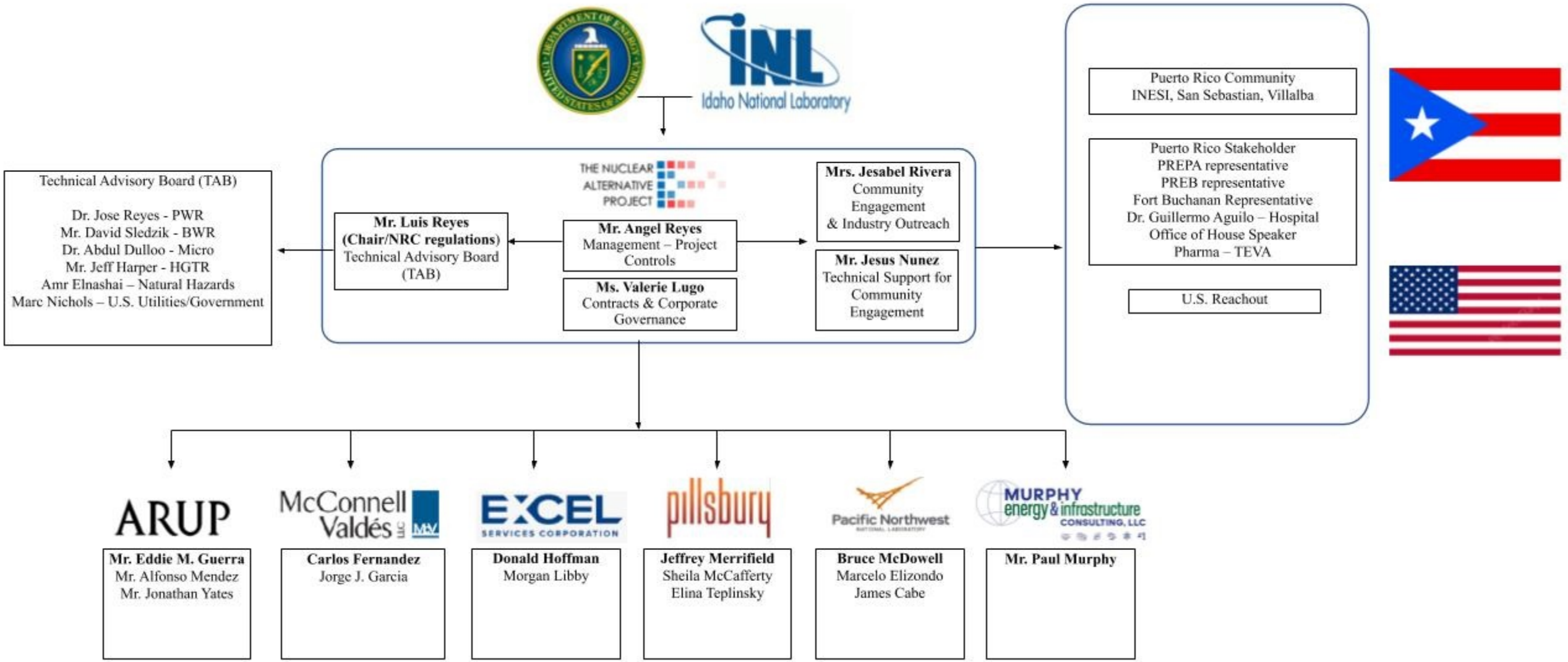
Recommendations

Legal

Financing

Need

Our Study: The Team



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

X-energy

Dr. Jose Reyes
Co-Founder and Chief
Technology Officer

NUSCALE

Dr. Abdul Dulloo
Director, Plant Technologies &
Product Development

Westinghouse

David Sledzik
Senior Vice President Sales &
Commercial Operations

GE HITACHI

Marcus Nichols
Director, New Reactor
Deployment

NEI

Dr. Amr Elnashai
Vice Chancellor Research and
Technology Transfer

UNIVERSITY of HOUSTON

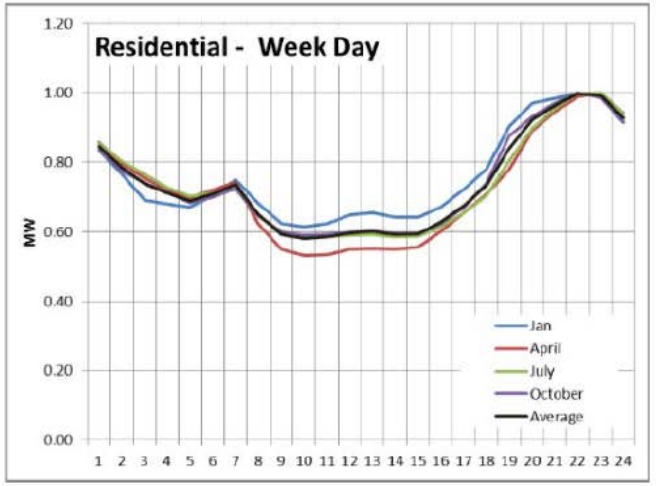
What we found?
Need for baseload power

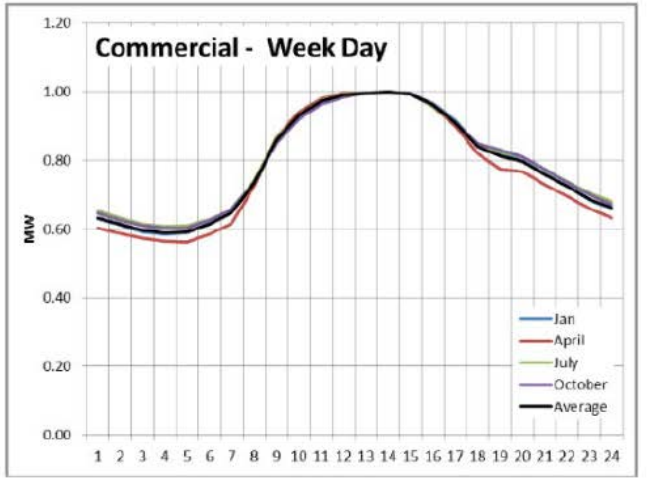
- Our study reviewed the June 2019 Version of the PREPA IRP.
