Rescue U.S. Energy Innovation

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President Trump proposed drastic cuts to U.S. government energy research, development, and demonstration spending, but Congress has the "power of the purse" and can rescue U.S. energy innovation. If major cuts are enacted, the pace of innovation will slow, harming the economy, energy security, and global environmental quality.

The Trump Administration has proposed a drastic 57% reduction in U.S. government investments in energy research, development, and demonstration (RD&D) at the Department of Energy (DOE), from US$3.8 billion in the fiscal year 2017 (FY2017) continuing resolution to US$1.6 billion in the FY2018 request (unless otherwise stated, all dollar figures are given in constant 2015 dollars). These reductions, if enacted by Congress, would reduce the pace of U.S. energy-technology innovation, ultimately harming the U.S. economy, energy security, environmental quality, and the capacity of the world's second largest emitter of greenhouse gases (GHGs) to do its share in reducing the emissions driving global climate change. This abdication of leadership would adversely impact not just U.S. interests but global interests as well.

Since the President's initial budget request in May, the relevant appropriation committees on both sides of Congress have considered it in the context of developing their own spending bills. Both the House and Senate must pass spending bills and then they must be reconciled in conference before a final version is sent to the President to be signed into law, if he does not veto it. The House passed its bill in late July, and it imposes draconian cuts to ARPA-E and the renewable energy and energy efficiency programs. The Senate appropriations committee appears to 'save' ARPA-E but would still impose cuts across all the energy technology offices ranging from a 39% cut to fusion to a 7% cut to renewables and efficiency (a complete comparison is available online[1]). Recognizing that there will be a continuing negotiation between the Trump Administration and the Congress on Trump's FY2018 budget, we seek here to put the proposed cuts in historical perspective, to elucidate the flaws in their rationales, and to elaborate on the harm they would cause. We focus on the President's request because the arguments and evidence we present still apply to proposed cuts in Congressional bills and because President Trump still has veto power over the bill.

Historical perspective

Figure 1 depicts the Trump administration's proposed FY2018 budgets for fossil fuel, fission, fusion, renewables, and energy efficiency RD&D, as well as for the Basic Energy Sciences and Biological and Environmental Research categories in DOE's Office of Science, compared with appropriations in FY2017. Amid other striking reductions, the Advanced Research Projects Agency for Energy (ARPA-E), which supports high-risk/high-return research on particularly innovative energy-technology improvements,[2] is singled out for complete elimination, although US$20 million is provided to close out the program. Moreover, the Trump budget would also eliminate DOE's loan guarantee program for early commercial use of advanced technologies, the advanced-technology vehicle-manufacturing program, the program for weatherization of low-income housing, and state energy grants.

We have tracked U.S. DOE RD&D investments at the program level since 1978[3], and it is clear in that historical context that the proposed cuts to U.S. government energy RD&D would be unprecedented in many respects. As shown in Figure 2, Trump's proposed cuts in aggregate are greater than the Reagan era cuts of 1982, which were the most drastic single-year cuts to U.S. energy RD&D budgets since 1978. The FY1982 cuts in the appropriations for total energy RD&D were 36% compared with President Trump's proposed 57%. Reagan's FY1982 budget resulted in a 4% increase for Basic Energy Services (BES), rather than Trump's proposed 16% cut. Reagan initially cut efficiency and renewables by 51% and 54% respectively compared with Trump's proposed 71% and 60%.

Flawed rationales

The Reagan cuts were motivated by a combination of plummeting oil prices in the early 1980s, indications that that the costs of synfuels technologies were larger than originally predicted, and the belief that the private sector would do most of the energy RD&D that was warranted. While we would not have agreed with the last rationale even in 1982, the justification for the still more drastic cuts in Federal energy-innovation funding now proposed by the Trump Administration has become flimsier in the meantime. Not only are oil prices now rising again, but the complementary roles of government and private-sector funding in energy-technology innovation are better understood now, and, perhaps most importantly, there is now an immensely powerful "public goods" argument for government investments to accelerate low-carbon innovation to address the challenge of climate change.

Consider the government-academia-industry symbiosis that is now understood to drive energy-technology innovation.[4] Industry funds about 70 percent of all R&D in the United States, and the Federal government funds less than 30 percent.[5] A similar split prevails in energy RD&D, although exact figures are elusive because of definitional and reporting issues. In terms of research stage, government funds the lion's share of basic research and early-stage applied research, while industry funds most late-stage applied research and an even larger share of development and demonstration. Most of the government-funded research is performed in universities, where a huge side benefit is the role of that research in teaching and training the students and post-graduate researchers who will populate the next generation of scientists, inventors, entrepreneurs, and professors, in a virtuous cycle.

