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The America COMPETES Acts: An Overview

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Summary

Scientific and technological advancement played a central role in ensuring U.S. prosperity and power in the 20th century. From the first flight of the Wright brothers in 1903 to the creation of Google in the 1990s, U.S. scientific and technological innovations have reshaped the global economy and provided both economic mobility and national security for generations of Americans.

Whether the United States will maintain its preeminence over the course of the 21st century is an open question. Some observers assert that U.S. leadership is at risk. They argue that the United States underinvests in physical sciences and engineering (PS&E) research and underperforms in science, technology, engineering, and mathematics (STEM) education. (PS&E research and STEM education are believed to be central pillars in the foundation supporting U.S. scientific and technological achievement.) At the same time, other nations are increasing their commitments to research and education in the STEM fields and, as a result, can compete for a growing percentage of the world's high-value jobs and industries.

Concern that the United States has fallen or could fall behind in the global race to innovate propelled passage of the 2007 America COMPETES Act (P.L. 110-69) and its successor, the America COMPETES Reauthorization Act of 2010 (P.L. 111-358). The COMPETES Acts authorized increasing funding for targeted federal accounts that support PS&E research (commonly referred to as the "doubling path policy") and authorized (or reauthorized) certain federal STEM education programs. The acts also established the Advanced Research Projects Agency-Energy (ARPA-E), allowed federal agencies to use prize competitions to spur innovation, and directed the executive branch to coordinate policies providing access to federally funded research—among many other provisions.

Neither of the COMPETES Acts has been fully funded or implemented. Actual funding for the targeted PS&E research accounts did not reach authorized levels, and most of the STEM education programs established by the acts were not realized. On the other hand, existing STEM education programs that were reauthorized by the acts generally continued to operate. ARPA-E, which was established by the acts, was implemented and continues to operate. Federal agencies are also using the act's prize authority—at least 100 competitions have been initiated under the authority of P.L. 111-358.

Most of the funding authorizations in the COMPETES Acts have expired. Legislation to reauthorize all or portions of the acts was introduced, but not enacted, in the 113th Congress. Legislators have introduced bills to reauthorize all or portions of the acts in the 114th Congress. This report provides an overview of the acts for readers seeking background and legislative context. It serves both as a primer and a reference document, including a description and legislative history of the acts, a summary of the broad policy debate, and an examination of the implementation status of selected COMPETES-related programs and policies. This report also highlights major bills to reauthorize the acts from the 113th and 114th Congresses.

For authorized and appropriated funding for COMPETES-related accounts, see CRS Report R42779, *America COMPETES Acts: FY2008 to FY2013 Funding Tables*, by Heather B. Gonzalez.

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Introduction

Enacted in response to concerns that the United States could lose its historical advantages in scientific and technological innovation, the 2007 America COMPETES Act (P.L. 110-69) sought "to invest in innovation through research and development, and to improve the competitiveness of the United States."[1] Containing eight titles and dozens of provisions affecting at least a half-dozen federal agencies, the principal policy contributions of the America COMPETES Act were the establishment of the doubling path policy for certain federal physical sciences and engineering (PS&E) research accounts and the authorization (or reauthorization) of various federal science, technology, engineering, and mathematics (STEM) education programs.

Major provisions of the America COMPETES Act, and its successor, the America COMPETES Reauthorization Act of 2010 (P.L. 111-358), have expired.[2] Most of the funding authorizations in the America COMPETES Act spanned the three-year period between FY2008 and FY2010. Congress extended these authorizations for a second three-year period—through FY2013—as part of the 2010 reauthorization. Congress has not enacted legislation to authorize funding for COMPETES Acts programs and agencies since then.[3] Bills were introduced, but not enacted, in the 113th Congress.

Legislators in the 114th Congress have also moved to reauthorize the COMPETES Acts. The America COMPETES Reauthorization Act of 2015 (H.R. 1806) and the America Competes Reauthorization Act of 2015 (H.R. 1898), as well as several stand-alone bills containing selected provisions from these reauthorization measures, have been introduced and, in some cases, passed by the House. In the Senate, Members have introduced a bill called the Energy Title of America COMPETES Reauthorization Act of 2015 (S. 1398).

This report provides an overview of the COMPETES Acts for readers seeking background and legislative context. It was written to serve as both a primer and a reference document. It includes a description and legislative history of the acts, a summary of the broad policy debate, and an examination of the implementation status of selected COMPETES-related programs and policies. This report also provides analysis of major bills to reauthorize the COMPETES Acts from the 113th and 114th Congresses.

For authorized and appropriated funding for COMPETES-related accounts through FY2013, see CRS Report R42779, *America COMPETES Acts: FY2008 to FY2013 Funding Tables*, by Heather B. Gonzalez.

The COMPETES Acts

The contemporary federal conversation about scientific and technological advancement generally centers on concerns about prosperity and security.[4] The possibility that the United States has or

[1] P.L. 110-69.

[2] For the most part, expired provisions include those authorizing appropriations for a limited number of fiscal years (as opposed to sunset provisions that may be associated with program authorizations).

[3] Congress has continued to provide actual appropriations to these programs and agencies through annual appropriations acts. For more information, see CRS Report RS20371, *Overview of the Authorization-Appropriations Process*, by Bill Heniff, Jr.

[4] In the past, concerns have focused on other facets of America life. For example, in the first State of the Union Address in 1790, President George Washington appealed to Congress to patronize science on the grounds that scientific knowledge in the electorate was essential for our democratic republic. See President George Washington, "First Annual

could lose its historic strengths in scientific and technological advancement—and therefore has or could lose the prosperity and security attributed to that advancement—has become the central rationale for a portfolio of otherwise disparate federal programs, policies, and activities. Sometimes identified as "innovation" or "competitiveness" policy, these programs, policies, and activities address education, tax, patent, immigration, economic development, research and development, telecommunications, and other policy issues—either alone or in combination—that policymakers perceive as critical to the U.S. scientific and technological enterprise.

The 2007 America COMPETES Act (P.L. 110-69) was an example of this type of policymaking. Designed to "invest in innovation through research and development, and to improve the competitiveness of the United States," the law authorized $32.7 billion in appropriations for certain federal PS&E research accounts, STEM education activities, and innovation-related programs and policies between FY2008 and FY2010.[5] In particular, the law established what is commonly referred to as the "doubling path policy" for PS&E research. This policy provided annual increases in authorized funding for the National Science Foundation (NSF), the Scientific and Technical Research and Services (STRS) and Construction of Research Facilities (CRF) accounts at the National Institute of Standards and Technology (NIST), and the Office of Science account at the Department of Energy (DOE)—with the implicit goal of doubling combined funding for these accounts over a seven-year period (from an FY2006 baseline).[6] Some of the STEM education and innovation-related programs and policies authorized by the act include the Math Now program at the Department of Education (ED), the Manufacturing Extension Partnership program at NIST, and the Advanced Research Project Agency-Energy (ARPA-E) at DOE.

The America COMPETES Reauthorization Act of 2010 (P.L. 111-358) reaffirmed the central policy thrusts of the America COMPETES Act. It, too, sought to "invest in innovation through research and development, and to improve the competitiveness of the United States."[7] However, under the reauthorization, funding for the PS&E doubling path accounts grew more slowly—they would have doubled over an 11-year period instead of a 7-year period—and STEM education provisions focused more on college and university-level programs rather than on programs targeting earlier grades. Other provisions in the America COMPETES Reauthorization Act of 2010 allow federal agencies to offer innovation prizes and direct the Department of Commerce

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Message to Congress on the State of the Union: January 8, 1790," *The American Presidency Project*, http://www.presidency.ucsb.edu/ws/index.php?pid=29431#axzz1IIvN0cSi.

[5] This funding total does not include appropriations authorizations for the Department of Energy's Office of Science in FY2008 and FY2009. The source of appropriations authorizations for the Office of Science in those years was the Energy Policy Act of 2005 (P.L. 109-58). The America COMPETES Act provided appropriations authorizations for the Office of Science in FY2010.