- Puerto Rico is in urgent need for **new generation**, more specifically **base load** generation.
- 3,600MW planned retirements by 2030
- Current: operational 3,200MW installed capacity with 700MW reserves
- Expecting 3,000MW of peak demand 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.

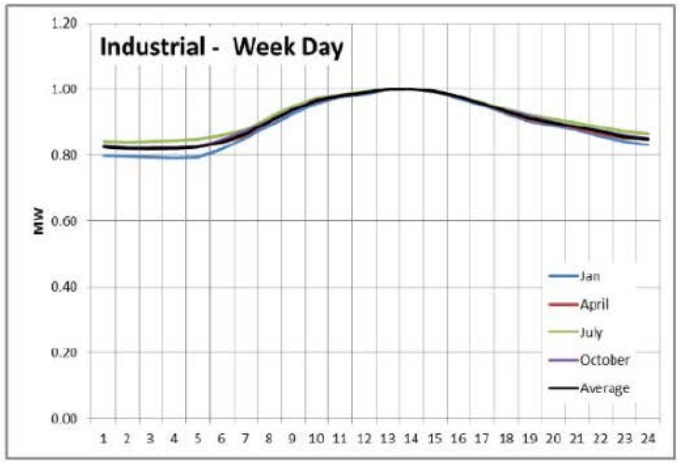
What we found?
Need for baseload power

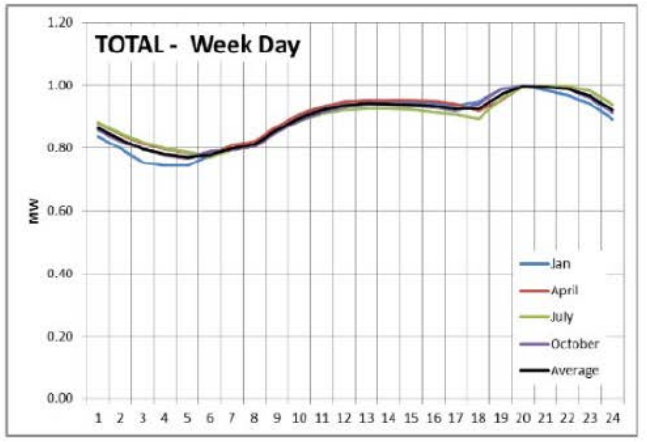
- Puerto Rico's daily electricity demand peaks at approximately 10% from average and utilization rates (load factors) in the range of 75%.

- Steady high-power demand throughout the year plus the nature of an isolated grid requires a higher than average reserve margin.

