
## RESEARCH & TEST REACTOR

# Utilizing a Class 104(c) Licensing Pathway for the Proposed UIUC Research & Test Reactor

**WHITE PAPER**

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# Utilizing a Class 104(c) Licensing Pathway for the Proposed UIUC Research & Test Reactor

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# CONTENTS

# ABBREVIATIONS & ACRONYMS

| Abbreviation or Acronym | Definition |
|---|---|
| AEA | Atomic Energy Act |
| HTGR | High Temperature Gas Cooled Reactor |
| MMR | Micro-Modular Reactor |
| NEIMA | Nuclear Energy Innovation and Modernization Act |
| NPRE | Department of Nuclear, Plasma, and Radiological Engineering |
| NRC | U.S. Nuclear Regulatory Commission |
| R&D | Research & Development |
| RTR | Research and Test Reactor |
| UIUC | University of Illinois Urbana-Champaign |

# 1. INTRODUCTION

As the global transition continues toward reductions in carbon emissions, legacy power generations systems are being examined for suitability for nuclear replacement. The University of Illinois at Urbana-Champaign (University of Illinois, University or UIUC) intends to deploy a Research and Test Reactor (RTR, also referred to as a "non-power" reactor)[1] on the UIUC campus to perform essential educational and research activities, including studying coupling of advanced nuclear reactors within existing power generation infrastructure. As a public, non-profit, land grant university founded in 1867, UIUC is committed to enabling technologies that benefit the common good through research and education.

The Department of Nuclear, Plasma, and Radiological Engineering (NPRE) is one of twelve departments in UIUC's Grainger College of Engineering and was home to one of the early non-power university reactors, a TRIGA® Mark II research reactor. UIUC successfully operated the TRIGA® in the heart of campus for 38 years (1960-1998), and its used fuel was safely stored on-site until 2004. It has since been successfully decommissioned and the site released for unrestricted use. The UIUC TRIGA was a critical facility for educating students in reactor operations, engaging the public on peaceful uses of nuclear power, and groundbreaking research in the areas of fission fragment physics, nuclear pumped lasers, nuclear batteries, neutron activation analysis, radioisotope production, nuclear reactor kinetics, coupled core kinetics, and neutron pulse propagation[2]. The reactor site's restoration to greenfield status demonstrates UIUC's experience at every stage of reactor licensing, construction, operations, and final decommissioning.

The proposed advanced RTR is based on the Micro-Modular Reactor (MMR®), a GEN-IV High Temperature Gas Cooled Reactor (HTGR) design developed by Ultra Safe Nuclear Corporation (USNC), Seattle, WA[3]. UIUC's proposed MMR facility will be designed, licensed and constructed to meet the emerging research and education needs of advanced reactor technologies, and enable wide adoption of microreactor technology to aid in decarbonizing the world's energy needs. UIUC will be the owner and operator of the RTR and related facilities, and as such will be the USNRC licensee of record.

The objective of this White Paper is to document the justification for the selected licensing pathway of the UIUC's advanced RTR project, as indicated in the Regulatory Engagement Plan[4]. UIUC will be pursuing a Class 104(c) license as enabled by the Atomic Energy Act of 1954, as amended, the Nuclear Energy Innovation and Modernization Act (NEIMA), and the related Code of Federal Regulations, 10 CFR 50.21(c). This White Paper describes the planned use of the facility and its qualification to be licensed and to operate under a Class 104(c) license.

[1] The terms Research & Test Reactor and Non-Power Reactor may be used interchangeably to refer to the proposed facility. https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/research-reactors-bg.html
® TRIGA is a registered trademark of General Atomics
[2] https://npre.illinois.edu/news/stories/former-triga-reactor-gains-ans-national-historic-landmark-status
® MMR is a registered trademark of Ultra Safe Nuclear Corporation
[3] www.usnc.com
[4] https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML22061A211

# 2. APPLICABLE STATUTES AND REGULATIONS

Applicable statutes and regulations associated with this licensing pathway for the UIUC RTR are summarized as follows:

## 2.1. ATOMIC ENERGY ACT, SECTIONS 103 AND 104(C)

The Atomic Energy Act of 1954, as amended (AEA), provides that two different types of licenses are available for activities related to utilization and production facilities. As relevant here, AEA Section 103 provides for "Commercial Licenses" for utilization and production facilities for industrial or commercial purposes, and AEA Section 104 authorizes "Research and Development" licenses for utilization and production facilities, in subsection c, that are "useful in the conduct of research and development activities of the types specified in section 31."[5]

