



# Summary of Clean Economy Jobs and Innovation Act Advanced Nuclear Energy Technology RD&D Provisions

*Resources for the Future, Fall 2020*

## Important Notes:

- This is a summary of the nuclear portion of Clean Energy Jobs and Innovation Act (HR4447 in the current Congress). We will call that portion “the Legislation.”
- In answering our questionnaire, please use the funding projections in this summary so that the funding scenarios you use are known by the readers of our report/paper and are consistent with those used by the other experts who are answering the same questions.
- The Legislation specifies funding authorizations only for FY2021-FY2025. This summary supplements those authorizations with a few additional assumptions to construct the “with-Legislation” funding scenario that we ask you to base your answers on:
  - The scenario assumes that funding authorizations will translate into actual funding.
  - Because FY2021 is well underway, it is unlikely that the Legislation would still provide substantial FY2021 funding. Consequently, all funding is shifted to one year later than what is stated in the Legislation.
  - It is quite common and expected for funding to continue beyond the initially authorized period. The funding scenario assumes that enacting the Legislation would result in higher funding for ten years (FY2022-FY2031), as specified below.
- For the first five years, the Legislation specifies the authorized funding. We base funding in years 6-10 on the average of the first five years of funding, scaled up with inflation except as otherwise noted.
- For the scenario in which the Legislation is *not* enacted, we assume FY20 funding continues but grows at inflation rate.
- All dollar values in this summary are in 2020 dollars. We assume annual inflation rate of 1.4%.
- The Legislation described below is a portion of a larger bill. However, this elicitation is just about this portion, not about the larger bill. In answering, please answer about the effects of this portion only.
- The Legislation specifies that all activities prescribed in it are to be the responsibility of the Department of Energy, unless otherwise mentioned.

## Summary of the Legislation

The Legislation (specifically sections 4101–4104 and 4202–4204) would result in a projected ten-year total of \$17.9 billion dedicated to advanced nuclear research, development, and demonstration activities for FY2022 – FY2031. This \$17.9 billion represents a \$8.55 billion increase over the corresponding projected total of \$9.35 billion during the same ten years without the AEIA (based on FY20 funding).

The programs that the Legislation would create or modify are listed below in approximate order from largest funding increase to smallest funding increase, compared to corresponding FY2020 funding. A table at the end of this summary repeats the program names, their projected annual average funding with the Legislation being enacted, and any corresponding funding that would occur without the Legislation being enacted.

The Legislation would establish the following:

- **Advanced Nuclear Reactor Research, Development, and Demonstration Program**
  - Total funding would be \$6.20 billion in FY2022-FY2031, for an average of \$620 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$230 million for the advanced reactors demonstration program.
  - The establishment of this program seeks to advance RD&D and commercial application of domestic advanced nuclear technologies that have characteristics such as the following:
    - i. Safer and lower cost relative to existing reactors
    - ii. Can be used for heating purposes such as community heating, industrial heating, synthetic fuel production, or heat storage
    - iii. Can be used for remote or off-grid applications
    - iv. Mission-critical power supplies
  - The program will advance RD&D through:
    - i. Advanced nuclear demonstration projects
    - ii. Identifying which important research areas are currently out of reach for the private sector to take on
    - iii. Facilitating access of federal research facilities, personnel and research results to the private sector
  - Evaluation criteria for selecting demonstration projects will include the diversity of advanced reactor designs (use different primary coolants, fuel types & compositions and neutron spectra), and accompanying factors such as the likelihood of commercial application, cost-competitiveness for the market, and unique technical challenges.
  - This legislation provides the opportunity for federally funded demonstrations to enter cost-sharing agreements with private industry partners, in which case a streamlined approval process should be established. Consultations on these projects will include representatives from groups such as: National Laboratories, universities, electric utilities, potential end users of new technologies, nuclear developers, health and safety experts.
- **Versatile Neutron Source**
  - Total funding is projected to be \$4.16 billion in FY2022-FY2031, for an average of \$416 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$65 million for versatile test reactor research & development.
  - The Versatile Test Reactor (VTR) project is a nuclear reactor planned by DOE to provide a source of fast (high energy) neutrons for “accelerated testing and qualification of advanced nuclear fuels, materials, instrumentation, and sensors”.
- **Nuclear Hybrid Energy Systems Research, Development, Demonstration and Commercial Application Program**
  - Total funding would be \$568 million in FY2022-FY2031, for an average of \$56.8 million per year. This program would not replace, absorb, or upgrade an existing program.