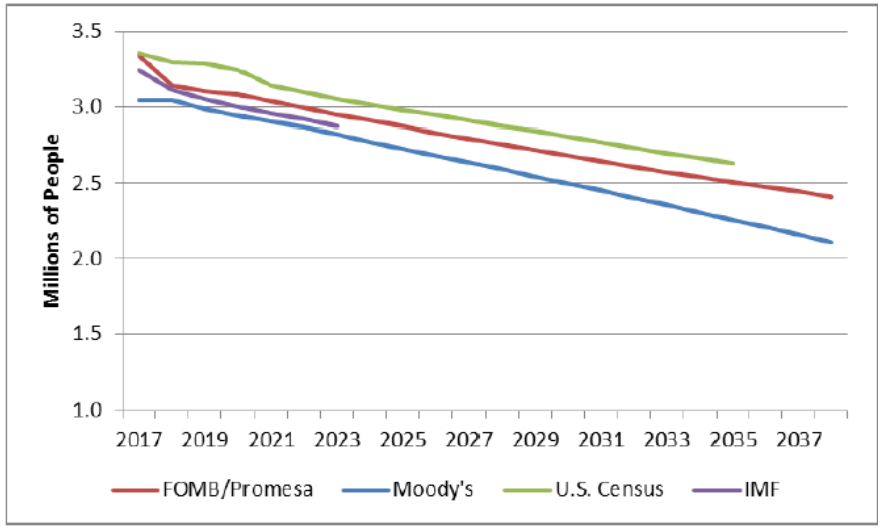


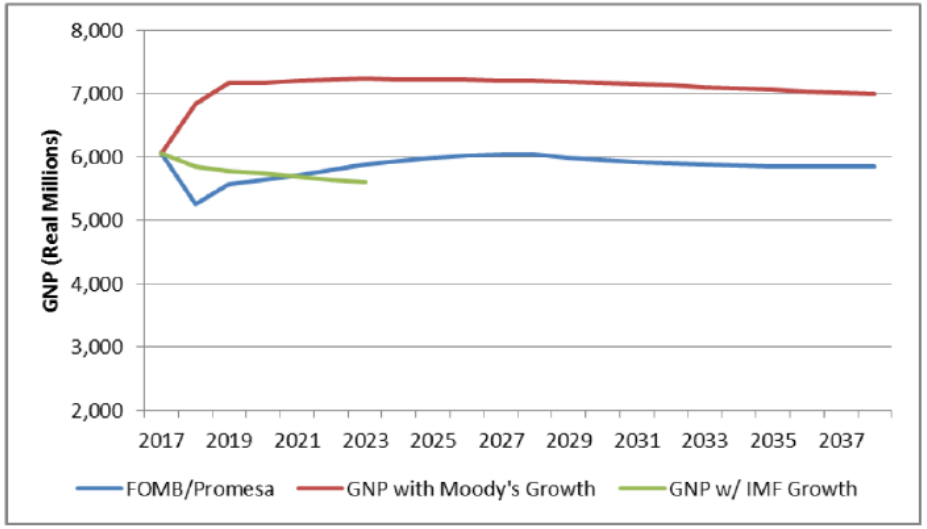


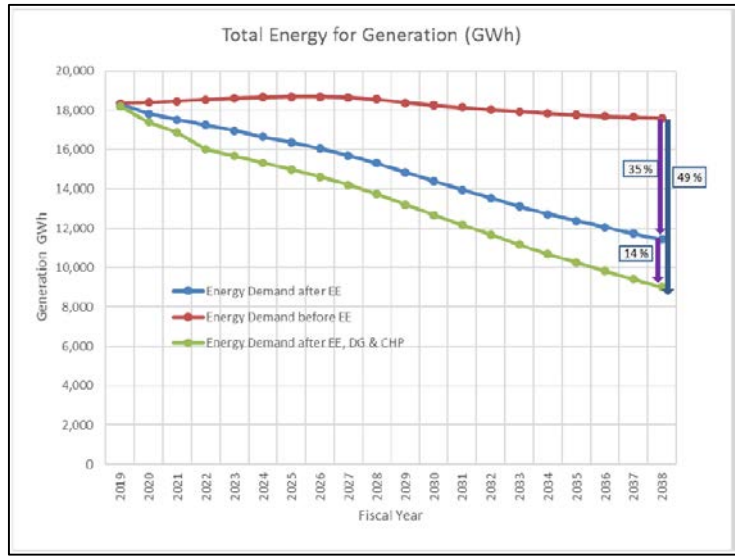




