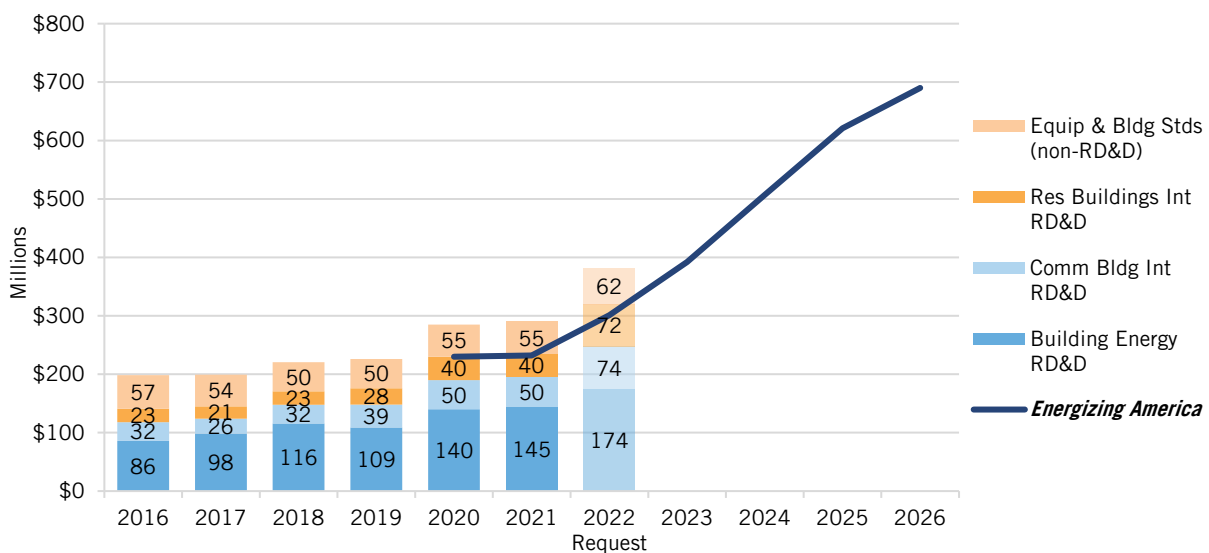


Federal Energy RD&D: Building Technologies

BY COLIN CUNLIFF AND LINH NGUYEN | JUNE 2021

The Department of Energy’s (DOE) Building Technologies Office (BTO) invests in research, development, and demonstration (RD&D) to advance novel technologies that are designed to improve the efficiency and reduce the energy costs of the nation’s residential and commercial buildings—particularly the largest energy users therein: lighting, space conditioning and refrigeration, water heating, appliances, and miscellaneous electric loads, as well as the building envelopes themselves. BTO also works on improved energy modeling and system controls to predict and manage both energy-efficient appliances or equipment and system and whole-building energy usage.¹

Figure 1: *Energizing America* recommends ramping up funding for building technologies RD&D by 150 percent by FY 2026.²



What’s at Stake

Residential and commercial buildings are the single largest energy-consuming sector in the U.S. economy, accounting for 72 percent of the nation’s electricity use and 40 percent of its total energy demand.³ As a result, Americans spend nearly \$400 billion each year to power their homes, offices, schools, hospitals, and other buildings.⁴ When all greenhouse gas emissions, including from electricity generation, are distributed by end-use sector, buildings account for the largest share of gross emissions at 32 percent, ahead of the industrial and transportation sectors.⁵ Despite its prominence as an energy-consuming sector and leading source of emissions, the buildings sector accounts for only 4 percent of DOE’s applied energy technology portfolio. The Information Technology and Innovation Foundation (ITIF) and other prominent organizations, including the International Energy Agency, have recommended that government energy RD&D programs increase focus on end-use innovations.⁶