[6] This report refers to the COMPETES Acts-authorized increases in funding for the NSF, DOE's Office of Science, and the targeted accounts at NIST as the "doubling path policy for PS&E research" or the "doubling path policy." It should be noted that neither of the COMPETES Acts specifically authorized a 100% increase in funding for these accounts within their respective authorization periods. Rather, the acts authorized funding levels that *would have* resulted in a 100% increase if (a) growth continued at the authorized rate in future years, and (b) actual appropriations reached authorized levels. (This is why the term "doubling *path*" is used.) Further, this report frequently refers to the doubling path policy authorized by the COMPETES Acts as the "doubling path policy for *PS&E research*." This distinguishes the COMPETES Acts-authorized doubling path policy from other efforts to double funding for federal research agencies, such as the 1998-to-2003 doubling of the National Institutes of Health (NIH) budget or the attempted 2002-to-2007 NSF doubling as authorized by the 2002 NSF authorization act (P.L. 107-368). However, it should also be noted that COMPETES Acts agencies are not the only sources of federal funding for PS&E research. Other agencies, such as the Department of Defense, also fund substantial amounts of PS&E research.

[7] P.L. 111-358.

(DOC) to establish a new loan guarantee program for manufacturers, as well as a regional innovation program. The reauthorization also repealed certain STEM education program authorizations, particularly those that did not receive appropriations between FY2008 and FY2010 (e.g., Math Now). Overall, the America COMPETES Reauthorization Act of 2010 authorized $45.5 billion in appropriations between FY2011 and FY2013.

Policy Debate

Congressional debate about the America COMPETES Act and the America COMPETES Reauthorization Act of 2010 was substantively similar. Advocates for the COMPETES Acts argued that additional support for R&D in the physical sciences and engineering, and in STEM education, would lead to innovation and improve U.S. competitiveness.[8] They noted that many experts consider innovation, particularly technological innovation, to be a driving force behind U.S. global economic competitiveness and national prosperity. As such, many observers consider innovation a crucial national asset.

Proponents of the acts further asserted that the United States is at risk of losing its innovation advantage. They argued that a combination of external pressures and internal weaknesses threatens the U.S. global position. For example, they noted that changes in the industrial bases and educational attainment rates of rapidly developing countries like China and India have led many analysts to conclude that these countries are able to compete for a growing percentage of the world's high-value jobs and industries. These global changes, advocates asserted, appeared to be accompanied by perceived weaknesses in areas that have long been U.S. strengths. In particular, the acts' proponents raised concerns about federal funding for research in the physical sciences and engineering and about the education and training of U.S. scientists, engineers, and technicians. This case was more fully laid out in the National Academies publication *Rising Above the Gathering Storm*, which is widely believed to have contributed to the shape and scope of the America COMPETES Act.[9] The argument for, as well as major provisions in, the America COMPETES Act can also be traced to a 2006 proposal by President George W. Bush, known as the American Competitiveness Initiative (ACI).[10]

Opposition to the acts tended to fall into three broad categories: (1) questions about fundamental assumptions, (2) preferences for alternative policies or approaches, and (3) cost. For example, some analysts disputed fundamental assumptions driving provisions designed to increase the number of STEM graduates, arguing that there is a lack of evidence of extensive STEM workforce shortages and that the bigger challenge is a dearth of attractive employment opportunities in STEM fields.[11] Other analysts preferred to use regulatory and tax policy tools to

[8] Representative Bart Gordon, "America COMPETES Reauthorization Act of 2010," remarks in the House, *Congressional Record*, daily edition, Vol. 156 (December 21, 2010), pp. H8841-H8842.

[9] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Committee on Prospering in the Global Economy of the 21st Century: An Agenda for America Science and Technology, and Committee on Science, Engineering, and Public Policy, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, National Academies Press, 2007, http://www.nap.edu/catalog/11463.html.

[10] The ACI proposed programs and policies—such as Math Now and increased funding for basic research—that became part of P.L. 110-69. See U.S. President (G.W. Bush), "Address Before a Joint Session of Congress on the State of the Union," January 31, 2006, http://www.presidency.ucsb.edu/ws/index.php?pid=65090#axzz1IZD3cJnu.

[11] Testimony of Alfred F. Sloan Foundation Vice President Michael S. Teitelbaum, in U.S. Congress, House Committee on Science and Technology, Subcommittee on Technology and Innovation, *The Globalization of R&D and Innovation, Part IV: Implications for the Science and Engineering Workforce*, hearings, 110th Cong., 1st sess., November 6, 2007, https://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/

achieve the acts' objectives, arguing that direct federal investment in R&D in the physical sciences and engineering and in STEM education could distort markets.[12] Finally, opponents raised concerns about costs, arguing that proposed funding increases were too expensive in light of the federal deficit and debt.[13]

Enactment and Reauthorization

The following sections describe enactment of, and selected legislative action related to, the COMPETES Acts.

America COMPETES Act

The America COMPETES Act (H.R. 2272, then called the 21st Century Competitiveness Act of 2007) was introduced in the House and referred to the House Committee on Science and Technology on May 10, 2007. As introduced, the bill represented a package of five bills that had previously passed the House:[14] H.R. 362 (10,000 Teachers, 10 Million Minds Science and Math Scholarship Act),[15] H.R. 363 (Sowing the Seeds through Science and Engineering Research Act),[16] H.R. 1867 (National Science Foundation Authorization Act of 2007),[17] H.R. 1868 (Technology Innovation and Manufacturing Stimulation Act of 2007),[18] and H.R. 1068 (To Amend the High-Performance Computing Act of 1991).[19] H.R. 2272 passed the House by voice vote on May 21, 2007.

The Senate received H.R. 2272 and on July 19, 2007, struck all language after the enacting clause and substituted the language of S. 761 (America COMPETES Act). The Senate then passed H.R. 2272, as amended, by unanimous consent. The House and Senate agreed to a conference, and on August 1, 2007, the conferees submitted a conference report (H.Rept. 110-289) containing both the agreed-upon bill text and a joint explanatory statement. In final form, H.R. 2272 (America COMPETES Act) passed by unanimous consent in the Senate and by a vote of 367-57 in the House. The President signed the bill, which became P.L. 110-69, on August 9, 2007.

America COMPETES Reauthorization Act of 2010

The America COMPETES Reauthorization Act of 2010 (H.R. 5116) was introduced in the House on April 22, 2010. The bill was referred to the House Committee on Science and Technology,

110607_teitelbaum.pdf.

[12] Testimony of Competitive Enterprise Institute Vice President for Policy/Director of Technology Studies, House Committee on Science and Technology, *The Future of Manufacturing: What Is the Role of the Federal Government in Supporting Innovation by U.S. Manufacturers?*, hearings, 111th Cong., 2nd sess., March 17, 2010, http://gop.science.house.gov/Media/hearings/full10/mar17/Crews.pdf.

[13] For example, see House debate, "Conference Report on H.R. 2272, America COMPETES Act," *Congressional Record*, daily edition, vol. 153 (August 2, 2007), pp. H9592-H9604.

[14] Rep. David Wu, "21st Century Competitiveness Act of 2007," remarks in the House, *Congressional Record*, daily edition, vol. 153, no. 83 (May 21, 2007), pp. H5496-H5513.

[15] See also H.Rept. 110-85.

[16] See also H.Rept. 110-39.

[17] See also H.Rept. 110-114.

[18] See also H.Rept. 110-115.

[19] See also H.Rept. 110-40.

where it was amended and reported (H.Rept. 111-478, Part 1). The House passed H.R. 5116 on May 28, 2010, by a vote of 262-150.

The Senate received H.R. 5116 and referred it to the Senate Committee on Commerce, Science, and Transportation, which discharged the bill by unanimous consent on December 17, 2010. The full Senate replaced the House-passed language in H.R. 5116 with its version of the bill (S.Amdt. 4843) and passed the bill as amended by unanimous consent on December 17, 2010. H.R. 5116 was returned to the House, which voted 228-130 to agree to the Senate amendment on December 21, 2010. The President signed H.R. 5116, which became P.L. 111-358, on December 28, 2010.

