4.

R&D

RESEARCH AND DEVELOPMENT DRIVES ENVIRONMENTAL, ECONOMIC PROGRESS

Key Takeaways:

- Research and development at the private and public levels spur scientific discoveries and technological breakthroughs to improve our knowledge base, human wellbeing, and the environment.
- Commercial breakthroughs that create jobs, drive economic growth, and reduce the risks of climate change will come from a variety of research channels.
- Removing barriers to private R&D and providing consistent expenditures for public R&D will accelerate the deployment of next generation technologies, strengthen American energy security, reduce global emissions, and strengthen the resilience of communities.

Research and development (R&D) at the private and public levels is essential to advance scientific discoveries, contribute to public knowledge, and accelerate next-generation technologies. Through the private sector, federal agencies, research institutions, and universities, R&D can deliver groundbreaking innovations and generate enormous positive economic spillovers.

THE ROLE OF RESEARCH AND DEVELOPMENT

Federal research expenditures should take on endeavors of national significance and focus on efforts that are not being undertaken by the private sector. Philip Rossetti, senior fellow at the R Street Institute, stresses that "Public spending on R&D is most effective when complementary to the private sector, and crowding out from public spending on R&D is most likely to occur when spending is too high, as the Organization for Economic Co-operation and Development (OECD) notes that funding business R&D beyond 25 percent of costs is more likely to crowd out rather than stimulate business R&D."[1] Therefore, public R&D should be complementary to private sector investments. Granted, what research the government should undertake versus what the private sector should undertake is not always abundantly clear. Federal agencies have provided some guidance by establishing Technology Readiness Levels (TRLs), but even so, the exact point at which commercialization is the sole responsibility of the private sector remains a gray area.[2]

Commercial breakthroughs that create jobs, drive economic growth, and reduce the risks of climate change will come from a variety of research channels and in a variety of forms. For instance, Department of Defense research for national security objectives has spawned many revolutionary commercial products such as the global positioning system (GPS) and the internet.[3] DOD's research in clean energy, whether that is solar photovoltaics, micro nuclear reactors, or battery storage, can enhance the mission capabilities of America's military while validating exciting, innovative technologies.[4] The same can be said for basic research at the Department of Energy's Office of Science.

> ***"In 2018 federal R&D directly and indirectly supported 1.6 million jobs, $126 billion in labor income, $197 billion in added economic value, and $39 billion in federal and state tax revenue."***

Other programs have a more direct mission to stimulate the commercialization of energy technologies to improve energy security and combat climate change. One example is DOE's Advanced Research Projects Agency-Energy, or ARPA-E. The agency has a mission to "overcome long-term and high-risk technological barriers in the development of energy technologies" that will reduce energy imports, reduce emissions, and improve energy efficiency.[5] The agency is meant to fund "scientific discoveries into marketable technologies"[6] in which venture capitalists would not yet invest. In FY21, the U.S. government awarded ARPA-E $427 million to conduct essential research and development for clean technologies. Importantly, federal dollars spent at ARPA-E have had positive ripple effects in private markets. In its ten-year history, more than 800 patents have been issued as a result of ARPA-E. Additionally, 185 projects supported by ARPA-E have attracted some $9.87 billion in private-sector follow-on funding, and 129 projects have gone on to form new companies.[7]

Outside of ARPA-E, federal investments in clean technologies have positive economic impacts. **In 2018 federal R&D directly and indirectly supported 1.6 million jobs, $126 billion in labor income, $197 billion in added economic value, and $39 billion in federal and state tax revenue.**[8] In 2022's fiscal year, the United States will invest close to $17 billion (0.3% of GDP) of public money into climate-related research and development. This more than doubles the $7.8 billion that the government allocated in 2021.[9]

> ***"From individual financiers to large corporate R&D investments, the private sector invests heavily in climate innovation research, development, and early-stage startups."***

Research institutions also play a vital role in research and development. For instance, researchers from the Massachusetts Institute of Technology created a new material that is stronger than steel and lighter than plastic, calling the discovery "a feat thought to be impossible."[10] The commercial application remains to be seen, but innovative breakthroughs like this could be the answer for hard-to-decarbonize industrial sectors of the economy and for improved climate resiliency.