Public-private cooperation on energy innovation has been particularly effective in the United States.[6] Perhaps the most striking example is the shale gas revolution, which came about as the result of early shale fracturing and directional drilling technologies developed by the Energy Research & Development Administration (later the DOE), the Bureau of Mines, and the Morgantown Energy Research Center, the Eastern Gas Shales Project (a public-private shale drilling demonstration program in the 1970s), public subsidization of demonstration projects including the first successful multifracture horizontal drilling play in West Virginia in 1986, and Mitchell Energy's first horizontal well in the Texas Barnett shale in 1991, among other collaborations.[7]

As serious studies involving energy-industry leaders as well as academic and government experts have long agreed, there is a crucial role for government support of energy innovation even beyond the early research stages—that is, in late-stage applied RD&D and accelerated deployment—when there are strong public-goods reasons for the government to bring new technologies that address those public goods to the point where they can compete with entrenched incumbent technologies that do not address them. This was one of the most important conclusions of a study of R&D challenges for the 21st century conducted twenty years ago by the Council of Advisors on Science and Technology (PCAST), with strong industry participation.[8] That study found that many public-goods rationales exist for moving beyond the incumbent fossil-fuel-based technologies dominating U.S. and world energy supply including reducing the potential for conflict over access to oil and improving air quality and thus public health. But, the reason that is most demanding and thus most deserving of government engagement, in partnership with industry, is climate change. Although practically every major study since the 1997 PCAST study, using newer information and different analytical tools, has agreed[9,10,11] and called for increases of 2- to 5-

(or even greater) fold in government support for energy-technology RD&D and accelerated deployment,[12,13,14,15,16,17] the Trump administration clearly does not agree.

The Trump administration's proposal to slash the federal government's energy RD&D investments appears to be based on three propositions: that the human role in whatever global climate change is going on is uncertain; that being so (and the hazards to humans and ecosystems from fossil-fuel-driven air pollution, oil spills, ground-water contamination, and acid precipitation, among others, being likewise negligible), expansion of the incumbent fossil-fuel technologies should be the energy strategy of choice; and, to the extent that any advances over those technologies should be thought desirable, the private sector can be relied upon to pay for the needed innovation. On climate change, the strongest statement came from Trump's Office of Management and Budget Director Mick Mulvaney, who announced that, "We're not spending money on [climate change] any more. We consider that to be a waste of your money."[18]

None of these propositions finds significant support in the extensive, international, peer-reviewed literature addressing these topics.[19,20] The multi-trillion dollar externalities of the incumbent fossil-fuel technologies are extremely well documented.[21,22] Furthermore, the economic literature shows that the private sector will never invest as much in basic and early-stage-applied research as the interests of society require (because of high uncertainty about realizing any economic returns and the long lead time for any that do materialize), and even less so where significant public goods are involved that are not reflected in the marketplace.[23]

History tells us that it is exceedingly unlikely that the private sector will come to the rescue. After growing steadily during the late 1970s, private energy R&D peaked around 1985 and declined steadily after that (concurrent with the declines in federal investments), eventually dropping to less than half of the 1985 peak.[24] Today, the R&D intensity (the percentage of sales invested in R&D) in the energy industry is only 1%, far lower than the 10-15% in the pharmaceutical and information technology industries.[25] But even if, optimistically, the private sector continues investing in energy RD&D at current levels, the proposed cuts would still cause total U.S. energy RD&D investments to be much lower and, crucially, less adventurous. In other words, the high-risk high-return investments exemplified by the types of research funded by ARPA-E will go missing.

Other countries are not likely to make up the shortfall either, as the magnitudes are too large to overcome. The U.S. government is by far the largest public investor in global clean energy RD&D, accounting for 43% of global public investments. China's overall public investments are larger than the United States' when their state-owned enterprises are included; but without them China's government investments are just one-fifth the size of the U.S. government investments. The EU's investments are even smaller than China's.[26]

The Trump cuts' harm if enacted

The Trump cuts in federal support for energy-technology innovation, if enacted through appropriations, could significantly slow the pace of energy-technology innovation in the United States. The consequences would include a diminution of the stream of future benefits to U.S. residential, commercial, and industrial consumers in the form of cost savings from improved energy-end-use efficiency; reduced competitiveness of U.S. energy technologies in global markets; reduced start-up creation and job generation in energy industries; the continuation and even worsening of the public-health and environmental burdens resulting from fossil-fuel-derived conventional pollution; and, of course, severely reducing the prospects of attaining the deep reductions in U.S. GHG emissions required for the United States to do its share in addressing global climate change.