Implementation Status

Overall, neither the America COMPETES Act nor the America COMPETES Reauthorization Act of 2010 were fully funded or implemented.[20] In 2013, the Government Accountability Office (GAO) released a report on implementation of the acts. In that report, GAO found that existing programs with defined (or specific) appropriations authorizations generally continued to operate, though not typically at authorized funding levels.[21] The implementation of new programs was less consistent.[22] According to GAO, the COMPETES Acts established 28 new programs with defined appropriations authorizations. Of these, one new program was fully implemented (ARPA-E) and five new programs were partially implemented as of May 2013.[23]

Less is known about the disposition of policy provisions that did not receive a specific funding authorization in the acts. The outcomes of such provisions are typically harder to assess because agencies may not explicitly report all implementation actions. However, insight into agency activities is possible in some cases. The following sections describe the disposition and implementation of selected COMPETES Acts provisions, including those with and without defined funding authorizations. They provide information on (1) the status of the doubling path for physical sciences and engineering research funding, (2) implementation of certain STEM education provisions, and (3) the implementation status of certain other provisions of ongoing interest to Congress, including the ARPA-E, data access, and innovation inducement prize provisions.

[20] As of January 2015.

[21] A "specific" or "defined" appropriations authorization is a precise funding level (such as $2.0 million) included in an authorization act. Authorization acts may also include nonspecific or undefined appropriations. An authorization bill that references "such sums as may be necessary" or that is silent on funding levels provides "undefined" or "not specified" appropriations authorizations. Appropriations acts, which provide funding to federal agencies, and related committee reports may also include defined/specified or undefined/not specified funding levels.

[22] Agencies report a variety of explanations for the inconsistent implementation. Some agencies assert that they engaged in activities that were consistent with the acts, whether or not those activities were overtly linked to specific provisions in one or both laws. Other agencies reported logistical challenges. Some agencies did not seek funding for COMPETES Acts activities in annual budget requests. In other cases, Congress did not provide defined appropriations for COMPETES Acts provisions.

[23] U.S. Government Accountability Office, *America COMPETES Acts: Overall Appropriations Have Increased and Have Mainly Funded Existing Federal Research Entities*, GAO-13-612, July 2013, p. 1, http://www.gao.gov/products/GAO-13-612. See also CRS Report R42779, *America COMPETES Acts: FY2008 to FY2013 Funding Tables*, by Heather B. Gonzalez.

PS&E Doubling Path Policy

As discussed in previous sections, the America COMPETES Act and the America COMPETES Reauthorization Act of 2010 authorized a doubling path policy for certain federal PS&E research accounts.[24] Because federal appropriations are distributed to agencies and programs, and not by scientific field, the PS&E doubling effort targeted certain federal agency accounts known to support PS&E research.[25] These accounts included the NSF (total), the STRS and CRF accounts at NIST, and the Office of Science account at the DOE—collectively, the "targeted accounts."

For the most part, actual appropriations to the targeted accounts did not reach authorized levels during either of the COMPETES Acts' authorization periods. (See **Figure 1**.)[26] Under the America COMPETES Act, combined funding for the targeted accounts was authorized to increase at a compound annual growth rate of 10.4% (between the FY2006 baseline and FY2010, the final year under P.L. 110-69). If actual and authorized appropriations had grown at the 10.4% pace, funding for the targeted accounts would have doubled in seven years. That is, combined funding for the targeted accounts would have increased to approximately twice the FY2006 level in FY2013. However, actual appropriations to the targeted accounts over the America COMPETES Act's authorization period increased at a compound annual growth rate of 6.3%. At this pace, funding for the targeted accounts would have doubled in about 11 years.[27]

Following the trend in actual appropriations during the first authorization period, the America COMPETES Reauthorization Act of 2010 authorized funding increases at a compound annual growth rate of 6.4% (between the FY2006 baseline and FY2013, the final year under P.L. 111-358). If actual and authorized appropriations had grown at this pace, funding for the targeted accounts would have doubled over about an 11-year period. In other words, combined funding for the targeted accounts would have increased to approximately twice the FY2006 level in FY2017. However, actual appropriations over the reauthorization act's authorization period increased at a compound annual growth rate of 3.1%. At this pace, it would take about 22 years for the targeted accounts to double.

[24] For more information about the doubling path policy for PS&E research, see CRS Report R41951, *An Analysis of Efforts to Double Federal Funding for Physical Sciences and Engineering Research*, by John F. Sargent, Jr.; CRS Report IN10263, *Decadal Effort to Double Funding for Physical Sciences and Engineering Research Stalled*, by John F. Sargent, Jr.; and, CRS Report IN10260, *How the Doubling Timeframe Affects the Increase in Purchasing Power of Funding for Physical Sciences and Engineering Research*, by John F. Sargent, Jr.

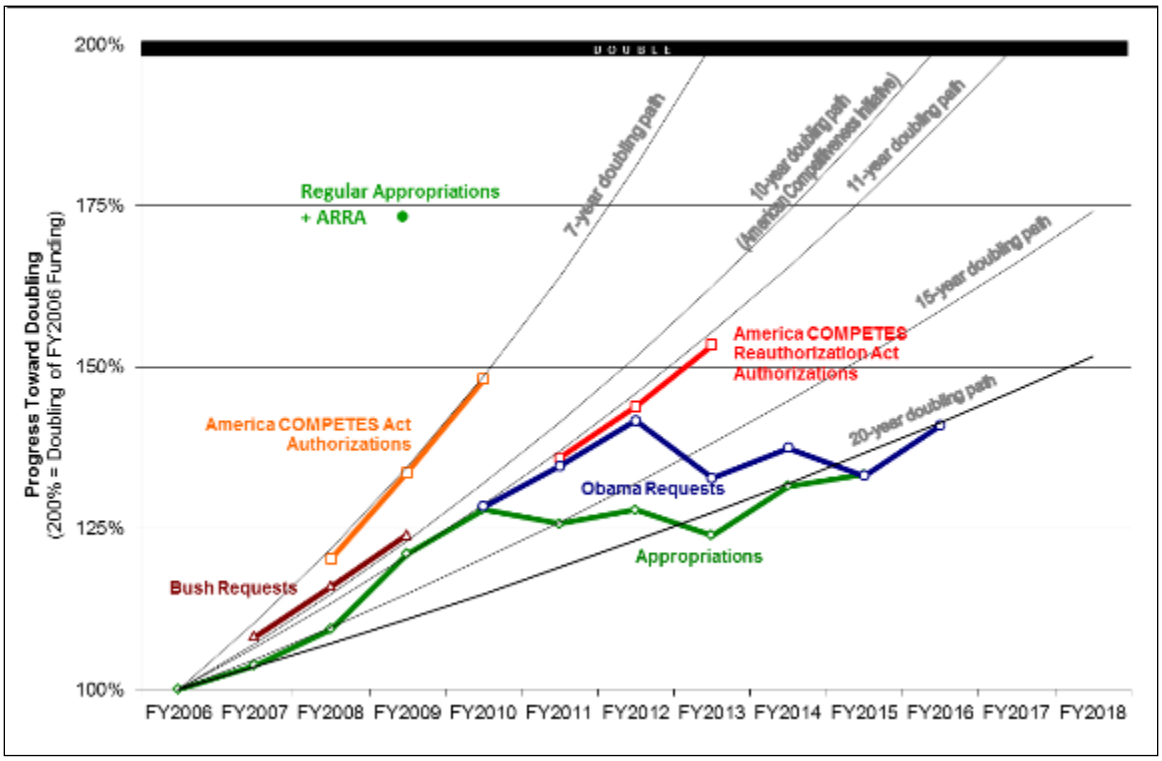
[25] Other agencies, such as the Department of Defense, also fund substantial amounts of PS&E research.

[26] Because Congress provides appropriations to federal agencies in current dollars (e.g., not adjusted for inflation), the analysis in this section uses current dollars. In constant (e.g., inflation-adjusted) terms, these trends would change considerably.

[27] CRS used actual appropriations to the NSF (total), the STRS and CRF accounts at NIST, and the Office of Science to calculate actual growth rates and doubling periods. Office of Science actual appropriations funding levels exclude DOE-wide transfers under the Small Business Innovation Research and (SBIR) and Small Business Technology Transfer (STTR) programs, but include all other changes incorporated in the office's annual budget justifications.

Figure 1. Funding for Accounts Targeted for Doubling: Appropriations, Authorizations, and Requests Versus Selected Doubling Rates

FY2006-FY2018



Source: Prepared by CRS based on data from the Office of Management and Budget, agency budget justifications for FY2008 to FY2015, and agency authorization levels from the America COMPETES Act (P.L. 110-69) and the America COMPETES Reauthorization Act of 2010 (P.L. 111-358).