## 2.2. ATOMIC ENERGY ACT, SECTION 31

The Atomic Energy Act (AEA), as amended was passed to promote the "… utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public."[6] Section 31 of the AEA specifically addresses Research, and states[7], " … the Commission is authorized and directed to make arrangements…for the conduct of research and development activities relating to … (1) nuclear processes, (2) the theory and production of atomic energy, including processes, materials, and devices related to such production; … (4) utilization of special nuclear material, atomic energy, and radioactive material and processes entailed in the utilization or production of atomic energy or such material for all other purposes, including industrial or commercial uses, the generation of usable energy, and the demonstration of advances in the commercial or industrial application of atomic energy; and (5) the protection of health and the promotion of safety during research and production activities..."

## 2.3. NUCLEAR ENERGY INNOVATION AND MODERNIZATION ACT, SECTION 106 NEIMA – ENCOURAGING PRIVATE INVESTMENT IN RESEARCH AND TEST REACTORS

In late 2018, Congress passed, and in early 2019, the President signed, the Nuclear Energy Innovation and Modernization Act (NEIMA)[8] to ensure the United States retains its leadership in the nuclear sector while clarifying the regulatory process for advanced reactors. Prior to the passage of NEIMA, the AEA did not prescribe criteria for a "commercial" license. Thus, the NRC prescribed certain criteria in its regulations (discussed below). However, Section 106 of

[5] 42 USC 2033 & 2034.

[6] 42 USC 2013, Section 3. Purpose, Paragraph (d)

[7] 42 USC 2051, Section 31. Research, Paragraph (a) Research Assistance

[8] Public Law No: 115-439 (01/14/2019)

the NEIMA, which is specifically titled *"Encouraging Private Investment in Research and Test Reactors"* establishes cost recovery requirements for Class 104(c) vs 103 licensing pathways. As part of the bill, Congress amended Section 104c of the AEA to provide that "The Commission is authorized to issue licenses under this section for utilization facilities useful in the conduct of research and development activities of the types specified in AEA section 31 in which the licensee sells research and testing services and energy to others, subject to the condition that the licensee shall recover not more than 75 percent of the annual costs to the licensee of owning and operating the facility through sales of nonenergy services, energy, or both, other than research and development or education and training, of which not more than 50 percent may be through sales of energy."

## 2.4. NRC REGULATIONS, 10 CFR 50.21 AND 50.22 - CLASS 103 VS 104(C) FACILITIES

The NRC issues licenses to non-power and utilization facilities through two typical pathways commonly referred to as Class 103 (10 CFR 50.22) and 104 (10 CFR 50.21) licenses. A Class 103 license is issued to an applicant who may "use a production or utilization facility for industrial or commercial purposes." A Class 104 (c) license is for a facility which, "… is useful in the conduct of research and development activities of the types specified in section 31 of the Act." Specifically, 10 CFR 50.21 states, "A Class 104 License will be issued, to an applicant who qualifies, for any one or more of the following: to transfer or receive in interstate commerce, manufacture, produce, transfer, acquire, process, or use … (c) A production or utilization facility which is useful in the conduct of research and development activities of the types specified in section 31 of the Act, and which is not a facility of the type specified in paragraph (b) of this section or in §50.22." Paragraph (b) of the section pertains to those facilities licensed prior to December 19, 1970, those that under the Cooperative Power Reactor Demonstration Program, or are production or utilization facilities for industrial or commercial purposes, when specifically authorized by law. Section 50.22 provides that "a production or utilization facility which is useful in the conduct of research and development activities of the types specified in section 31 of the Act is deemed to be for industrial or commercial purposes if the facility is to be used so that more than 50 percent of the annual cost of owning and operating the facility is devoted to the production of materials, products, or energy for sale or commercial distribution, or to the sale of services, other than research and development or education or training."