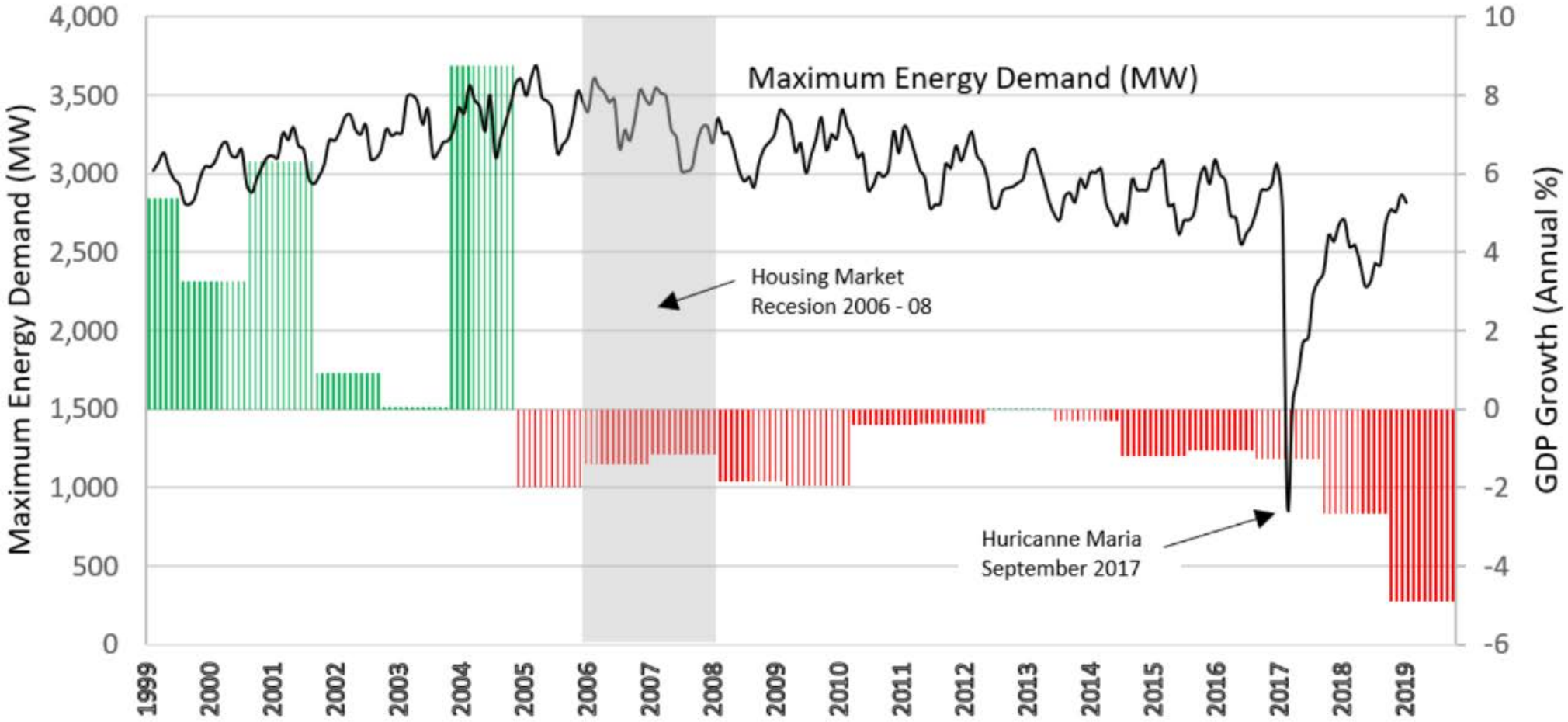
Energy and Economic Forecasts used in the IRP to justify PREPAs Plan for the next 20 years