Notes: The 7-year doubling path represents annual increases of 10.4%, the 10-year doubling path represents annual increases of 7.2%, the 11-year doubling path represents annual increases of 6.5%, the 15-year doubling path represents annual increases of 4.7%, and the 20-year doubling path represents annual increases of 3.3%. The lines connecting aggregate appropriations, authorizations, and requests for the targeted accounts are for clarification purposes only. ARRA is the American Recovery and Reinvestment Act.

Policymakers have sought to double funding for various federal research accounts on several occasions. President Ronald Reagan, for example, proposed a doubling of the NSF budget in FY1987.[28] The 2002 NSF authorization (P.L. 107-368) also sought to double funding for the NSF over a five-year period. Neither the Reagan effort nor the 2002 NSF authorization act resulted in a doubling of NSF's budget within the proposed time frames. An effort to double funding for the National Institutes of Health (NIH) resulted in a nearly 100% increase in that research agency's budget. (NIH funding increased from $13.7 billion in FY1998 to $27.1 billion in FY2003.)[29]

[28] Reagan announced the NSF doubling proposal in a January 31, 1987, radio address on Administration goals and highlighted the NSF doubling in his messages to Congress (transmitting the budget) for FY1988, FY1989, and FY1990.

[29] For more information about the NIH and NSF doubling efforts, see CRS Report R43341, *NIH Funding: FY1994-FY2016*, by Judith A. Johnson and CRS Report R43585, *The National Science Foundation: Background and Selected Policy Issues*, by Heather B. Gonzalez.

Selected STEM Education Activities[30]

Implementation of the STEM education provisions from both the America COMPETES Act and the America COMPETES Reauthorization Act of 2010 has been mixed. Certain preexisting programs appear to have continued to operate, while most new programs appear to have been either partially implemented or not implemented at all. The following sections highlight some of the STEM education provisions from the COMPETES Acts and describe agency efforts to implement authorized activities.

By budget authority, the largest STEM education account in the COMPETES Acts was the main education account at NSF (called Education and Human Resources or E&HR). Although funding for E&HR did not reach the levels authorized by the COMPETES Acts, it increased by 20% between FY2007 ($696 million), which was the year before the first COMPETES-related authorization for this account, and FY2013 ($835 million), the last authorized year under the COMPETES Acts.[31] STEM education funding at the NSF—the bulk of which is in E&HR—provided about a third of annual federal STEM education funding during the COMPETES Acts' authorization periods.[32]

Overall, the federal STEM education effort appears to have changed substantially since the enactment of the America COMPETES Reauthorization Act of 2010. In FY2014 and FY2015, the Obama Administration used the federal budget process to propose significant changes to the federal STEM education portfolio. Although overall funding levels stayed about the same, the number of programs and activities has been significantly reduced. For example, in FY2012 (enacted), the federal STEM education effort was estimated at 229 investments worth about $2.9 billion. A comparable assessment of the federal effort in FY2015 (estimated) was 129 investments, totaling $2.9 billion.[33] It is not clear what impact these changes had, if any, on COMPETES-authorized agencies and programs.

America COMPETES Act

In general, the America COMPETES Act (P.L. 110-69) included more kindergarten-to-grade 12 (K-12) education provisions than the America COMPETES Reauthorization Act of 2010. However, many of the K-12 STEM education provisions in the America COMPETES Act were not funded, and several were later repealed by the 2010 reauthorization. Repealed programs include the Pilot Program of Grants to Specialty Schools for Science and Mathematics and Experiential-Based Learning Opportunities at the DOE; as well as the Math Now for Elementary

[30] For more information about the federal STEM education effort, see CRS Report R42642, *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer*, by Heather B. Gonzalez and Jeffrey J. Kuenzi.

[31] Taken in broader context, such an increase may be a bit misleading. FY2007 represents an historical low for E&HR within the 10-year period for which there are comparable actual appropriations data for this account: FY2003 to FY2013. For comparison, average E&HR funding during this period was $805 million. For more information about STEM education funding trends at NSF, see CRS Report R42470, *An Analysis of STEM Education Funding at the NSF: Trends and Policy Discussion*, by Heather B. Gonzalez.

[32] Other sources of STEM education funding at the NSF include H-1B nonimmigrant petitioner fees and the Research and Related Activities Account (R&RA).

[33] Based on CRS analysis of various Office of Science and Technology Policy and National Science and Technology Council inventories of the federal STEM education portfolio. For details, see CRS Report IF10229, *The Changing Federal STEM Education Effort*, by Heather B. Gonzalez; and CRS Report IF10212, *The President's FY2015 Budget and STEM Education*, by Heather B. Gonzalez.

School and Middle School Students Program, Foreign Language Partnership Program, and Mathematics and Science Partnership Bonus Grant at ED.

Of the ED programs with defined funding authorizations in the America COMPETES Act, only one appears to have received defined appropriations: Teachers for a Competitive Tomorrow (TCT). TCT received approximately $2.2 million in funding per fiscal year between FY2008 and FY2010. The FY2011 appropriations act (P.L. 112-10) provided no funding for TCT.[34] Congress has not appropriated defined funding for TCT since then.

Although Congress did not provide defined appropriations for the education alignment and data systems provisions in the America COMPETES Act—which authorized appropriations of up to $120 million for these activities in FY2008, as well as such sums as may be necessary in FY2009—ED propagated the education data system elements included in P.L. 110-69, Section 6401, through its Statewide Longitudinal Data System Grant Program.[35]

The degree to which DOE implemented its America COMPETES Act-authorized STEM education provisions is not clear. The department has stated that some of its activities were consistent with the law, but these activities are not easily traced to specific provisions in P.L. 110-69. Further, DOE has terminated some of the activities that it had previously identified as consistent with the America COMPETES Act—such as the DOE Academies Creating Teacher Scientists (DOE ACTS) program. Prior to the program's termination, DOE asserted that the DOE ACTS program was consistent with the Summer Institutes program authorized by the America COMPETES Act (Section 5003).[36]

NSF's implementation of America COMPETES Act-authorized STEM education programs was also mixed. The Mathematics and Science Partnership and the Robert Noyce Teacher Scholarship programs—both of which were preexisting programs reauthorized by the America COMPETES Act—continued to operate between FY2008 and FY2013. However, the Hispanic-Serving Institutions and Laboratory Science Pilot programs do not appear to have been implemented.[37] NSF initiated the Professional Science Master's (PSM) program using American Recovery and Reinvestment Act (ARRA) funding in FY2010, but the program does not appear to have received funding since then and GAO reports that the program shut down.[38] NSF asserts that existing programs serve the same or similar functions as the PSM.[39]

America COMPETES Reauthorization Act of 2010

In general, the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) focused more on postsecondary STEM education and on governance issues than did the America COMPETES Act. Section 101 of the 2010 reauthorization, for example, directed the National Science and

[34] The Department of Defense and Full-Year Continuing Appropriations Act, 2011 (P.L. 112-10), §1842 states that, "no funds shall be available" for certain specified ED activities, including the Teachers for a Competitive Tomorrow program, in FY2011.

[35] For more information about the Statewide Longitudinal Data System Grant Program and its nexus with §6401, go to http://nces.ed.gov/Programs/SLDS/index.asp.

[36] Email communication between CRS and DOE staff, multiple dates. Congressional clients may contact the author for more information.

[37] Similar activities may be funded through related programs at NSF or at other federal agencies.

[38] U.S. Government Accountability Office, *America COMPETES Acts: Overall Appropriations Have Increased and Have Mainly Funded Existing Federal Research Entities*, GAO-13-612, July 2013, p. 9, http://www.gao.gov/products/GAO-13-612.

[39] Email communication between CRS and NSF staff, dated July 29, 2013.