Increases in U.S. oil and gas production as a result of the shale revolution and the rise of more affordable renewable electricity generation have moved the United States closer to energy independence than it has been since before the Arab-OPEC oil embargo of 1973 (although it must be added that energy security, and not energy independence, should be the policy goal in this realm); U.S. net energy-import dependence in 2016 was under 12%, and only 8% of the U.S. negative trade balance was due to the energy sector. Similarly, the US$7 billion (in 1999$) invested by DOE in energy efficiency and fossil fuels between 1978 and 2000 resulted in a benefit to consumers and firms of US$30 billion by 2000 (not including from reductions in damages from conventional pollutants or climate mitigation).[27] At ARPA-E, one-third of the grants between 2009 and 2016 went to small U.S. companies and start-ups; 56 new companies were established and US$1.8 billion in follow-on funding was attracted as of February 2017.[28] Also, although it is too soon to fully understand the impact of the Obama Administration's public-private energy-innovation hubs, early assessments are positive.[29]

A slowdown in the pace of energy-technology innovation in the United States could be catastrophic to the competitiveness of U.S. energy technologies in global markets, where other countries are speeding up their efforts. Using many energy technologies originally developed in the United States and Europe, China is now the largest global manufacturer of solar panels and wind turbines, and it is positioning itself to capture newer markets, such as electric vehicles.[30]

Concerning energy RD&D explicitly focused on reducing GHG emissions, 22 countries including the United States established the Mission Innovation consortium in Paris in December 2015 with the aim of doubling their public funding of clean-energy R&D over the space of five years. If the United States does not honor its pledge (which accounted for 43% of the baseline), other countries will have less incentive to honor theirs. The global public good of stabilizing the climate simply compels cooperation and cost-sharing.

Prioritise improving not slashing

Our critique of the proposed cuts is not to suggest that there are no options for improving the effectiveness of U.S. government investments in energy RD&D. On the contrary, the last 10 years have seen significant institutional innovation in the U.S. energy RD&D space, the emergence of new analyses on the effectiveness of different energy RD&D programs, and the application of novel decision- support methods for energy RD&D investments.

Research has found, for example, that the productivity of DOE investments in energy innovation can be improved through more effective utilization of DOE's national labs and increased use of partnerships. In particular, increasing lab-directed research funds at the margin, facilitating the interaction of lab researchers with the private sector, and providing new contracting mechanisms by the labs may improve their already important inputs.[31]

The ARPA-E model has produced very promising outputs in its 8 years of operation[32]. As innovation necessitates timescales exceeding that duration[33], it should be given at least another 5-10 years to demonstrate that a portfolio of high-risk investments can, in fact, produce substantial rewards.

As for DOE-wide improvements, the Administration should renew the appointment of a joint Undersecretary for Science and Technology to reduce siloing of investments across all programs and to dissolve the divisions between basic and applied research.[34] Finally, new analytical approaches to energy innovation policy could lead to better decisions regarding the allocation of energy RD&D investments across technology areas, leading to a more coherent and strategic portfolio approach.[35,36]

Having said this, every study we know of has concluded that these kinds of improvements need to be accompanied by a substantial increase in total public funding for energy-technology innovation, if the immense challenges at the intersection of energy supply, the economy, public health, and the global climate are to be met. Deep cuts would be folly.

FIGURES

Figure 1: Present and proposed energy RD&D investments at the U.S. Department of Energy. Shown here are the proposed Trump administration investments for FY2018 (dark blue) compared to the FY2017 appropriations (light blue), in constant FY2015 U.S. dollars. EERE = Energy Efficiency and Renewable Energy; CCT = Carbon Capture Technology; T&D = Transmission and Distribution; BES = Basic Energy Sciences. Data from Reference 3.