THE IMPORTANCE OF PRIVATE SECTOR R&D

Of course, one cannot overlook the leading role the private sector plays in climate entrepreneurship. **From individual financiers to large corporate R&D investments, the private sector invests heavily in climate innovation research, development, and early-stage startups.** For example, Earthshot Ventures launched a new venture capital fund to "invest in entrepreneurs solving climate's toughest challenges."[11] Earthshot invests in both hardware and software companies from Seed through Series B funding. The fund spun off from Elemental Excelerator and brings a team that has invested in more than 150 climate startups.[12] The proliferation of startup incubators in recent years is an exciting model that brings together innovators, entrepreneurs, and investors.[13]

Another innovative, private sector led funding model is philanthropic VC. For example, Prime Coalition is a "nonprofit organization focused on addressing the critical funding gap for transformative, early stage solutions to climate change. Prime's unique model blends different forms of catalytic capital to support innovative technologies with the potential to reduce or sequester greenhouse gas (GHG) emissions at the gigaton scale by 2050."[14] Catalytic capital differs from other capital investments in that investors may accept more risk or wait longer for returns. The hope and expectation is that the investment could result in the commercialization of profitable, game-changing technologies.[15] Those game changers could pay off big for investors and the planet. Not every venture investment falls explicitly into the research and development category. Nevertheless, the appetite for venture capital to make aggressive commitments toward climate innovation, even at very early stages, is extremely promising.

An April 2021 report from the International Energy Agency on global trends in clean energy innovation provides more encouraging news. Patents for low-carbon energy technologies grew significantly from 2004-2014 and, after a bit of a slump from 2014-2016, climbed again from 2017-2019.[16] Importantly, the report emphasizes: "Countries are specializing nationally and collaborating internationally to foster local technology advantages."[17] **Free and open markets encourage innovators in different countries to specialize, producing goods in which they have a competitive advantage. The result is greater productivity, greater trade flows, and greater deployment of a wide variety of clean energy technologies.**

> ***"Free and open markets encourage innovators in different countries to specialize, producing goods in which they have a competitive advantage. The result is greater productivity, greater trade flows, and greater deployment of a wide variety of clean energy technologies."***

Indeed, the private sector in America is investing heavily in research and development. In 2019, the private sector spent $493 billion on total R&D, $429 billion of which was funded by companies themselves, nearly a 12% increase.[18] Climate specific private sector R&D is also increasing. **In 2021 companies made historic investments in clean energy and low-carbon technologies on the global stage, with total spending reaching $920 billion.** $165 billion of that was categorized as funding for climate technology innovation (versus deployment). Of this $165 billion, $111 billion came from public markets; $62.4 billion came from IPOs and secondary offerings; $53.7 billion came from private investors; and $35 billion came from SPAC reverse mergers.[19]

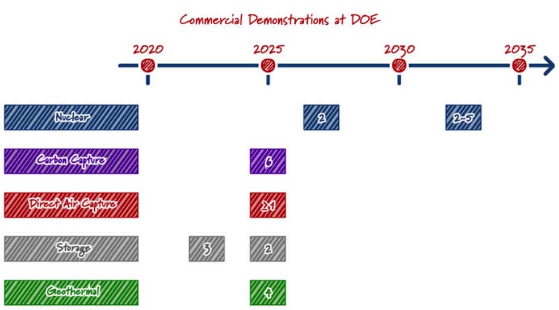
In the Americas, investments in low or zero-carbon technologies grew by 21% to $150 billion in 2021, with electric vehicle investment growing by 84%. While impressive, the Americas rank third (out of 3) in energy transition investments. The Asia Pacific region is first (49% of total investments) and Europe and the Middle East is second, accounting for 31%.