- This program supports RD&D of nuclear hybrid energy systems, which are composed of at least two systems of energy generation, storage, or other technologies. Applications of hybrid nuclear systems eligible within this program include:
  - i. Water desalination
  - ii. Hydrogen or liquid/gaseous fuel and chemical production
  - iii. Heat/electricity generation & storage, heat for industrial processes, district heating
  - iv. Carbon capture, utilization, and storage
  - v. Microgrid applications
  - vi. Integrated systems modeling, analysis and optimization
  - vii. Integrated design, planning, building and operations of systems with existing infrastructure
  
- **Advanced Fuels Program**
  - Total funding would be \$1.44 billion in FY2022-FY2031, for an average of \$144 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$125.6 million for the advanced fuels program including accident tolerant fuels and TRISO fuels.
  - Section 1503 would authorize a program for new research and development in Advanced Fuels for existing commercial reactors and advanced reactors. Objectives of the program include:
    - i. Improve performance and accident tolerance
    - ii. Improve the use of fuel resources (such as recovery of uranium and plutonium from spent fuel)
    - iii. Improve nuclear weapons proliferation resistance (to reduce the potential weapons use of recovered plutonium).
  - By the end of 2026, the program has a goal for initial commercial application of these advanced fuel development technologies (such as fabrication).
  
- **Used Nuclear Fuel Research, Development, Demonstration and Commercial Application Program**
  - Total funding would be \$993 million in FY2022-FY2031, for an average of \$99.3 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is a total of \$87.5 million, including \$62.5 million for Used Nuclear Fuel Disposition R&D and \$25 million for the Integrated Waste Management System program.
  - This program provides funding for RD&D for improving the advanced fuel cycle, establishes a RD&D and commercial application program focusing on improving fuel cycle performance and supporting the reuse, storage and disposal options of used nuclear fuel, especially for advanced nuclear reactors and non-reactor concepts. In greater detail, this program focuses on:
    - i. Storage options like dry cask storage, consolidated interim storage, and deep geological storage and disposal
    - ii. Transportation for used nuclear fuel
    - iii. Integrated waste management systems
    - iv. Vitrification
    - v. Fuel recycling and transmutation tech (such as electrochemical and molten salt tech, advanced redox extraction)
  
- **Sustainability Program for Light Water Reactors**
  - Total funding would be \$595 million in FY2022-FY2031, for an average of \$59.5 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$47 million for light water reactor sustainability.

- This program serves as to support RD&D and commercial applications to improve existing light-water reactor nuclear power plants, with an emphasis on improving factors like reliability, capacity, flexible operations, safety, efficiency and resilience.
- **University Nuclear Leadership Program**
  - Total funding would be \$140 million in FY2022-FY2031, for an average of \$14 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$10 million for the integrated university program and related R&D subprograms, including support similar to this subprogram.
  - This section renames an existing joint program between DOE, National Nuclear Security Administration (NNSA) and the Nuclear Regulatory Commission (NRC) into the University Nuclear Leadership Program. The program allocates funds to be used for scholarships, fellowships, and R&D projects at institutions of higher education, specifically related to research on advanced nuclear reactors, fuel cycle technologies and generally the field of nuclear science/engineering.
- **Nuclear Energy Apprenticeship Subprogram**
  - Total funding would be \$46.7 million in FY2022-FY2031, for an average of \$4.67 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$10 million for the integrated university program and related R&D subprograms, including support similar to this subprogram.
  - Funding would be available for the Nuclear Energy Apprenticeship Subprogram with the objective of coordinating with National Laboratories, universities, and industry partners to provide graduate-level training and apprenticeships aligned to “meet critical mission needs of the Department”.
- **Radiological Facilities Management Program**
  - Total funding would be \$187 million in FY2022-FY2031, for an average of \$18.7 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$9 million for the research reactor infrastructure subprogram.
  - The existing Radiological Facilities Management Program at the DOE includes the Research Reactor Infrastructure (RRI) subprogram. This subprogram provides “project management, technical support, quality engineering and inspection, and nuclear material support” to university research reactors.
- **Advanced Nuclear Fuel Availability Program**
  - Total funding would be \$341 million in FY2022-FY2031, for an average of \$34.1 million per year.
  - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$32MM for the centrifuge program to enrich available uranium to high-assay low-enriched uranium fuel (HA-LEU) levels (Civil Nuclear Research, Fuel Cycle R&D Program).
  - The DOE would establish a program to support the availability of HA-LEU for use in advanced nuclear reactors for both demonstration and commercial use.
  - As part of the program, DOE would:
    - Develop criticality benchmark data to assist the Commission in certifying transportation packages and regulating category II spent nuclear fuel fabrication and enrichment facilities
    - Certify fuel transportation package designs by Jan 1, 2026

- Provide HA-LEU for commercial and demonstration projects, but retain responsibility “for the storage, use, and disposition of all radioactive waste created by the irradiation, processing, or purification of such uranium”
  - Establish a consortium to support the availability of HALEU for demonstration or commercial purposes
- **Advanced Reactor Technologies Program**
    - Total funding would be \$513 million in FY2022-FY2031, for an average of \$51.3 million per year.
    - For comparison, corresponding projected annual funding in the without-Legislation scenario is \$55 million for the advanced reactor technologies program.
    - This program supports RD&D of advanced reactor technologies, which includes:
      - i. Reactors that are resistant to proliferation and are passively safe
      - ii. Promoting plant designs that are economically competitive, improve on factors like efficiency, cost, environmental impact, and use fuels that produce less waste.
      - iii. R&D support for extreme environment challenges, advanced fuels, modeling & simulation, waste reuse/reduction, advanced sensors & control systems, and advanced manufacturing/construction techniques such as digital twins, etc.
      - iv. Ensuring the maintenance of nuclear research infrastructure at National Laboratories and institutions of higher education (hot cell facilities, versatile fast neutron source, and advanced coolant testing facilities)
    - An advisory board of technology experts and private sector representatives will be created to advance the development of advanced reactor designs and shall submit an annual report to Congress. Additional consulting with the National Nuclear Security Administration will focus on the integration of reactor safeguards and security measures in these designs.
- **International Nuclear Energy Cooperation**
    - This program will coordinate international efforts to promote nuclear research, commercialization, and nonproliferation. Such collaborative efforts include:
      - i. International R&D agreements
      - ii. Maintaining or establishing new international commitments such as the International Framework for Nuclear Energy Cooperation and the International Atomic Energy Agency.
    - This program is not a funding line item in the Legislation, so there is no identifiable funding change associated with it.