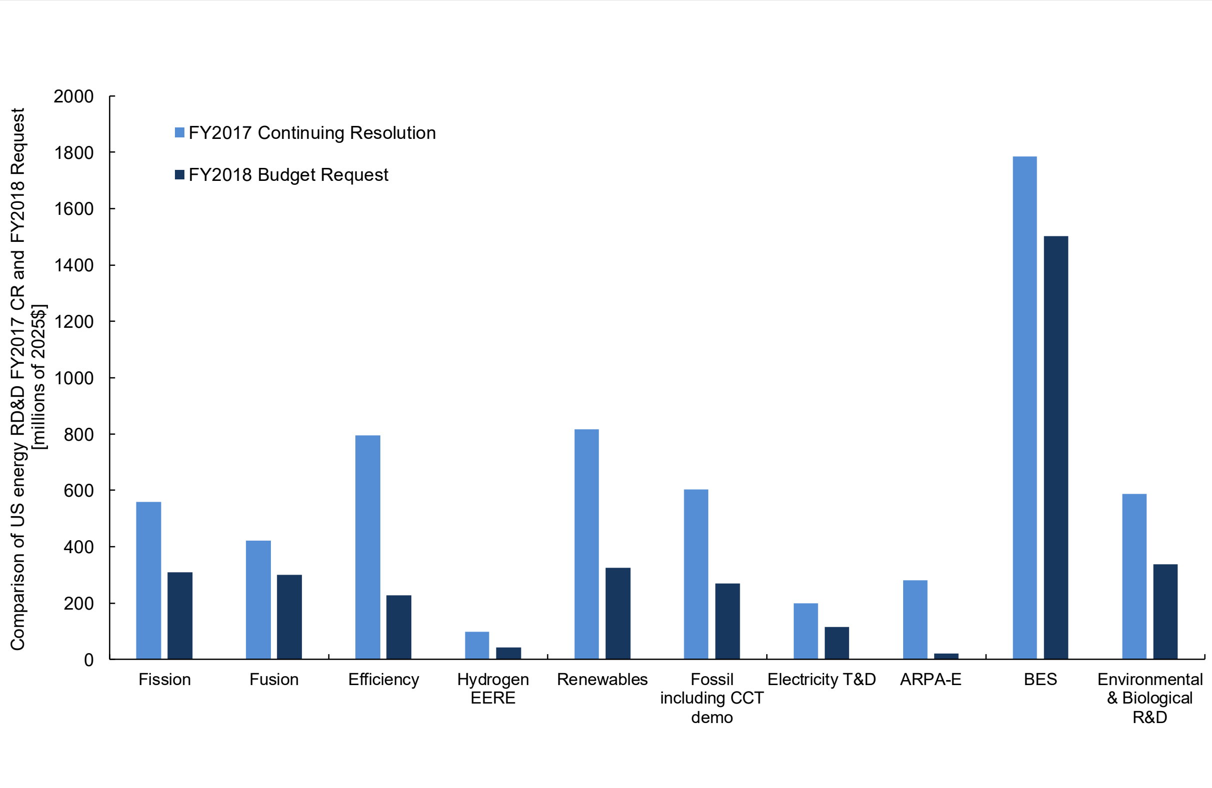
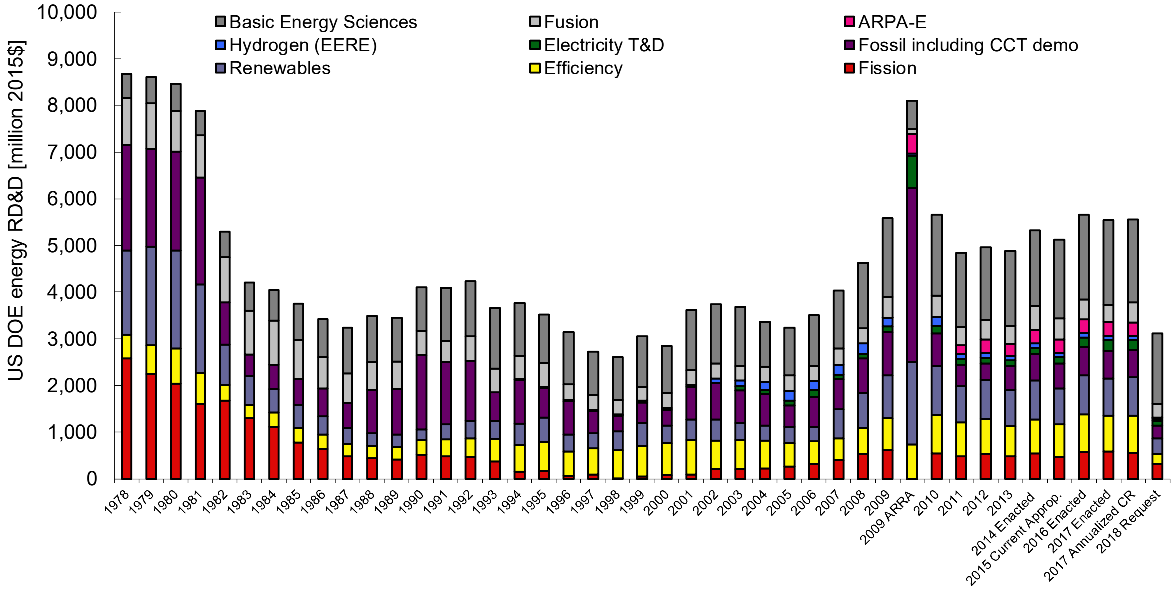


Figure 2: Historic funding for energy RD&D. The breakdown of funding for energy RD&D (defined here as for the 'applied' programs at DOE and ARPA-E) and for research in Basic Energy Sciences and Fusion at DOE from 1978 until the FY2018 budget request. For most recent five years, the final status of the budget is provided (e.g. enacted, continuing resolution (CR), current appropriation, budget request). Investments are shown in constant 2015$. CCT = Carbon Capture Technology; T&D = Transmission and Distribution. Data from Reference 3.



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