> ***"In 2021 companies made historic investments in clean energy and low-carbon technologies on the global stage, with total spending reaching $920 billion."***

FEDERAL SPENDING ON R&D

Over the past few years, the United States government has made significant commitments at the federal level for next-generation technologies and demonstration projects. In 2020, Congress passed the Energy Act of 2020, which packaged together several bipartisan energy and climate bills. The most comprehensive energy legislation in over a decade, the Energy Act authorized several research and development programs and demonstration projects to accelerate clean energy deployment in the United States.[20]

Importantly, the Energy Act programs included funding for research and development for a wide range of technologies including carbon capture for natural gas operations (LEADING Act), energy storage (BEST Act), and advanced geothermal (AGILE Act). The Energy Act also authorized the Advanced Reactor Demonstration Program (ARDP), which will give seven awards to U.S. nuclear reactor companies: two for advanced reactor demonstrations by 2027, and five for risk reductions for future demonstrations in the early 2030s.[21]



Source: ClearPath

In 2021, Congress again made big commitments for energy research and development and for next generation technologies, this time through the Infrastructure Investment and Jobs Act (IIJA). The IIJA includes funding for direct air capture projects and for carbon capture demonstration projects. The IIJA expanded DOE's hydrogen research program and included funding for four clean hydrogen hubs which could accelerate the commercialization and deployment of the technology. The legislation also included $3 billion for battery recycling research and development and $500 million for R&D to support greenhouse gas reductions from industrial sources.[22]

In addition to funding several new and Energy Act programs, the IIJA also appropriated $21.5 billion in funding to the first-year Office of Clean Energy Demonstration (OCED). The OCED will distribute funds for a wide range of technologies including regional hydrogen hubs ($8 billion), carbon capture and storage demonstration ($2.5 billion), energy storage ($355 million), and several others. Importantly, the OCED will seek to bridge the "valley of death" between funding and development for early stage energy projects.[23]

While American research and development at the federal level has had positive economic and environmental impacts, the United States still lags globally. In the Information Technology and Innovation Foundation's (ITIF) 2021 Global Energy Innovation Index, the United States ranked 17 out of 34, a 13-place drop from its ranking in 2016. ITIF's Knowledge Development and Diffusion subindex, which includes public R&D and invention, placed the United States 20th overall.[24]

> ***"While American research and development at the federal level has had positive economic and environmental impacts, the United States still lags globally. In the Information Technology and Innovation Foundation's (ITIF) 2021 Global Energy Innovation Index, the United States ranked 17 out of 34, a 13-place drop from its ranking in 2016."***

Public sector investment may be lagging compared to other nations, but the U.S. ranks high (7th overall) in ITIF's Entrepreneurial Experimentation and Market Formation subindex. The reality is the United States is home to Silicon Valley, some of the world's most entrepreneurial companies, world-class research facilities, and top-quality colleges and universities. As the authors note:

> *The United States also does well in the entrepreneurial ecosystem category. It is home to many more high-impact start-ups and far more venture capital funding in absolute terms than any other country, although these totals pale a bit when scaled by GDP, leaving it in third place in this category. The United States is pulled down to the 12th spot on this subindex, however, by its dismal rankings in trade and market readiness. It held fourth place in the subindex in 2016, when it scored much better in market readiness and came in first in entrepreneurial ecosystem.*

The U.S. has made important strides at the federal and private level to accelerate energy innovation, but policymakers can do more to capitalize on public R&D and unleash more private R&D.

POLICY RECOMMENDATIONS TO EXPAND R&D AND INCREASE COMMERCIAL OPPORTUNITIES FOR INNOVATIVE BREAKTHROUGH TECHNOLOGIES

To accelerate R&D expenditures for breakthrough technologies, Congress and the administration should:

- **Make immediate expensing permanent and apply it to longer asset class lives and research and development.** Immediate expensing allows companies to deduct the cost of capital purchases at the time they occur rather than deducting that cost over many years based on cumbersome depreciation schedules. Without expensing, the tax code is biased against new investment; however, full and immediate expensing would incentivize investments in cleaner, more efficient technologies. Immediate expensing increases capital stock turnover in energy systems, manufacturing equipment, retrofits and new equipment. This would save energy and reduce emissions.[25] Immediate expensing would also improve energy efficiency—one of the most cost-effective ways of reducing emissions—in homes, buildings, vehicles, and equipment. However, because energy efficient technologies typically have higher upfront costs, businesses may forego these investments.