Technology Council (NSTC) to establish a Committee on Science, Technology, Engineering, and Math Education (Co-STEM) to survey, coordinate, develop, and implement a strategy for the federal STEM education effort. The NSTC established Co-STEM in February 2011 and has since produced an inventory of federal STEM education programs, a report on its efforts to coordinate the federal STEM education effort, and a five-year strategic plan.[40] In March 2015, the Office of Science and Technology Policy (OSTP) published a progress report describing these and related Co-STEM activities. The progress report included an updated federal STEM education program inventory which provided funding levels for FY2014 (enacted) and FY2015 (requested).[41]

NSF mostly implemented provisions from the America COMPETES Reauthorization Act of 2010 that required it to provide 50% of program funds for the Graduate Research Fellowship (GRF) and Integrative Graduate Education and Research Traineeship (IGERT) from the Research and Related Activities (R&RA) account between FY2011 and FY2013.[42] However, it is unclear if NSF treated these programs equally, as the act also required. The annual percentage change in funding for the GRF differed from that of the IGERT for each fiscal year between FY2011 and FY2013.[43] It is unclear if this is what Congress intended when it enacted the equal treatment provisions.[44]

With respect to provisions authorizing the STEM Training Grant Program,[45] NSF does not appear to have sought funds in its annual budget justifications to establish this program or to have otherwise implemented this program during the authorization period. The STEM Training Grant Program is widely believed to be both modeled on, and intended to provide federal support for postsecondary replication of, the University of Texas's UTeach program.[46] UTeach, which was

[40] See Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Fast-Track Action Committee on Federal Investments in STEM Education, *The Federal Science, Technology, Engineering and Mathematics (STEM) Education Portfolio*, December 2011, http://www.whitehouse.gov/sites/default/files/microsites/ostp/costem__federal_stem_education_portfolio_report_1.pdf; Executive Office of the President, National Science and Technology Council, Federal Coordination in STEM Education Task Force, *Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education Investments: Progress Report*, February 2012, http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc_federal_stem_education_coordination_report.pdf; Executive Office of the President, National Science and Technology Council, Committee on STEM Education, Fast-Track Action Committee on Federal Investments in STEM Education, *2010 Federal STEM Education Inventory Data Set*, http://www.whitehouse.gov/sites/default/files/microsites/ostp/2010%20Federal%20STEM%20Education%20Inventory%20Data%20Set.xls and *Guide to Using the 2010 Federal STEM Education Inventory Data Set*, http://www.whitehouse.gov/sites/default/files/microsites/ostp/Guide%20to%20STEM%20Ed%20Data%20Set.pdf, April 13, 2012; and Executive Office of the President, National Science and Technology Council, Committee on STEM Education, *Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan*, May 2013, http://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_stratplan_2013.pdf.

[41] Executive Office of the President, Office of Science and Technology Policy, *Progress Report on Coordinating Federal Science, Technology, Engineering, and Mathematics (STEM) Education*, March 25, 2015, https://www.whitehouse.gov/sites/default/files/microsites/ostp/stem_ed_budget_supplement_fy16-march-2015.pdf.

[42] See P.L. 111-358, §510. Previously, these programs were funded primarily from E&HR. CRS analysis of funding for these accounts indicates that R&RA funding for the IGERT was close to 50% between FY2011 and FY2013. R&RA funding for the GRF was not 50% in FY2011 but was close to 50% in FY2012 and FY2013.

[43] For example, in FY2011, actual funding for the GRF increased by $1.5 million (1.1%). Actual funding for the IGERT, on the other hand, decreased by $8.6 million or 12.4%.

[44] §510 attempts to tie funding changes in the IGERT to that of the GRF, such that funding for the IGERT would increase or decrease at the same rate that funding for the GRF increased or decreased. However, a CRS attorney found potential ambiguity in the language of this statute. Congressional clients may contact the author for more information.

[45] See P.L. 111-358, Subtitle B.

[46] Information about UTeach is available at https://uteach.utexas.edu/about. Information about replication of the UTeach model is available at the UTeach Institute, http://www.uteach-institute.org/.

launched in 1997, was first funded by NSF in 2000 through the now-defunct Teacher Preparation Program. NSF does not appear to have established a program targeted specifically at UTeach activities and projects, but it funds similar activities through the Robert Noyce Teacher Scholarship and related STEM education programs. The Department of Education has also provided funding for UTeach replication.[47] UTeach Institute administrators anticipate that there will be 44 UTeach programs in 21 states and the District of Columbia beginning in spring 2015.[48]

Selected Other Provisions

In addition to the doubling path policy and STEM education provisions in the COMPETES Acts, both bills included provisions that sought to address a variety of innovation-related policy issues. The following sections provide information about the implementation status of some of these provisions—including those related to ARPA-E, innovation inducement prizes, and public access to federally funded research.

Advanced Research Projects Agency-Energy (ARPA-E)

The America COMPETES Act established ARPA-E at the Department of Energy. As enacted, P.L. 110-69 prescribes ARPA-E's administrative structure and leadership; its relationship to other DOE programs; and its responsibilities, reporting requirements, and evaluation.

The America COMPETES Reauthorization Act of 2010 (P.L. 111-358, Section 904) reauthorized ARPA-E and made certain program changes. As amended, the ARPA-E statute requires the director of ARPA-E to take a number of steps designed to ensure that research projects supported by the agency focus on areas that industry is not likely to undertake.[49] Other provisions in Section 904 address administrative issues (e.g., staff, award authority) and add "research and development (R&D) in advanced manufacturing process and technologies for domestic manufacturing of novel energy technologies" to the list of the director's responsibilities. Section 904 also adds "identifying mechanisms for commercial application of successful energy technology development projects, including through establishment of partnerships between awardees and commercial entities" to the list of staff responsibilities.

The DOE has implemented ARPA-E. The agency issued its first open funding solicitation in 2009 using ARRA funds. Congress first provided regular appropriations to ARPA-E in FY2011 ($180 million, actual). The energy agency received $251 million in FY2013, the final year of authorization under COMPETES.[50] ARPA-E asserts that it has funded over 400 energy technology projects since 2009.[51]

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[47] For example, in 2010 ED awarded $2.3 million in Teacher Quality Partnership Grants to the National Math and Science Initiative (NMSI) to help implement the UTeach program at Cleveland State University. See National Math + Science Initiative, "NMSI Awarded $2.2 [sic] Million Grant by Department of Education to Launch UTeach Program at Cleveland State University," press release, April 1, 2010.

[48] UTeach Institute, "UTeach Expands to 44 Universities," press release, December 1, 2014, http://uteach-institute.org/news/detail/uteach-expands-to-44-universities/.

[49] §5012(c)(2)(C) of the America COMPETES Act (P.L. 110-69) directs ARPA-E to achieve its goals by, among other things, "accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty." §904 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) includes provisions designed to enhance this directive.

[50] For more information about current-year budget and appropriations for ARPA-E, see CRS Report R43986, *ARPA-E and the FY2016 Budget Request*, by Heather B. Gonzalez.

[51] U.S. Department of Energy, Advanced Research Projects Agency-Energy, "About: ARPA-E History," http://arpa-

Some analysts have questioned whether ARPA-E projects have focused on areas that industry is not likely to undertake, as required by Section 904. However, a 2012 GAO report on ARPA-E found that "most ARPA-E-type projects could not be funded solely by private investors."[52] The GAO report also identified 18 of 121 award winners that had received prior private sector investment. According to GAO, the agency took steps to identify and understand how this prior funding related to currently proposed projects and now requires applicants to explain why private investors are not willing to fund their proposals.[53] GAO further determined that 91 of 121 winning projects involved technological concepts that had not been proven in a laboratory setting, noting that the private sector may consider projects too risky to invest in at this stage.[54] GAO recommended that ARPA-E

> provide guidance with a sample response to assist applicants in providing information on sources of private funding for proposed ARPA-E projects,
>
> require that applicants provide letters or other forms of documentation from private investors that explain why investors are not willing to fund the projects proposed to ARPA-E, and
>
> use venture capital funding databases to help identify applicants with prior private investors and to help check information applicants provide on their applications.[55]

The House Committee on Science, Space, and Technology, Subcommittee on Investigations and Oversight, held a hearing on the above-described GAO findings in January 2012.[56] The majority staff report and Subcommittee's ranking Member appeared to disagree on the extent to which private industry might fund ARPA-E projects. The majority staff report suggested that there may be "many exceptions" to ARPA-E's general practice of funding research that is too risky for private investment.[57] The Subcommittee's ranking Member, on the other hand, reiterated and expressed support for GAO's general conclusions and stated that the exceptions identified in the majority staff report were "cherry-picked."[58] ARPA-E former director, Arun Majumdar, who testified on behalf of ARPA-E at the hearing, generally endorsed GAO's findings and stated

> Importantly, GAO did not identify a single instance in which private investors would have funded an ARPA-E project within the same, accelerated timeframe (i.e., 3 years or less).