The Building Technologies program has established the goal of reducing from 2010 levels the average energy use per square foot of all U.S. buildings by 30 percent by 2030, with a long-term goal of reducing energy intensity of homes and commercial buildings by 50 percent or more.⁷ In addition to these whole-building targets, BTO is pursuing substantial improvements to the efficiency of energy services within buildings, including lighting (65 percent improvement); water heating (35 percent); heating, ventilation, and air conditioning (HVAC) (25 percent); building envelopes and windows (35 percent); appliances (30 percent); and sensors and controls (20 percent).⁸ Achieving these goals by 2030 would decrease total energy use by 5 quadrillion BTUs, cut carbon emissions by 450 million metric tons, and save consumers over \$100 billion in energy costs annually.⁹

BTO leads DOE's research in smart buildings, smart appliances, and grid-integrated efficient buildings (GEBs). As part of a new research initiative to develop GEBs, DOE is exploring artificial intelligence (AI) applications in whole building controls, sensors, modeling, and analytics, as well as applications in advanced lighting and HVAC systems.¹⁰ In October 2020, BTO also launched a Connected Communities funding opportunity announcement, which will provide up to \$65 million for communities to pilot new technologies that enable groups of buildings and distributed energy resources to connect and cooperate to optimize energy performance.¹¹

BTO also supports collaborative partnerships through the Better Buildings Initiative (BBI) to accelerate the rapid uptake and continued improvement of building innovations, and to develop new resources to lower energy costs. Through BBI, DOE has partnered with more than 900 organizations, including businesses, schools, hospitals, state and local governments, public housing authorities, retailers and grocery stores, and residential organizations across the country. BBI partners represent 32 of the country's Fortune 100 companies, 12 of the top-25 U.S. employers, 12 percent of the U.S. manufacturing energy footprint, and 13 percent of total commercial building space, as well as 17 federal agencies, 28 states, 90 local governments, and 8 national labs. As a result of innovative energy solutions developed through BBI, its partners have reported an estimated cost savings of \$10.7 billion, 1.76 quadrillion BTUs in energy savings, and 105 million tons of avoided carbon dioxide emissions since 2011, while partnerships with other federal agencies have resulted in over \$12.3 billion in cumulative energy cost savings.¹²

The Energy Act of 2020 provides the first reauthorization of DOE's Building Technologies program in over a decade. The bill directs DOE to establish a Federal Smart Building Program to demonstrate the cost and benefits of smart buildings and implement associated technologies. It also establishes an RD&D program that targets innovation for building-to-grid integration, including low-cost, low-power, wireless sensors to monitor building energy load, forecast building energy need, and enable building-level energy control; advanced data management capabilities to enhance building and grid interoperability; and advanced energy management components such as control systems to enable energy efficiency and savings. Moreover, as part of the agency's Better Buildings Challenge, the bill requires DOE to demonstrate innovative policies and strategies for the transition to smart buildings in the public, institutional, and commercial buildings sectors.¹³

Figure 1 shows historical DOE investment in building technologies RD&D by subprogram, for fiscal years 2016 through 2021, and the FY 2022 budget request. The blue line shows

recommended RD&D funding levels from the *Energizing America* report (see box 1). Recommended funding levels are for RD&D subprograms only and exclude the Equipment and Building Standards subprogram. Because buildings make up a disproportionately small share of the federal energy RD&D budget (32 percent of U.S. greenhouse gas emissions, when emissions from electricity generation are distributed according to use) *Energizing America* recommends a fast ramp-up to 150 percent above FY 2020 levels over the next five years.