  The Tax Cuts and Jobs Act of 2017 allowed for immediate expensing for assets with lives of 20 years or less, and the expensing begins phasing out by 20 percent from 2023 through 2026. Congress should remove the phase out and make immediate expensing available for short-lived and long-lived assets, including for research and development (R&D). Rossetti (R Street Institute) found that the implementation of R&D expensing through the 2017 tax reform bill had profound positive effects on private sector energy and environment R&D.[26] Rossetti noted that "Prior to the tax reform, private sector E&E R&D was relatively stagnant, only increasing by 2 percent from 2012-2017. After the tax reform, E&E R&D jumped by $3.3 billion, or 11.8 percent. Private sector E&E R&D is roughly seven times as large as public sector R&D and fulfills a fundamentally different role in the innovation life cycle than public sector R&D, so the increase in private sector innovation may mark a win for investment in technologies that are key in the pursuit of global climate objectives."[27] In the long-run, businesses may adjust R&D expenditures as they adjust to the permanency of immediate expensing. However, the option to deduct costs immediately rather than amortized over five years would likely generate more R&D.[28]

- **Reform the research and development tax credit.** The United States is one of the most innovative countries in the world.[29] Public investments through research and development by the federal government and through higher education contribute to the general knowledge base and scientific inquiry but also lead to groundbreaking discoveries and attract the brightest minds to America. Importantly, the private sector is a clear leader on R&D spending. According to the National Science Foundation's 2020 report on research and development trends, R&D conducted in the U.S. in 2017 (the most recent year available) totaled $547.9 billion. The report notes that "[b]usinesses continue as the predominant performers and funders of U.S. R&D (73% and 70%, respectively, in 2017)."[30] Businesses spent $400 billion on R&D while higher education spent $71 billion, and the federal government spent $53 billion. Recognizing the importance of R&D and the private sector's leadership role, Congress passed an R&D tax credit in 1981. The credit initially "equaled 25 percent of a corporation's research spending in excess of its average research spending in the preceding three years, or alternatively, 50 percent of its current-year spending."[31]

  After expiring in 1985, Congress reinstated an R&D tax credit that included four different types of credits: regular research, alternative simplified research, basic research, and energy research.[32] Section 174 of the tax code also allows immediate expensing of qualified research activities.[33] Businesses can expense R&D costs or use the tax credit but not both. Research has generally shown that the tax credit increased R&D spending, though to varying degrees.[34] Several documented problems have reduced the efficacy of the R&D tax credit, most notably the high compliance costs, which disproportionately affects smaller companies.[35] In fact, the beneficiaries of the tax credit have largely been big businesses, though changes through the PATH Act made the credit more accessible to small businesses by allowing "businesses with less than five years of revenues and less than $5 million in current year revenues to use the R&D tax credit to offset up to $250,000 in payroll tax liability."[36] Ways to simplify and improve the R&D tax credit and expand opportunities for small businesses include:
    - Harmonizing the definition of research expenditures for the R&D tax credit and for R&D expensing.
    - Eliminating the regular credit and replace it with a modified alternative simplified credit.[37]
    - Raising the payroll tax liability that can be offset from the R&D credit to benefit small businesses and startups.
    - Expanding eligibility for startups and new businesses by raising the gross receipts threshold.[38]

- **Maintain support and continue to fund key programs at the Department of Energy.** Programs such as ARPA-E, the Advanced Reactor Demonstration Program (ARDP), the Milestone-based Fusion Development Program, and others have yielded significant developments for clean energy technologies or have significant potential to spark commercial breakthroughs. These programs, and similar ones, play a pivotal role in advancing early-stage technologies that would otherwise not be profitable. ARDP, for instance, is funding America's first small modular reactor projects with TerraPower and X-energy. Importantly, these programs enlist a competitive process to determine which projects receive funding. Every year, ARPA-E awards funding to only 5% of applicants, when roughly 20% are judged through a peer review process to be both scientifically sound and potentially transformative.