**Projected DOE Nuclear Fission Funding Without and With the Legislation Being Enacted**  
(in 2020 dollars)

In the following table, the programs and projected funding in the with-Legislation scenario are shown on the right. The ones in blue are in the Legislation. To the left of them are the FY20 funding items that they would replace. Below the rows with blue are the current programs that would not be affected by the Legislation so they are the same in the without-Legislation and with-Legislation scenarios.

DOE FY20 Budget – Nuclear Program Items	Avg. Annual Spending based on FY20	Match Status	HR4447 – Nuclear Program Items	Avg. Annual Spending FY22-31 with HR4447
Advanced Reactors Demonstration Program	\$230,000,000	<-Match->	Advanced Nuclear Reactor Research, Development, and Demonstration Program	\$619,870,000
Versatile Advanced Test Reactor R&D	\$65,000,000	<-Match->	Versatile Neutron Source	\$416,219,000
		New	Nuclear Hybrid Energy Systems Research, Development, Demonstration and Commercial Application Program	\$56,762,000
Accident Tolerant Fuels (Advanced)	\$95,600,000	<-Match->	Advanced Fuels Program	\$143,797,000
TRISO Fuel and Graphite Qualification (Advanced)	\$30,000,000			
Used Nuclear Fuel Disposition R&D	\$62,500,000	<-Match->	Used Nuclear Fuel Research, Development, Demonstration and Commercial Application Program	\$99,333,000
Integrated Waste Management System	\$25,000,000			
Light Water Reactor Sustainability	\$47,000,000	<-Match->	Sustainability Program for Light Water Reactors	\$59,465,000
Research & Development (Includes Integrated University Program & STEP R&D)	\$10,000,000	<-Match->	University Nuclear Leadership Program	\$13,995,000
			Nuclear Energy Apprenticeship Subprogram	\$4,665,000
Research Reactor Infrastructure	\$9,000,000	<-Match->	Radiological Facilities Management Program	\$18,661,000
Mining, Conversion, Transport [Fuel Cycle Research & Development]	\$2,000,000	<-Match->	Advanced Nuclear Fuel Availability Program	\$34,057,000

Material Recovery and Waste Form Development	\$30,000,000			
Advanced Reactor Technologies	\$55,000,000	<-Match->	Advanced Reactor Technologies Program	\$51,317,000
-	-	New	International Nuclear Energy Cooperation	N/A
Crosscutting Tech Development [Nuclear Energy Enabling Techs]	\$25,000,000	Unaffected	Crosscutting Tech Development [Nuclear Energy Enabling Techs]	\$25,000,000
Joint Modeling and Simulation Program [Nuclear Energy Enabling Techs]	\$35,000,000	Unaffected	Joint Modeling and Simulation Program [Nuclear Energy Enabling Techs]	\$35,000,000
Nuclear Science User Facilities [Nuclear Energy Enabling Techs]	\$30,000,000	Unaffected	Nuclear Science User Facilities [Nuclear Energy Enabling Techs]	\$30,000,000
Transformational Challenger Reactor [Nuclear Energy Enabling Techs]	\$23,450,000	Unaffected	Transformational Challenger Reactor [Nuclear Energy Enabling Techs]	\$23,450,000
Civil Nuclear Enrichment [Fuel Cycle Research & Development]	\$40,000,000	Unaffected	Civil Nuclear Enrichment [Fuel Cycle Research & Development]	\$40,000,000
Fuel Cycle Lab R&D	\$20,000,000	Unaffected	Fuel Cycle Lab R&D	\$20,000,000
Advanced Small Modular Reactor RD&D	\$100,000,000	Unaffected	Advanced Small Modular Reactor RD&D	\$100,000,000
<b>Projected Annual Total if Legislation not Enacted</b>	<b>\$934,550,000</b>		<b>Projected Annual Total if Legislation Enacted</b>	<b>\$1,791,591,000</b>

For the first five years, the Legislation specifies the authorized funding. We base funding in years 6 – 10 on the year-5 funding, but scaled up with inflation. There is one exception, which is that for the Versatile Neutron Source we base the funding in years 6-10 on the amount necessary to bring the total for the Versatile Neutron Source to \$4.5 billion in nominal dollars, the central estimate of the total cost of the project.