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e.energy.gov/?q=arpa-e-site-page/arpa-e-history.

[52] U.S. Government Accountability Office, *Department of Energy: Advanced Research Projects Agency-Energy Could Benefit from Information on Applicants' Prior Funding*, Highlights, GAO-12-112, January 2012, http://www.gao.gov/products/GAO-12-112.

[53] ARPA-E established this requirement in the third round of funding.

[54] On this point the GAO cites the American Energy Innovation Council, *Catalyzing American Ingenuity: The Role of Government in Energy Innovation*, September 2011, http://americanenergyinnovation.org/catalyzing-ingenuity-2011/.

[55] Government Accountability Office, *Department of Energy: Advanced Research Projects Agency-Energy Could Benefit from Information on Applicants' Prior Funding*, GAO-12-112, January 2012, p. 22, http://www.gao.gov/products/GAO-12-112.

[56] Video, testimony, and commentary from the hearing is available at http://science.house.gov/hearing/investigations-and-oversight-subcommittee-hearing-review-advanced-research-projects-agency.

[57] U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Investigations and Oversight, *Majority Staff Report*, hearing on the Advanced Research Projects Agency-Energy, 112th Cong., 2nd sess., January 24, 2012, p. 1. A webcast and materials from the hearing are available at http://science.house.gov/hearing/investigations-and-oversight-subcommittee-hearing-review-advanced-research-projects-agency.

[58] Opening Statement of Ranking Member Paul D. Tonko, in U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Investigations and Oversight, *A Review of the Advanced Research Projects Agency-Energy*, hearings, 112th Cong., 2nd sess., January 24, 2012, http://democrats.science.house.gov/sites/democrats.science.house.gov/files/documents/Tonko%20draft.pdf.

> This demonstrates that selected projects were appropriate and fulfilled a critical criterion and objective of the agency.[59]

It is not clear whether ARPA-E implemented Section 904 provisions relating to R&D in advanced manufacturing process and technologies for the domestic manufacturing of novel energy technologies. Although ARPA-E does not appear to have operated a specific program focused solely on advanced domestic manufacturing during the authorization period, some of its projects seek to develop manufacturing capabilities.

ARPA-E's capacity for technology transfer has also been of interest to policymakers. In a 2011 audit, the DOE's Inspector General stated that

> ARPA-E had not established a systematic approach to ensure that it was meeting the technology transfer and outreach requirement of the COMPETES Act that it spend 2.5% of its budget on technology transfer and outreach activities.[60]

The Inspector General also stated that ARPA-E was working to address the auditing office's concerns about its commercialization and technology transfer activities, noting

> More recently, in the five funding opportunity announcements it issued in April 2011, ARPA-E included a requirement for recipients to spend a minimum of 5 percent of their awards on technology transfer and outreach and to track and report to ARPA-E on such expenditures.[61]

Two other external researchers who assessed ARPA-E in 2011 concluded that the agency's program managers "have adopted a 'hands-on' relationship with award recipient" and that they "promote contacts with venture and commercial funding."[62]

ARPA-E uses a variety of mechanisms designed to help move technologies into the marketplace. For example, ARPA-E's Technology-to-Market team assists project teams in constructing and implementing their Technology-to-Market plans.[63] The agency also hosts an annual Innovation Summit that is designed to move technologies out of the lab and into the marketplace.[64] At the 2015 ARPA-E summit, the agency announced that 34 projects had received $850 million in follow-on funding from the private sector, after an initial aggregate ARPA-E investment of approximately $135 million.[65] In 2012, the agency joined with NSF to allow its project teams to participate in NSF's Innovation Corps (I-Corps) program.[66] I-Corps program participants form entrepreneurial-academic teams that follow an accelerated version of Stanford University's Lean

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[59] Testimony of ARPA-E Director Arun Majumdar, in U.S. Congress, House Committee on Science, Space, and Technology, Subcommittee on Investigations and Oversight, *A Review of the Advanced Research Projects Agency-Energy*, hearings, 112th Cong., 2nd sess., January 24, 2012, http://science.house.gov/sites/republicans.science.house.gov/files/documents/hearings/HHRG-112-SY-WState-AMajumdar-20120124.pdf.

[60] U.S. Department of Energy, Office of the Inspector General, *Audit Report: The Advanced Research Projects Agency–Energy*, OAS-RA-11-11, August 22, 2011, p. 1, http://energy.gov/sites/prod/files/OAS-RA-11-11.pdf.

[61] Ibid., 2.

[62] William Bonvillian and Richard Van Atta, "ARPA-E and DARPA: Applying the DARPA Model to Energy Innovation," *Journal of Technology Transfer*, vol. 36 (2011), pp. 469-513.

[63] ARPA-E, "Engage: Tech-to-Market (T2M)," accessed December 9, 2014, http://arpa-e.energy.gov/?q=arpa-e-site-page/tech-market-t2m.

[64] ARPA-E, "About the Summit," accessed on December 9, 2014, http://www.arpae-summit.com/About/About-the-Summit.

[65] ARPA-E, "ARPA-E Announces Start-up Companies, Strategic Partnerships and Private Sector Funding at 2015 Innovation Summit," press release, February 9, 2015, at http://arpa-e.energy.gov/?q=news-item/arpa-e-announces-start-companies-strategic-partnerships-and-private-sector-funding.

[66] More information about this partnership is available at http://arpa-e.energy.gov/?q=arpa-e-site-page/i-corps-arpa-e.

LaunchPad course (among other I-Corps-specific elements), with the ultimate goal of teaching participants how to identify product opportunities that can emerge from academic research.[67]

Innovation Inducement Prizes

Although prizes have a long history as innovation inducement tools, some analysts suggest that their use is increasing.[68] The federal government is among the types of entities (including philanthropic organizations and other governmental bodies) that use prizes to induce innovation. Before passage of the America COMPETES Reauthorization Act of 2010, only certain federal agencies had the authority to initiate prize competitions. Section 105 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) provided federal agencies with broad authority to carry out programs designed to stimulate innovation through prize competitions.

Although the authorization is only five years old, federal agencies' use of innovation inducement prizes authorized under Section 105 is relatively well documented. OSTP has published annual reports on the implementation of Section 105 as required by the America COMPETES Reauthorization Act of 2010. In its May 2014 progress update, OSTP reported that the executive branch was initiating prize competitions under the authority of Section 105 and that it had issued guidance to agencies and created a contract vehicle, as required by the provision.[69] In its April 2015 progress report, OSTP further noted that federal agencies had initiated at least 100 prize competitions at 30 agencies specifically under the authority of Section 105.[70]

With the legal authority for federal innovation inducement prizes established for most agencies, and the evidence that agencies are initiating competitions, focus has turned to implementation. OSTP states that prizes have enabled federal agencies to

> Pay only for success and establish an ambitious goal without having to predict which team or approach is most likely to succeed;
>
> Reach beyond the "usual suspects" to increase the number of solvers tackling a problem and to identify novel approaches, without bearing high-levels of risk;
>
> Bring out-of-discipline perspectives to bear; and
>
> Increase cost-effectiveness to maximize the return on taxpayer dollars.[71]

Other observers, examining a large universe of federal innovation inducement prize activities conducted between 2010 and 2014, identified a wide range of still-evolving competition practices and experimentation in federal prize design. They found a mix of desired outcomes and competition goals, as well as "growth in the pursuit of bolder outcomes that require more

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[67] National Science Foundation, "About I-Corps," accessed December 9, 2014, http://www.nsf.gov/news/special_reports/i-corps/about.jsp.

[68] The Longitude Prize offered by the British Parliament in 1714 is one oft-cited example. See McKinsey and Company, "*And the Winner Is ...": Capturing the Promise of Philanthropic Prizes*, 2009, pp. 15-18, http://www.mckinseyonsociety.com/downloads/reports/Social-Innovation/And_the_winner_is.pdf.

[69] Executive Office of the President, Office of Science and Technology Policy, *Implementation of Federal Prize Authority: Fiscal Year 2013 Progress Report*, May 2014, http://www.whitehouse.gov/sites/default/files/microsites/ostp/competes_prizesreport_fy13_final.pdf.