## 2.5. NRC POST-NEIMA POLICY

As noted above, the NRC's regulatory criterion for "commercial" licenses is based on the percentage of the annual cost of owning and operating a facility that is *devoted to* commercial activities, whereas the new criteria NEIMA added to AEA Section 104c focus on the percentage of the annual cost of owning and operating a facility that is *recovered from* commercial activities. Since the passage of NEIMA on January 14, 2019, "… the NRC applies *both* the cost recovery criteria in Section 104c of the AEA and the criterion on cost expenditures in 10 CFR 50.22 to all applicants for initial and renewed Class 104c licenses for utilization facilities. Both are applied because the cost recovery criteria in Section 104c of the AEA do

not conflict with the cost expenditure criterion in the current regulations in 10 CFR 50.22 (and therefore do not serve as a de facto replacement for 10 CFR 50.22), and NEIMA does not provide any direction to the contrary."[9]

## 2.6. NRC REGULATIONS, 10 CFR 50.2 - RELEVANT DEFINITIONS

The following relevant definitions in 10 CFR 50.2 are applicable to a Class 104(c) license application, and are included here for completeness.

*Testing facility* means a nuclear reactor which is of a type described in 10 CFR 50.21(c) of this part and for which an application has been filed for a license authorizing operation at: (1) A thermal power level in excess of 10 megawatts; or (2) A thermal power level in excess of 1 megawatt, if the reactor is to contain: (i) A circulating loop through the core in which the applicant proposes to conduct fuel experiments; or (ii) A liquid fuel loading; or (iii) An experimental facility in the core in excess of 16 square inches in cross-section.

*Utilization facility* means: (1) Any nuclear reactor other than one designed or used primarily for the formation of plutonium or U–233; or (2) An accelerator-driven subcritical operating assembly used for the irradiation of materials containing special nuclear material and described in the application assigned docket number 50–608.

[9] SECY-20-0042, Rulemaking Plan on Cost Recovery Criteria for Research and Development Utilization Facilities at 4 (May 6, 2020).

# 3. PLANNED REACTOR PURPOSE

The project's overall mission is to advance the commercial readiness of advanced reactor technology through education, research, and at-scale demonstrations. Deploying the MMR RTR as a campus resource is expected to leverage the diversity of expertise and spirit of innovation across all relevant areas of science and technology at the University of Illinois. The deployment is designed around two core missions, education and research, and a cross-cutting mission of at-scale demonstration, which are key tenets of a Class 104(c) facility as envisioned in the Atomic Energy Act. These are described below:

## 3.1. CORE MISSION 1: EDUCATION

The reactor deployment is being designed to address the acute emerging shortcomings in the nuclear workforce and public understanding. Licensing and operating advanced nuclear reactors will require training facilities representative of those technologies. Between 1958 and 1972, over 50 U.S. university research reactors were built. Many of these university facilities were shut down in the 1980s & 1990s in response to waning federal funding and student enrollments. In the 2000s, student enrollment in nuclear engineering and enthusiasm for carbon-free nuclear energy rebounded significantly. However, no new university research reactors have been built in nearly 30 years. Simultaneous with an unprecedented launch of next-generation reactor demonstrations, the gap in student access to hands-on training is widening.

The workforces of regulatory bodies face a similar shortage of human capital familiar with evaluating construction permits and operating licensing applications, particularly for non-light-water technologies. Domestic and foreign governmental oversight organizations are tasked with answering the call to ensure public health and safety. Engineers who have hands on experience at advanced facilities will be better equipped to satisfy congressional mandates, the code of federal regulations, and guidance documents in novel reactor technologies. To realize the full potential of advanced nuclear reactor technologies, attention should be given to developing the future workforce needed for these technologies to be successful.

Research reactors on campuses have historically been a powerful driver of public engagement. Their low risk profile and variable operational posture make them accessible to the public, valuable to the communities in which they are embedded, and underpinned by trusted university researchers. For maximum impact, microreactor demonstrations should prioritize sites where the public can witness, understand, benefit, and recognize the case for nuclear power. A university microreactor can further enhance public confidence and trust in nuclear power, educating broad stakeholders in the innovations of next generation reactor technology.