- **Identify and remove barriers for commercialization federally funded research and development.** Many commercial breakthroughs originating from federally funded research have come through collaborative relationships with the private sector. Furthermore, agencies have created catalytic programs within the federal government for researchers with an entrepreneurial eye to identify and accelerate the development of innovative technologies. For example, the Defense Advanced Research Projects Agency (DARPA) has its Embedded Entrepreneurship Initiative to connect DARPA researchers with entrepreneurs, investors, mentors, and other business experts. Congress, the administration, and agencies should continue to identify and remove any obstacles to create more productive relationships with researchers, research facilities, and the private sector.

R&D WORKS CITED

[1] Philip Rossetti, "The Effects of the Tax Reform on Energy and Environmental Research and Development," R Street Institute, R Street Shorts No. 103, May 2021, https://www.rstreet.org/wp-content/uploads/2021/05/Final-Short-103.pdf

[2] National Energy Technology Laboratory, "DOE Technology Readiness Levels," U.S. Department of Energy, https://netl.doe.gov/coal/rare-earth-elements/program-overview/definitions

[3] Matthew Step et al., "Turning the Page: Reimagining the National Labs in the 21st Century Innovation Economy," Information Technology and Innovation Foundation, June 2013, https://www2.itif.org/2013-turning-page-national-lab-innovation-economy.pdf

[4] Dorothy Robyn and Jeffrey Marqusee, "The Clean Energy Dividend: Military Investment in Energy Technology and What It Means for Civilian Energy Innovation," Information Technology and Innovation Foundation, March 2018, http://www2.itif.org/2019-clean-energy-dividend.pdf?_ga=2.133613257.674204463.1551967655-1212308.1551734962

[5] Advanced Research Projects Agency-Energy, "ARPA-E: Accelerating U.S. Energy Innovation," U.S. Department of Energy, https://arpa-e.energy.gov/technologies/publications/arpa-e-accelerating-us-energy-innovation

[6] Ibid.

[7] Advanced Research Projects Agency- Energy "Our Impact," U.S. Department of Energy, https://arpa-e.energy.gov/about/our-impact

[8] Breakthrough Energy. "Impacts of Federal R&D Investment on the U.S. Economy." September 2020. https://www.breakthroughenergy.org/-/media/files/bev/bepwcreport09162020.pdf
Breakthrough Energy. "Impacts of Federal R&D Investment on the U.S. Economy." September 2020. https://www.breakthroughenergy.org/-/media/files/bev/bepwcreport09162020.pdf

[9] Information Technology and Innovation Foundation. "Energy Innovation in the Federal Budget." March 28, 2022. https://itif.org/publications/2022/03/28/energizing-innovation-fy-2022-interactive-dataviz

[10] Anne Trafton, "New lightweight material is stronger than steel," MIT News, February 2, 2022, https://news.mit.edu/2022/polymer-lightweight-material-2d-0202

[11] Earthshot Ventures, "Our Story," https://www.earthshot.vc/about

[12] Press release, "Elemental Excelerator Unveils Earthshot Ventures, a New Climate Technology Fund," PR Newswire, September 8, 2021, https://www.prnewswire.com/news-releases/elemental-excelerator-unveils-earthshot-ventures-a-new-climate-technology-fund-301370955.html

[13]Several climate-specific ventures have emerged in recent years, too, including Congruent Ventures, Energy Impact Partners and Greentown Labs. Perhaps the most well-known is Bill Gates-led Breakthrough Energy Ventures. In January, Breakthrough announced it raised its second round of $1 billion that will fund approximately 40-50 climate-focused start-ups.

[14] Prime Coalition, "Catalytic Investing," https://www.primecoalition.org/investments

[15] Ibid.