Box 1: An Innovation Agenda for Building Technologies

The *Energizing America* report co-authored by ITIF and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate innovation in building technologies. Similarly, ITIF's March 2021 report "How Congress and the Biden Administration Could Jumpstart Smart Cities with AI" makes recommendations to DOE and Congress on grid-integrated buildings and smart building technologies:

- Congress should ramp up investment in building technologies RD&D by 150 percent over the next five years. This increase is needed to rebalance the research portfolio and make up for historical underinvestment. The buildings sector accounts for 12 percent of direct U.S. greenhouse gas emissions, which jumps to 32 percent when emissions from electricity are distributed by end-use sector. But buildings make up just 6 percent of DOE's research portfolio.¹⁴
- Congress should increase investment in RD&D of AI for building energy applications, including DOE programs in advanced grid RD&D, grid-integrated efficient buildings, and energy systems integration.¹⁵
- DOE and the Environmental Protection Agency (EPA) should research alternatives to F-gas refrigerants with high global warming potential. DOE should also support the development of refrigerant-free air conditioning technologies such as solid-state cooling.¹⁶
- DOE should expand investment in advanced air flow, air sealing, ventilation controls, and high-performance windows to improve building energy efficiency.¹⁷
- DOE should invest in developing energy-efficient air conditioners that are suitable for hot or humid climates and collaborate with international partners such as India.¹⁸
- BTO should coordinate with the Geothermal Technologies Office to research geothermal heat pumps that enable buildings to exchange heat with the ground through connections with HVAC systems.¹⁹

Building Technologies RD&D Subprograms

BTO RD&D activities are divided among three main subprograms:²⁰

- **Building Energy R&D (BERD)** sponsors research and development (R&D) in energy-efficient building technologies; buildings-to-grid; lighting; heating, ventilation, and air-conditioning & refrigeration; windows & envelopes; solid-state lighting; and building energy modeling.
- **Commercial Buildings Integration (CBI)** conducts RD&D and analytical studies of building systems (e.g., lighting, HVAC, envelopes, sensors, and controls) and whole commercial buildings (e.g., office buildings, schools, hospitals, stores, warehouses, and public infrastructure buildings) to assess the interactive effects of combining multiple novel technologies within a commercial building system; and also supports commercial building partnerships through stakeholder networks such as BBI to develop and demonstrate innovative energy-saving technologies and solutions.
- **Residential Buildings Integration (RBI)** conducts RD&D to identify technology areas and technical solutions that offer the potential for large energy savings in new and existing homes, and works to demonstrate and validate innovative technology solutions through its Advanced Building Construction (ABC) initiative—an effort that integrates energy-efficiency solutions into construction practices—Building America, Zero Energy Ready Homes, and BBI.

Additionally, the Equipment and Building Standards subprogram implements statutory requirements to set minimum efficiency standards for appliances and equipment.

Key Elements of the FY 2022 Budget Proposal²¹

The budget proposal seeks \$382 million for BTO RD&D activities, a 32 percent boost from FY 2021 enacted levels. Some highlights include:

- **A 48 percent increase in the Commercial Buildings Integration subprogram**, including funding for later-stage development and commercialization activities, such as the High Impact Technology Innovation Catalyst (HIT Catalyst) program which supports demonstration and validation of building systems optimization and advanced technology solutions and continued funding for the Better Buildings Initiative.
- **An 80 percent increase in the Residential Buildings Integration subprogram**, including expanded RD&D funding for Advanced Building Construction (ABC) technologies to meet the Administration's goal of building or retrofitting 1 million homes in four years; continued funding for the Solar Decathlon challenge to design and build new highly-efficient solar-powered homes; and technical assistance and partnerships to scale the use of high efficiency technologies such as heat pumps and low-emissivity windows.
- **A 13 percent increase in the Emerging Technologies (formerly Building Energy R&D) subprogram**, with increased funding for projects focused on advanced building energy management systems and grid interactive control technologies to reduce energy consumption and carbon emissions. The request also increases funding for research on lower global warming potential refrigerant technologies, especially for supermarket refrigeration application.

Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), <http://www2.itif.org/2020-energizing-america.pdf>.
- Colin Cunliff, Ashley Johnson, and Hodan Omar, “How Congress and the Biden Administration Could Jumpstart Smart Cities with AI” (ITIF, 2021), <https://itif.org/publications/2021/03/01/how-congress-and-biden-administration-could-jumpstart-smart-cities-ai>.
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ENDNOTES

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7. Ibid.
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