## 3.2. CORE MISSION 2: RESEARCH

The reactor deployment is being designed as a research testbed to further the viability of advanced reactor technology. Microreactors represent a paradigm shift in nearly all aspects of nuclear power deployment and operation. In contrast to traditional nuclear power, wide adoption of microreactors will require streamlined factory fabrication, limited site preparation, long core life, minimal operation interventions and maintenance demands, small footprint for co-location with energy demand, flexible dispatch of electrical and thermal energy, and seamless return of the host site to greenfield. These requirements are substantial, but they also seed opportunity. With a robust, research-focused microreactor deployment on a university campus such design constraints can be overcome. Direct research with a microreactor includes instrumentation and monitoring systems, operations and control methodologies, validation of reactor analysis codes, optimization of system components and performance, system integration with existing power generation infrastructure, system coupling with energy intensive processes such as hydrogen production, and many other research and development areas currently being considered in the project planning.

## 3.3. CROSS CUTTING MISSION: AT-SCALE DEMONSTRATION

This cross-cutting mission is focused on the research and education enabled through at-scale demonstration of emerging microreactor markets. Large U.S. university campuses are a microcosm of the national landscape of energy needs and source diversification. The commercial viability and applicability can be demonstrated through interfacing with existing university-owned power generation and distribution infrastructure. Beyond their role as research and test reactors, microreactors have the potential to be commercially viable power sources for a large number of existing university, medical, industrial, and military campuses. University demonstration can provide an example of microreactor performance for broadly anticipated microreactor markets, such as high-performance computing and data storage, steam production for local heating, hydrogen generation for energy storage and decarbonization of transportation, resilient backup of critical infrastructure, traditional coal power replacements, and remote microgrids. The research and education performed in this cross-cutting mission is designed to accelerate the viability of advanced reactor technology to these non-traditional nuclear markets.

# 4. APPLICABILITY OF LICENSING PATH WITH PLANNED ACTIVITIES

The UIUC MMR project is required to meet the emerging education and research needs of the advanced reactor community. These education and research activities, including the cross-cutting mission of at-scale demonstration described in Chapter 3, provide clear alignment with the purpose and definition outlined under section 31 of the AEA. The reactor's capability to perform essential education and research includes initiatives which are designed to enhance the commercial viability of advanced reactor technology and lower uncertainty for future commercial investment. These viability enhancing activities, as described by the Core Missions and Cross-cutting Mission, extend the research and development value of the reactor beyond what is found in existing university-based non-power reactors. Such activities are still permissible through, and a significant component to, the Class104(c) licensing pathway. While no sales of energy or energy products are currently envisioned, if the scope of the facility's mission changes in the future, the University would expect to remain within the ownership and operations cost safe harbors prescribed in NEIMA and NRC regulations. The direct alignment of the proposed project with the Class 104(c) licensing pathway is presented here with reference to section 104(c) of the AEA, and 10 CFR 50.21(c).

## 4.1. ALIGNMENT WITH AEA SECTION 104(C)

Based on AEA Section 104(c) the following criteria must be met:

i. Utilization or production facility:
The proposed reactor is a Utilization Facility as defined in 10 CFR 50.2, because it is a reactor that is not designed for, and cannot to be used for, the production of plutonium or U-233.

ii. Conduct research and development activities of the types specified in section 31:
The stated activities in Chapter 3 align directly with four of the five permissible R&D activities defined in Section 31:

(1) research and development activities relating to nuclear processes:
R&D activities relating to nuclear processes, such as those associated with fission, burnup, long core life in the context of advanced non-light-water reactors and their resulting effect on the thermal behavior of the system, are central to the planned research and educational mission. Investigation of such processes and their resulting effects on the reactor system, system operation, and overall performance are inherent in the development and validation of computational tools related to reactor performance. As an at-scale facility, students and researchers will learn how fundamental nuclear interactions ultimately lead to process heat during the changing reactor states of start-up, operation, and shut down.

(2) research and development activities relating to the theory and production of atomic energy, including processes, materials, and devices related to such production:
R&D activities relating to the production of atomic energy, including processes, materials, and devices related to such production will be performed at the UIUC MMR through research in the operational performance of the facility. These research thrusts will include the critical enabling and synergistic technologies that

can advance its operational capabilities such as reactor instrumentation design, control methodologies, system monitoring, and future operational processes, materials, and devices that can enhance the safety or performance of the reactor system.

(3) research and development activities relating to utilization of atomic energy entailed in the production of atomic energy for the demonstration of advances in the commercial or industrial application of atomic energy:

R&D activities relating to the demonstration of advances in the commercial or industrial application of atomic energy is directly targeted by the cross-cutting mission of at-scale demonstration. The areas under the cross-cutting mission are enabled through integration of the reactor system within existing campus power generation infrastructure and additional technologies for process heat applications. Important applications of future advanced reactors are centered around nuclear installations for repurposing legacy carbon intensive energy sites and clean production of energy intensive products. With this capability, R&D will directly target advancements in the reactor system, operations, and support components to advance the commercial and industrial effectiveness of advanced reactor technology deployments.

