Small Modular Reactor and Advanced Reactor

Feasibility Study

MICHAEL B. CLINE, OCTOBER 6, 2023

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Nuclear Energy for Purdue – Why Now?

1 **Campus continues to grow**
Student enrollment, facility footprint and energy use are growing

2 **Boilers and chillers are aging**
Significant capital investment required for equipment replacement and added capacity

3 **Current fuels result in greenhouse gas emissions**
Reduction efforts have decreased emissions, but no path to zero

↑17%

GROWTH IN PURDUE OWNED GROSS SQUARE FOOTAGE (GSF)

↓27%

REDUCTION IN GREENHOUSE GAS EMISSIONS SINCE 2011

↑28%

GROWTH IN WEST LAFAYETTE CAMPUS STUDENT ENROLLMENT

Determine if nuclear energy allows for continued safe, reliable, affordable utilities and zero greenhouse gas emissions

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Feasibility Study Goal

Feasibility study launched in April 2022; interim report issued in May 2023

Provide **safe, reliable and affordable energy** to meet Purdue University's West Lafayette campus long-term steam and power generation needs while **reducing greenhouse gas emissions** to achieve our campus sustainability goals.

Purdue has partnered with Duke Energy Indiana and other industry experts to conduct a study to **determine the feasibility** of transforming our existing combined heat and power system into a new system that uses **advanced nuclear technology**.

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Feasibility Study Organization

EXECUTIVE ADVISORY COMMITTEE

Mung Chiang *Purdue University*
President

Arden Bement *Purdue University*
David A Ross Distinguished Professor Emeritus, Nuclear Engineering

Stan Pinegar *Duke Energy Indiana*
State President, Indiana

William Dudley Jr. *Bechtel Group*
Vice Chairman

Maria Korsnick *Nuclear Energy Institute*
President and CEO

William Magwood *OECD Nuclear Energy Agency*
Director-General

Luis Reyes *U.S. Nuclear Regulatory Commission*
Former Executive

Carlos Hernandez *Pacific Gas & Electric*
Board of Directors

NUCLEAR TECHNICAL ADVISORY GROUP

Lefteri Tsoukalas *Purdue University*
Professor of Nuclear Engineering

Amit Varma *Purdue University*
Professor of Civil Engineering

Janelle P Wharry *Purdue University*
Associate Professor, Materials Engineering

Tim Hanley *Exelon Nuclear*
Senior Vice President, Operations Support

Other Purdue Experts on Decarbonization, Renewables and Environment

REACTOR VENDOR GROUP

PRINCIPALS IN CHARGE

Michael B. Cline *Purdue University*
Senior Vice President, Administrative Operations

Seungjin Kim *Purdue University*
Department Head and Professor of Nuclear Engineering

Chris Nolan *Duke Energy*
Vice President, New Nuclear Generation

UTILITY TECHNICAL GROUP

Ryan Gallagher *Purdue University*
Associate Vice President, Administrative Operations

Brad Runda *Purdue University*
Director, Energy and Utilities

Norman Kunkel *Duke Energy*
Engineering Manager, New Nuclear Generation

Lee Grzeck *Duke Energy*
Licensing Manager, New Nuclear Generation

Kelley Karn *Duke Energy of Indiana*
Vice President, Regulatory Affairs & Policy

INDUSTRY & GOVERNMENT RELATIONS GROUP

Debbie Hohlt
Anne Hazlett
Other Experts as Needed

MEDIA AND COMMUNICATIONS

FINANCIAL

LEGAL

STUDENT AMBASSADORS

Lecture Series Overview

Aug. 30, 2022: Clean Nuclear Energy: Past, Present and Future
Dr. Arden Bement, David A. Ross Distinguished Professor Emeritus of Nuclear Engineering, Purdue University

Oct. 5, 2022: A New Landscape for New Nuclear
Maria Korsnick, President and CEO of the Nuclear Energy Institute

Oct. 24, 2022: The 21st Nuclear Resurgence: Opportunities and Challenges
Director-General William D. Magwood, IV, OECD Nuclear Energy Agency

Nov. 30, 2022: Tough Tech' for Climate: Innovation Challenges, University Responsibilities, and Some Comments on the Nuclear Role
Dr. Richard K. Lester, associate provost of the Massachusetts Institute of Technology

Jan. 18, 2023: Nuclear Power in 2050
Dr. Kathryn D. Huff, assistant secretary for nuclear energy, Department of Energy

Feb. 22, 2023: Implementing Advanced Nuclear Technology
Tim Hanley, Constellation Nuclear; **Luis Reyes**, U.S. Nuclear Regulatory Commission; **Ahmet Tokpinar**, Bechtel

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Lecture Series Key Takeaways

1. Innovation is happening now
2. SMRs are inherently safe and bring other benefits
3. SMRs and ARs will be necessary to achieve net-zero carbon emissions
4. Hurdles exist but can be overcome
5. Research universities will play a critical role especially in workforce development

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Advanced nuclear technology

- Nuclear power plants are the only carbon-free source of energy that is safe, reliable and available 24 hours a day regardless of weather conditions
- Advanced nuclear technology offers operators flexibility and can complements variable renewables like wind and solar
- Small modular reactors and advanced reactors are easier, faster and more affordable to build, offering potential economic benefits
- Small modular reactors can produce up to 300 megawatts electric (MWe) per unit, and some newer SMR designs have higher generating capacities.

Small modular reactors and advanced reactors are safe

Cooled by water, some SMRs will operate like traditional nuclear plants that have a proven safety record and history of operational excellence.

If an event occurs that requires safe shutdown of the reactor, passive safety systems will automatically shut down and continuously cool the reactor without external power or operator action.

Due to their small size and added safety features, emergency planning zones for SMRs and ARs will likely be much smaller than those of traditional nuclear plants and might not extend beyond the site boundary.

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Interim Study Findings and Challenges

	FINDINGS	CHALLENGES
SITING	Advanced nuclear technology offers various options in site selection, some of which also allow for district steam.	Remote sites would require significant capital investments to electrify current steam and chilled water utility infrastructure.
WORKFORCE	Purdue is uniquely positioned to play a critical role in workforce development (along with other research universities, community colleges, etc.).	SMR workforce availability is low, and workforce development needs are high to meet anticipated need in the coming years.
POLICY	Federal and Indiana law and policy are supportive of advanced nuclear development, but more support will be needed.	The federal regulatory approval process is complex and lengthy, and streamlined planning, design, construction and financing are needed to establish private sector markets and supply chains for building and operating SMRs.
TECHNOLOGY	Dozens of private companies are developing advanced nuclear technologies, and the U.S. Department of Energy is supporting many through research, development and demonstration projects. First-of-a-kind projects are expected to be in service in the U.S. within a decade.	SMR designs need to be finalized by the private sector. Construction of the current first-of-a-kind projects need to be completed to establish preliminary project risk and cost profiles for future projects. Future fuel availability is uncertain.

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Next Steps

Monitor technology assessments and conduct economic and site studies

- **Continue monitoring developments in advanced nuclear technologies**
- **Quantify economic benefits through state-sponsored economic impact study**
- Perform more detailed studies and identify designs and viable locations for new nuclear units

Explore financial incentives

- Support for development activities
- Potential for future state tax credits
- Federally backed funding insurance options, public-private advanced reactor program, fuel availability program

Engage stakeholders

- **Increasing workforce development programs**
- **More engagement is needed on topics like carbon reduction, safety, reliability, economics and fuel supply and storage**

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