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

Figure 5-1: Municipalities of Interviewed Puerto Rican Residents

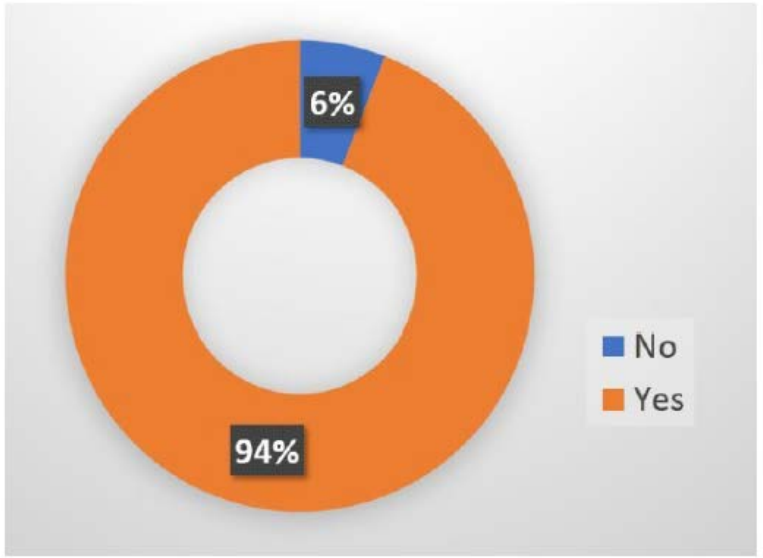


Figure 5-2: PR Residents Support More Research of Nuclear Energy

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

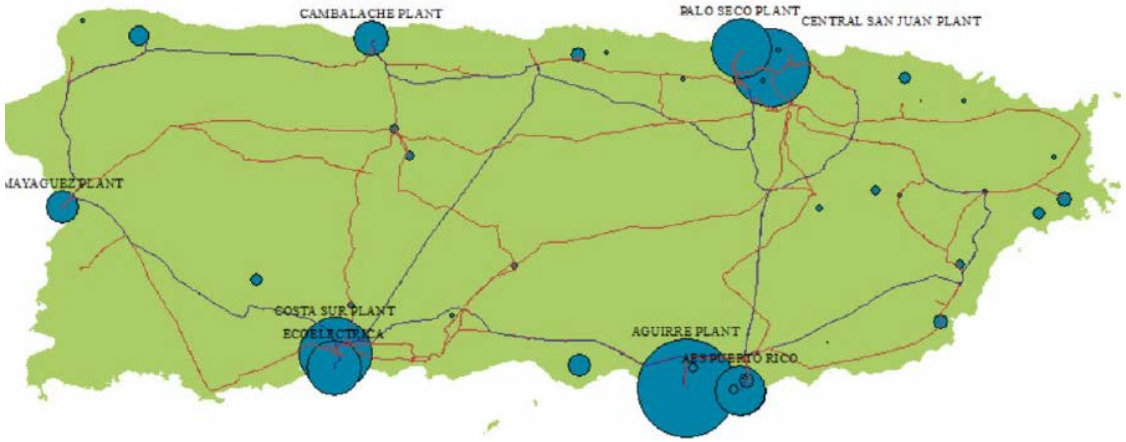
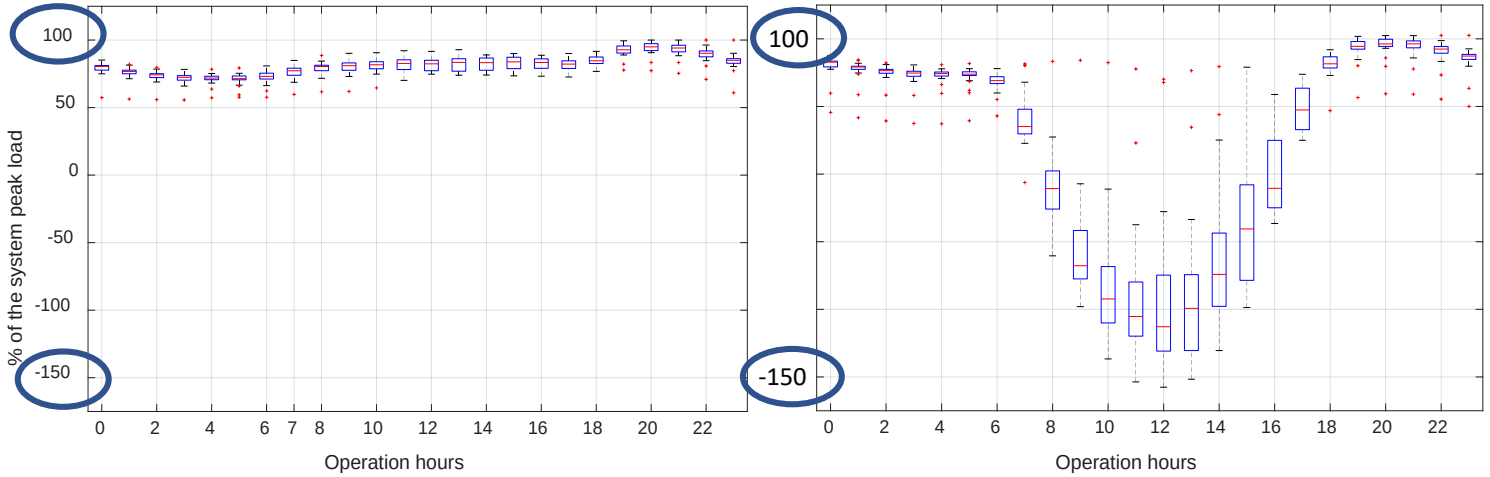


Figure 4-4: Geographic Location of Minigrids[116].

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



One-hourly observed load variability

One-hourly observed net-load variability

ESTADO LIBRE ASOCIADO DE PUERTO RICO
LA FORTALEZA
SAN JUAN, PUERTO RICO

Boletín Administrativo Núm. OE-1993-57

ORDEN EJECUTIVA DEL GOBERNADOR DEL ESTADO LIBRE ASOCIADO DE PUERTO RICO

PARA DECLARAR LA POLITICA PUBLICA ENERGETICA DE PUERTO RICO; ORDENAR A LAS DEPENDENCIAS GUBERNAMENTALES A LLEVAR A CABO SUS FUNCIONES DE MANERA CONSONA CON LA POLITICA PUBLICA ENERGETICA; ORDENAR AL DEPARTAMENTO DE RECURSOS NATURALES Y AMBIENTALES OFRECER UN PROCESO DE PARTICIPACION CIUDADANA PARA RECIBIR COMENTARIOS SOBRE EL PLAN DE IMPLANTACION DE LOS OBJETIVOS Y ESTRATEGIAS DE LA POLITICA PUBLICA ENERGETICA.

CUARTO: Al considerar fuentes alternas para generar energía eléctrica, serán prioritarias las consideraciones ambientales, de salud y seguridad pública además de las consideraciones económicas, por lo cual actualmente la energía nuclear no luce como una fuente alterna viable;

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.