[16] International Energy Agency, "Patents and the energy transition
Global trends in clean energy technology innovation," April 2021, https://iea.blob.core.windows.net/assets/d14427c6-2aa2-4422-9074-5a68940a5a96/Patents_and_the_energy_transition_-_keyfindings.pdf

R&D WORKS CITED

[17]Ibid

[18] R Wolfe. "Businesses Reported an 11.8% Increase to Nearly a Half Trillion Dollars for U.S. R&D Performance During 2019." National Center for Science and Engineering Statistics. https://ncses.nsf.gov/pubs/nsf22303

[19] Bloomberg NEF. "Energy Transition Investment Trends 2022." January 2022. https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends-Exec-Summary-2022.pdf

[20] Rich Powell, Mitch Kersey, and Spencer Nelson. "The Energy Act of 2020: A Monumental Climate and Clean Energy Bill." ClearPath, April 1, 2021. https://clearpath.org/our-take/the-energy-act-of-2020-a-monumental-climate-and-clean-energy-bill/

[21]IBID

[22] Eric L. Christensen, James M. Auslander, and Zachary B. Pilchen. "The Bipartisan Infrastructure Package: What it Means for Energy and Climate." The National Law Review, November 16, 2021. https://www.natlawreview.com/article/bipartisan-infrastructure-package-what-it-means-energy-and-climate

[23] Molly Christian. "New DOE office could help bridge 'valley of death' for clean energy technologies." S&P Global, November 12, 2021. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/new-doe-office-could-help-bridge-valley-of-death-for-clean-energy-technologies-67566604

[24] Chad Smith and David Hart. "The 2021 Global Energy Innovation Index: National Contributions to the Global Clean Energy Innovation System." Information Technology and Innovation Foundation, October 18, 2021. https://itif.org/publications/2021/10/18/2021-global-energy-innovation-index-national-contributions-global-clean

[25]Alex Muresianu, "How Expensing for Capital Investment Can Accelerate the Transition to a Cleaner Economy," Tax Foundation, January 12, 2021, https://taxfoundation.org/energy-efficiency-climate-change-tax-policy/#Key

[26] Philip Rossetti, "The Effects of the Tax Reform on Energy and Environmental Research and Development," R Street Institute, R Street Shorts No. 103, May 2021, https://www.rstreet.org/wp-content/uploads/2021/05/Final-Short-103.pdf

[27] Ibid

[28] Alex Muresianu and Garrett Watson, "Reviewing the Federal Tax Treatment of Research & Development Expenses," Tax Foundation, April 13, 2021, https://taxfoundation.org/research-and-development-tax/#Spending

[29] The Bloomberg Innovation Index, https://www.bloomberg.com/graphics/2015-innovative-countries/

[30]Mark Boroush, "Research and Development: U.S. Trends and International Comparisons," National Science Foundation, January 15, 2020, https://ncses.nsf.gov/pubs/nsb20203

[31] Alex Muresianu and Garrett Watson, "Reviewing the Federal Tax Treatment of Research & Development Expenses," Tax Foundation, April 13, 2021, https://taxfoundation.org/research-and-development-tax/#Spending

[32] Legal Information Institute, "26 U.S. Code § 41 - Credit for increasing research activities," Cornell Law School, https://www.law.cornell.edu/uscode/text/26/41

[33] Ibid

[34] For a literature review of the economic effects, see Alex Muresianu and Garrett Watson, "Reviewing the Federal

R&D WORKS CITED

Tax Treatment of Research & Development Expenses," Tax Foundation, April 13, 2021, https://taxfoundation.org/research-and-development-tax/#Spending

[35] Ibid

[36] Ibid

[37] U.S. Government Accountability Office, "Tax Policy: The Research Tax Credit's Design and Administration Can Be Improved," November 2009, https://www.gao.gov/products/gao-10-136

[38] The last two recommendations come from the American Innovation and Jobs Act. See, S.4822 - American Innovation and Jobs Act, https://www.congress.gov/bill/116th-congress/senate-bill/4822/titles