(4) research and development activities relating to the protection of health and the promotion of safety during research and production activities:

R&D activities relating to protection of human health and promotion of safety during research and production activities is central to the core missions and cross-cutting missions of the project. Advancements and innovations in reactor safety systems and safety procedures, furthering the safety basis for advanced reactor technology, have clear alignment with the research and at-scale demonstration missions. These activities aim to improve the state of modeling and simulation of reactor behavior, develop instrumentation and monitoring systems and processes, enhance regulatory body technical expertise, and provide a test bed for demonstrating new systems and components that can advance the safe operation of the technology for various market applications.

iii. Sales of nonenergy, energy, or both, other than research and development or education and
training, not in excess of 75% ownership and operating costs:

No sales of nonenergy services nor energy are planned for the proposed UIUC RTR. Expected research partnerships, training initiatives, and educational collaborations are expected to closely follow the non-power reactor community's legacy activities. Energy generation with the reactor and subsequent use of the generated energy is not planned to be sold, rather it may be used on-campus (internal to the university organization, which is the "licensee") for demonstration purposes and associated research and technology development. If sales of nonenergy, energy, or both are considered in a future expansion of the reactor's mission, as part of the Class 104(c) license stipulations, the university expects to remain under the 75% threshold of the ownership and operating costs (recovered from such activities).

iv. Of these sales, sale of energy not in excess of 50%:
As noted above, no sales of energy are planned for the proposed UIUC RTR. If energy generated by the reactor is sold in a future expansion of the reactor's mission, as part of the Class 104(c) license stipulations, the university expects to remain under the 50% threshold of the ownership and operating costs (recovered from such activities).

## 4.2. ALIGNMENT WITH 10 CFR 50.21(C)

Based on 10 CFR 50.21(c) the following criteria will be met:

i. Utilization or production facility: See 4.1.i

ii. Conduct research and development activities of the types specified in section 31: See 4.1.ii

iii. Not a facility of the type specified in paragraph (b) of this regulation: (b) (1) A production or utilization facility the construction or operation of which was licensed pursuant to subsection 104b of the Act prior to December 19, 1970; (2) A production or utilization facility for industrial or commercial purposes constructed or operated under an arrangement with the Administration entered into under the Cooperative Power Reactor Demonstration Program, except as otherwise specifically required by applicable law; and (3) A production or utilization facility for industrial or commercial purposes, when specifically authorized by law:
Item (1) does not apply to the UIUC MMR as this facility will be constructed and operated after December 19, 1970. Item (2) does not apply as this reactor will not be constructed or operated under an arrangement with the Administration entered into under the Cooperative Power Reactor Demonstration Program. Item (3) does not apply as no law has authorized this reactor to be used for industrial or commercial purposes (and no industrial or commercial purpose is being considered).

iv. Not a facility of the type specified in 10 CFR 50.22: Class 103 licenses; for commercial and industrial facilities. A class 103 license will be issued, to an applicant who qualifies, for use a production or utilization facility for industrial or commercial purposes; Provided, however, That in the case of a production or utilization facility which is useful in the conduct of research and development activities of the types specified in section 31 of the Act, such facility is deemed to be for industrial or commercial purposes if the facility is to be used so that more than 50 percent of the annual cost of owning and operating the facility is devoted to the production of materials, products, or energy for sale or commercial distribution, or to the sale of services, other than research and development or education or training.
As noted above, no sales or commercial distribution of materials, products, or energy are planned for the proposed UIUC RTR. If materials, products, or energy from the reactor are sold or commercially distributed in a future expansion of the reactor's mission, as part of the Class 104(c) license stipulations, the university expects to remain under the 50% threshold of the annual ownership and operating costs (devoted to such activities).

# 5. CONCLUSION

The University of Illinois Urbana-Champaign is pursuing a license for an advanced test reactor to provide the educational and research needs for the advanced reactor community. The UIUC RTR will satisfy all applicable statutory and regulatory criteria to be licensed as a Class 104c utilization facility.