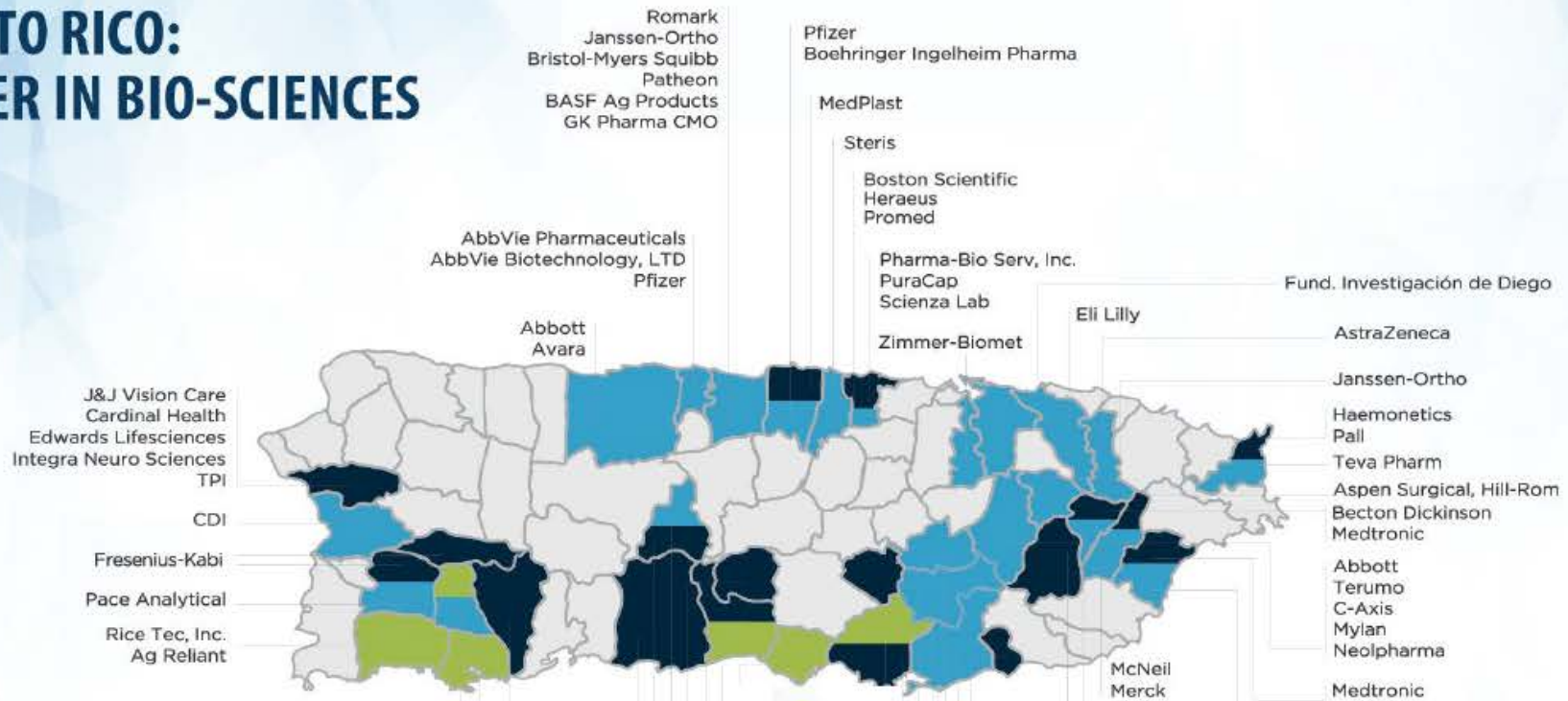
A Variety of Applications Identified in Puerto Rico: Strong Focus on Distributed Generation and Microgrid Integration – Hospitals, military, energy-intensive industries, pharma, medical device and manufacturing, municipality consortiums.

Part 3

Puerto Rico’s Pharmaceutical Industry

WHY PUERTO RICO

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 AGBIO STATIONS

6 TOP OF THE 10
PRINCIPAL MEDICAL DEVICE

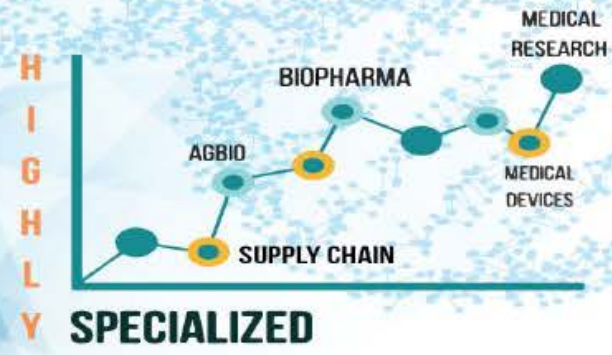
PUERTO RICO
BIOSCIENCE DESTINATION

GDP 34% REPRESENTED BY LIFE SCIENCES

45% OF INDUSTRIAL JOBS REPRESENTED BY BIOSIENCE SECTOR

TOP 7
USA EMPLOYMENT CONCENTRATION AND SPECIALIZED HUMAN CAPITAL

BIOSCIENCE DESTINATION
USA Jurisdiction with Access to Global Markets



68%
EXPORTS TO OVER
85 COUNTRIES

AUDITED BY
- USFDA
- 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

U.S. CONGRESSWOMAN
JENNIFFER GONZÁLEZ-COLÓN
REPRESENTING PUERTO RICO IN CONGRESS

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Home » Media » Press Releases

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

April 5, 2020 | Press Release

Washington, D.C.- Puerto Rico's Resident Commissioner, Jenniffer González-Colón introduced bipartisan leg
jurisdictions, which poses a risk to U.S. supply chain as evidenced by the pandemic caused by Covid-19.

H.R. 6443, Securing the National Supply Chain Act of 2020, would secure the national stockpile supply cha
States, including the territories. This initiative would help drive the consolidation of the manufacturing ind