[70] Executive Office of the President, Office of Science and Technology Policy, *Implementation of Federal Prize Authority: Fiscal Year 2014 Progress Report*, April 2015, p. 7, https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/fy14_competes_prizes_-_may_2015.pdf.

[71] Executive Office of the President, Office of Science and Technology Policy, *Implementation of Federal Prize Authority: Fiscal Year 2014 Progress Report*, April 2015, p. 5, https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/fy14_competes_prizes_-_may_2015.pdf.

complex design." They also asserted that the most ambitious prize competition outcomes, which they defined as "market stimulation" and "inspiring transformation," made up a small percentage (2%) of the historical competitions examined.[72]

Questions about the design and management of innovation contests appear frequently in the literature on innovation inducement prizes. For example, one study focused on whether (and in what ways) the number of contestants affects the outcome of innovation contests. This study found both positive and negative effects from so-called open innovation contests and suggested that open contests may be most appropriate for problems with a high degree of uncertainty.[73] Another scholar raised questions about the design of innovation inducement competitions, including whether policymakers ought to condition prize payments on a market test (e.g., award the prize only if consumers purchase the technology) and whether prizes can be designed (via pricing conditions) to ensure widespread access to the technologies developed.[74] A third scholar assessed prizes as a policy tool, identifying a wide range of issues for policymakers to consider, such as trade-offs and complementarities between prizes and other innovation policy tools (e.g., patents, grants), as well as prize design considerations and conditions (e.g., rules, outcomes, incentives, deadlines).[75] Several scholars have noted that publicity appears to be a key non-monetary motivation in prize competitions.[76]

At least one observer has highlighted the conditions under which prizes may be a uniquely effective tool and suggested best practices for their use.[77] Other observers have sought to provide practical guidance on strategic considerations and tactical guidance in prize design.[78] Analysts who object to government-sponsored inducements (in general) may view prizes as unnecessary, arguing that consumer demand and the potential for profit are sufficiently powerful motivators.

Public Access to Federally Funded Research

Section 103 of the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) directed the National Science and Technology Council (NSTC) to establish an Interagency Public Access Committee to "coordinate federal science agency research and policies related to the dissemination and long-term stewardship of the results of unclassified research, including digital

[72] This study examined federal prize competitions based on data from *Challenge.gov*, the federal prize portal. Jesse Goldhammer et al., *The Craft of Incentive Prize Design: Lessons from the Public Sector*, Doblin, Deloitte Consulting LLP, June 18, 2014, p. 47, http://dupress.com/articles/the-craft-of-incentive-prize-design/.

[73] Kevin J. Boudreau, Nicole Lacetera, and Karim R. Lakhani, "Incentives and Problem Uncertainty in Innovation Contests: An Empirical Analysis," *Management Science*, vol. 57, no. 5 (May 2011), pp. 843-863.

[74] Heidi Williams, "Innovation Inducement Prizes: Connecting Research to Policy," *Journal of Policy Analysis and Management*, vol. 31, no. 3 (Summer 2012), pp. 752-776.

[75] Luciano Kay, "Opportunities and Challenges in the Use of Innovation Prizes as a Government Policy Instrument," *Minerva*, vol. 50, no. 2 (June 2012), pp. 191-196. See also Luciano Kay, "The Effect of Inducement Prizes on Innovation: Evidence from the Ansari X Prize and the Northrop Grumman Lunar Lander Challenge," *R&D Management*, vol. 41, no. 4 (2011), pp. 360-377.

[76] Ibid., and Petra Moser and Tom Nicholas, "Prizes, Publicity, and Patents: Non-Monetary Awards as a Mechanism to Encourage Innovation," *The Journal of Industrial Economics*, vol. LXI, no. 3 (September 2013), pp. 763-788.

[77] Erika B. Wagner, "Why Prize? The Surprising Resurgence of Prizes to Stimulate Innovation," *Research Technology Management*, vol. 54, no. 6 (November-December 2011), p. 32.

[78] For example, see Jesse Goldhammer et al., *The Craft of Incentive Prize Design: Lessons from the Public Sector*, Doblin, Deloitte Consulting LLP, June 18, 2014, http://dupress.com/articles/the-craft-of-incentive-prize-design/.

data and peer-reviewed scholarly publications, supported wholly, or in part, by funding from the federal science agencies."[79]

According to the NSTC, the council established two working groups pursuant to Section 103. The council published a progress report on the working groups' activities in March 2012.[80] The report stated that the working groups focused on scholarly publications and digital data and that they issued a series of requests for comments to collect ideas about how to facilitate data sharing and public access. Commenters varied in their opinions about how to implement increased access.[81]

In February 2013, OSTP Director John P. Holdren issued a government-wide policy memorandum directing each federal agency with over $100 million in annual R&D expenditures to develop a plan to increase public access to the results of research it funds. The memorandum stated that these plans must be consistent with the objectives set out in the memorandum, which were designed to comply with Section 103. As per the memorandum, agencies were to submit draft plans to OSTP within six months—i.e., on or about August 22, 2013—at which point OSTP and the Office of Management and Budget (OMB) would review the draft plans and provide guidance.[82] In a November 13, 2014, letter to congressional appropriators, Director Holdren reported that OSTP and OMB had given final approval to two agency plans (DOE and an unnamed agency)[83] and that other federal agency plans remained in the revise-review stage of the approval process. However, Director Holdren's letter also stated that most agencies would "be releasing their public access plans over the next three months."[84]

Efforts to Reauthorize in the 114th Congress

At least three bills have been introduced to reauthorize selected provisions of the COMPETES Acts in the 114th Congress: H.R. 1806, H.R. 1898, and S. 1398.[85] Both H.R. 1806 and H.R. 1898

[79] §103 primarily addresses public access to general purpose scholarly research that is funded by the federal government. A closely related policy issue focuses on the public release of federally funded data that federal agencies use to inform regulatory decisions. For more information about the second issue, see CRS Report R42983, *Public Access to Data from Federally Funded Research: Provisions in OMB Circular A-110*, by Eric A. Fischer.

[80] Also in March 2012, the House Committee on Science, Space, and Technology, Subcommittee on Investigations and Oversight held a hearing on various research dissemination models and their effects on scientific progress. Discussion referenced §103 and the effort to increase public access to federally funded research. More information about the hearing—including a webcast, hearing charter, and testimony—is available at http://science.house.gov/hearing/subcommittee-investigations-and-oversight-hearing-examining-public-access-and-scholarly.

[81] Executive Office of the President, National Science and Technology Council, *Interagency Public Access Coordination: A Report to Congress on The Coordination of Policies Related to the Dissemination and Long-Term Stewardship of the Results of Federally Funded Scientific Research*, March 2012, http://www.whitehouse.gov/sites/default/files/microsites/ostp/public_access-final.pdf.

[82] "Memorandum for the Heads of Executive Departments and Agencies," from John Holdren, Director of the Office of Science and Technology Policy, Executive Office of the President, February 22, 2013, http://www.whitehouse.gov/sites/default/files/microsites/ostp/ostp_public_access_memo_2013.pdf. See also Executive Office of the President, Office of Science and Technology Policy, "OSTP Public Access Policy Forum," http://www.whitehouse.gov/administration/eop/ostp/library/publicaccesspolicy.

[83] DOE's public access plan is available at http://www.energy.gov/sites/prod/files/2014/08/f18/DOE_Public_Access%20Plan_FINAL.pdf.

[84] Letter from John P. Holdren, Director of the Office of Science and Technology Policy and Assistant to the President for Science and Technology, to House and Senate Appropriations Committees, November 13, 2014, http://www.whitehouse.gov/sites/default/files/microsites/ostp/public_access_report_to_congress_ostp_11.13.14.pdf.

[85] Several stand-alone bills with similar provisions have also been introduced in the 114th Congress. For example, H.R. 1806 includes selected provisions from H.R. 35 (Low-Dose Radiation Research Act of 2015), H.R. 874 (American Super Computing Leadership Act), H.R. 1020 (STEM Education Act of 2015), H.R. 1119 (Research and Development

include provisions authorizing activities and appropriations for physical sciences and engineering research, STEM education, and related programs at multiple COMPETES Acts agencies. S. 1398 focuses on the Office of Science and ARPA-E within the Department of Energy. The following sections summarize these bills and highlight some of their provisions.

Information about efforts to reauthorize in the 113th Congress is included in the **Appendix**.