Washington Examiner

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

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

March 2014
Revision 3

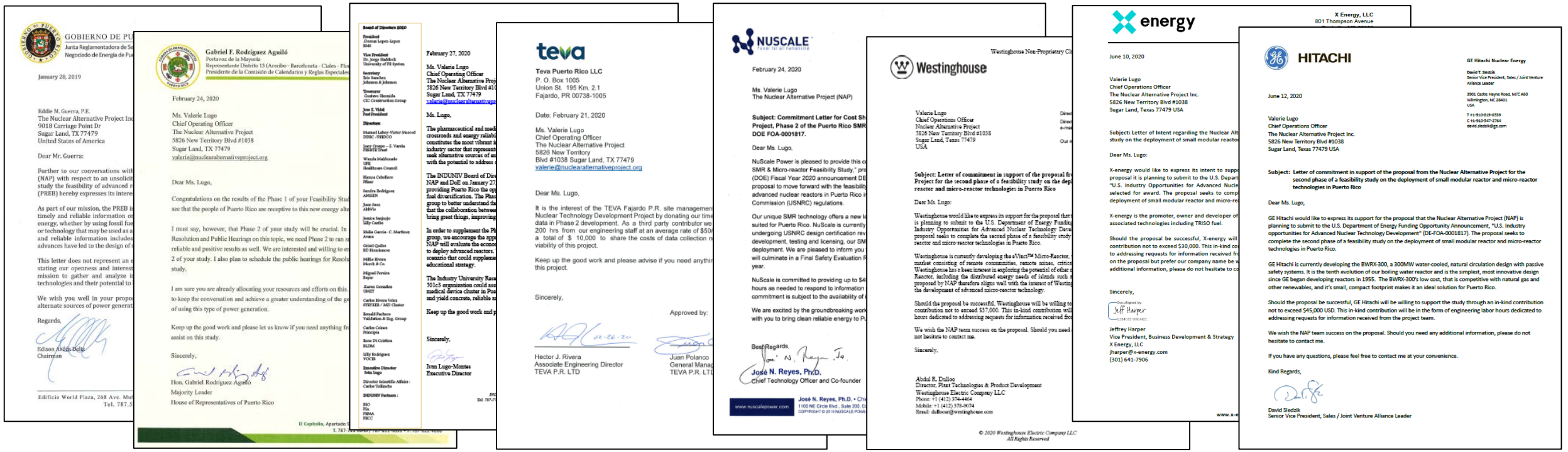
Technical Lead
Jacob Philip

REGULATORY GUIDE

REGULATORY GUIDE 4.7
(Draft was issued as DG-4021 on December 30, 2011)

GENERAL SITE SUITABILITY CRITERIA FOR NUCLEAR POWER STATIONS

A fully integrated approach to site suitability



Community + Industry + Government + Technology

Figure 9-1: Timeline for Earliest Case Scenario Deployment in Puerto Rico

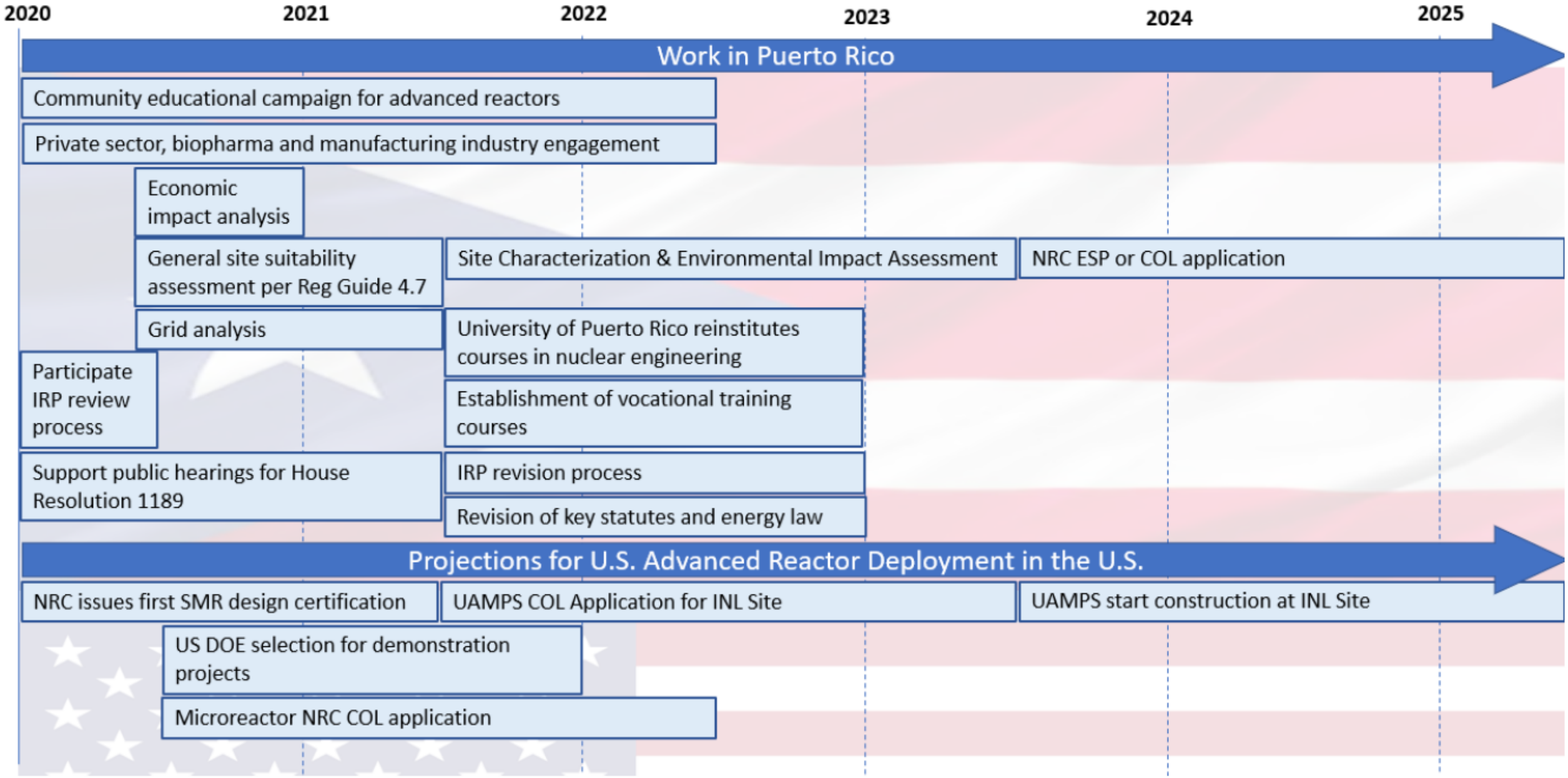
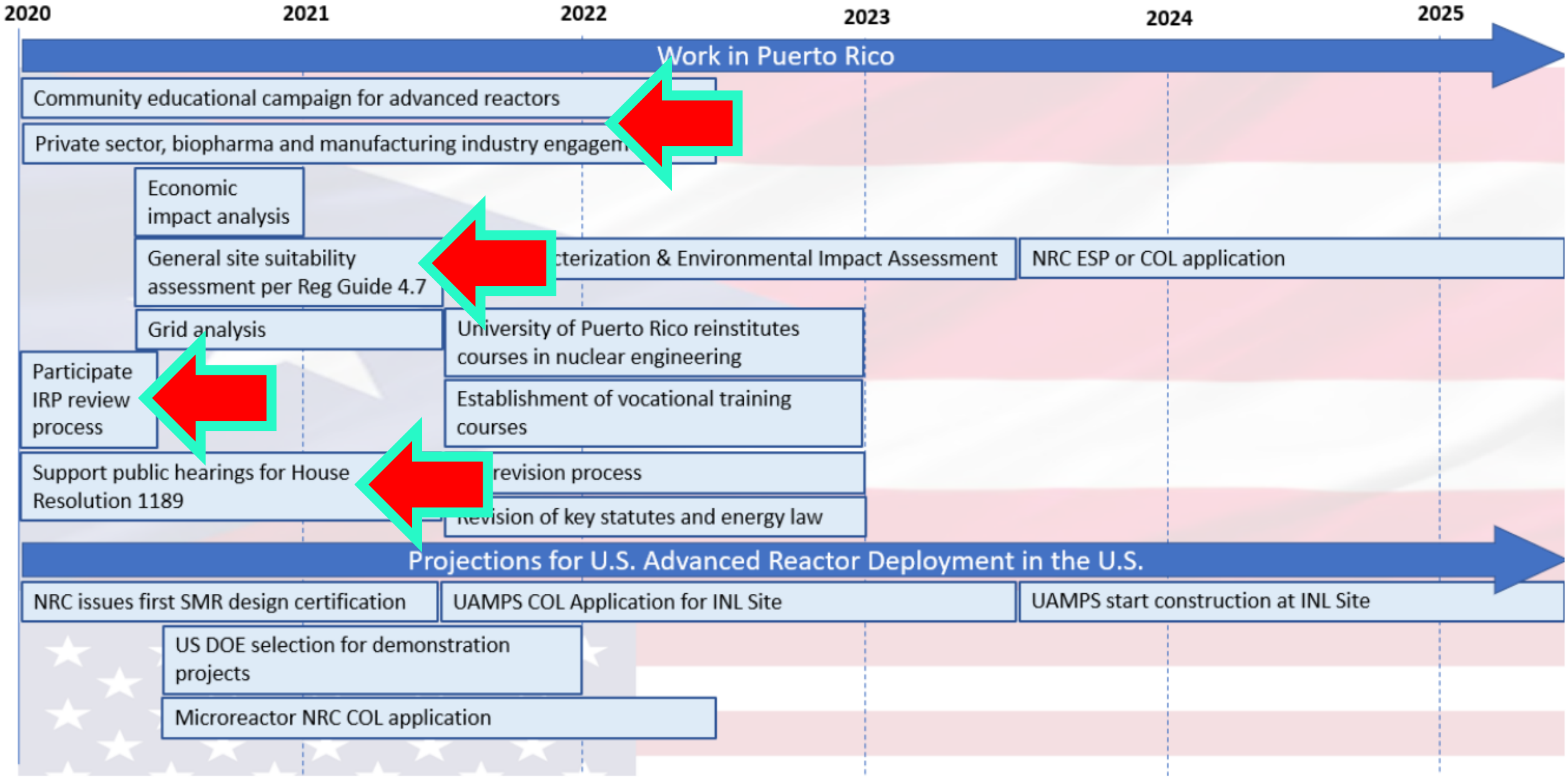


Figure 9-1: Timeline for Earliest Case Scenario Deployment in Puerto Rico



¡Gracias!

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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**.