H.R. 1806

As passed by the House, the America COMPETES Reauthorization Act of 2015 (H.R. 1806)[86] seeks to

> provide for technological innovation through the prioritization of Federal investment in basic research, fundamental scientific discovery, and development to improve the competitiveness of the United States, and for other purposes.[87]

H.R. 1806 would authorize appropriations for NSF, NIST, and the DOE Office of Science and would authorize various research, STEM education, and innovation-related programs and activities (including ARPA-E) at various federal agencies. H.R. 1806 would also authorize appropriations for selected other research activities at the Department of Energy—including electricity delivery and energy reliability R&D, nuclear energy R&D, energy efficiency and renewable energy R&D, and fossil energy R&D.[88] Most of the appropriations authorizations in H.R. 1806 are for two years (FY2016 and FY2017). Although many of the provisions in H.R. 1806 are similar to provisions in H.R. 4186 and H.R. 4869 from the 113th Congress, the bills are not identical. H.Rept. 114-107 (parts 1 and 2) accompanied H.R. 1806 when it was reported from the House Committee on Science, Space, and Technology on May 8, 2015. The House passed H.R. 1806, as amended, on May 20, 2015 by a vote of 217-205.

Funding for the Targeted Accounts. H.R. 1806 would authorize appropriations to NSF, NIST, and the DOE Office of Science for FY2016 and FY2017.[89] **Table 1** provides the FY2014 actual, current, or enacted funding levels as reported by each agency; the FY2015 enacted levels; the Administration's FY2016 request; and the FY2016 and FY2017 authorization levels. Explanatory materials associated with H.R. 1806 do not mention the doubling path policy or targeted accounts; rather, they highlight provisions authorizing year-over-year increases. Accordingly, **Table 1** shows the compound annual growth rate (CAGR) in funding for these agencies under H.R. 1806, treating FY2015 enacted appropriations as the baseline and FY2017 as the final year.

Efficiency Act), H.R. 1156 (International Science and Technology Cooperation Act of 2015), H.R. 1158 (Department of Energy Laboratory Modernization and Technology Transfer Act of 2015), H.R. 1162 (Science Prize Competitions Act), and H.R. 1764 (United States Chief Technology Officer Act). H.R. 1898 also contains selected provisions from H.R. 35, H.R. 1020, H.R. 874, H.R. 1156, and H.R. 1158 as well as selected provisions from H.R. 467 (STEM Opportunities Act of 2015), H.R. 591 (Engineering Biology Research and Development Act of 2015), H.R. 1870 (To Authorize Energy Innovation Hubs), H.R. 1871 (To Authorize a Nuclear Physics Program), and H.R. 1872 (To Authorize Energy Frontier Research Centers).

[86] This section describes H.R. 1806 as passed by the House on May 20, 2015, unless otherwise noted.

[87] H.R. 1806, official title.

[88] H.R. 1806, Title VI, Subtitle G.

[89] H.R. 1806, §§101, 401, and 510, respectively.

Table 1. Compound Annual Growth Rate (CAGR) in Funding for NSF, NIST, and the Office of Science under H.R. 1806, as Passed by the House

Dollars in Millions, Rounded

Agency	FY2014	FY2015 Enacted	FY2016 Request	As Authorized Under H.R. 1806		
				FY2016	FY2017	CAGR[a]
NSF (total)	$7,131.4	$7,344.2	$7,723.6	$7,597.1	$7,597.1	1.7%
NIST (total)	$850.0	$863.9	$1,119.7	$938.7[b]	$938.7[b]	4.2%
Office of Science (total)	$5,070.2	$5,071.0	$5,339.8	$5,339.8	$5,339.8	2.6%

Source: CRS analysis of H.R. 1806, as passed by the House on May 20, 2015, as well as NSF, NIST, and Office of Science FY2016 congressional budget justifications.

Notes: Figures in the column titled "FY2014" are actual, enacted, or current funding levels as reported by each agency in their respective FY2016 congressional budget justifications. For the sake of comparability, Office of Science funding levels in FY2014 and FY2015 do not include changes due to rescissions, use of prior year balances, or certain small business program transfers.

a. Percentages in this column represented the CAGR in funding for each specified agency from FY2015 enacted to the final year of authorized funding under H.R. 1806 (i.e., FY2017).

b. As introduced, H.R. 1806 would have authorized $933.7 billion in funding for NIST in FY2016 and FY2017.

STEM Education. Among other things, H.R. 1806 seeks to address governance concerns about the federal STEM education effort. It includes provisions to establish a STEM Education Advisory Panel to advise the President and other policymakers,[90] update the duties of NSTC's Committee on STEM Education,[91] and establish a STEM Education Coordinating Office at the NSF.[92] Additionally, H.R. 1806 contains language that would authorize informal STEM education activities[93] and make changes to the Noyce program,[94] among other things, at NSF. The bill would also clarify that the definition of STEM education includes computer science (for the purposes of the act)[95] and would require NSF to establish the Hispanic-Serving Institutions program that was authorized by the 2007 America COMPETES Act.[96]

Other Provisions. Other provisions in H.R. 1806 would provide for coordination of international science and technology partnerships[97] and would establish the position of U.S. Chief Technology Officer within OSTP.[98] The bill also includes provisions to authorize certain Office of Science research programs and activities (e.g., High Energy Physics, Fusion Energy),[99] address various

[90] H.R. 1806, §202.

[91] H.R. 1806, §203.

[92] H.R. 1806, §204.

[93] H.R. 1806, §125.

[94] H.R. 1806, §124.

[95] H.R. 1806, §2.

[96] H.R. 1806, §127.

[97] H.R. 1806, §303.

[98] H.R. 1806, §306.

[99] H.R. 1806, Title V.

commercialization issues within DOE (e.g., technology transfer, early-stage technology demonstration, participation in I-Corps),[100] and amend the ARPA-E statute.[101]

Some of the more intensely debated provisions in H.R. 1806 would authorize appropriations to NSF by directorate (e.g., $832.0 million for Biological Sciences and $150.0 million for Social, Behavioral, and Economic Sciences in FY2016 and FY2017)[102] and would authorize funding below current spending levels for certain DOE and NSF accounts and programs. These accounts include ARPA-E, Energy Efficiency and Renewable Energy, and Biological and Environmental Research within the Office of Science at DOE,[103] as well as the Social, Behavioral, and Economic Sciences and Geosciences directorates at NSF.[104] For example, H.R. 1806 would authorize ARPA-E at $140 million in both FY2016 and FY2017. With the exception of FY2013—when ARPA-E was subject to reductions as a result of certain rescissions and the sequestration process—Congress has funded ARPA-E at about $280 million since FY2012.[105]

H.R. 1898

As introduced, the America Competes Reauthorization Act of 2015 (H.R. 1898) seeks to "provide for investment in innovation through research and development and STEM education, to improve the competitiveness of the United States, and for other purposes."[106]

H.R. 1898 would authorize funding for NSF, NIST, and the Office of Science and would authorize or amend various federal STEM education and innovation-related programs, policies, and activities. It is similar, but not identical, to H.R. 4159 from the 113th Congress.

Funding for the Targeted Accounts. H.R. 1898, as introduced, would authorize appropriations to NSF, NIST, and the Office of Science from FY2016 through FY2020.[107] **Table 2** includes FY2014 actual, current, or enacted funding levels (as reported by each agency); the FY2015 enacted levels; the Administration's FY2016 request; and the FY2016 to FY2020 authorization levels. Explanatory materials associated with H.R. 1898 do not mention the doubling path policy or the targeted accounts; rather, they highlight provisions authorizing year-over-year increases for NSF, NIST, and the Office of Science. Accordingly, **Table 2** shows the compound annual growth rate (CAGR) for these agencies under H.R. 1898, treating FY2015 enacted appropriations as the baseline and FY2020 authorized levels as the final year.

[100] H.R. 1806, Title VII.

[101] H.R. 1806, Title VI, Subtitle F.

[102] For more information about these debates at NSF, see CRS Report R43585, *The National Science Foundation: Background and Selected Policy Issues*, by Heather B. Gonzalez.

[103] For more information about funding for the Office of Science, see CRS Report R43963, *DOE's Office of Science and the FY2016 Budget Request*, by Heather B. Gonzalez.

[104] H.R. 1806, §§101, 509, and 681.

[105] For more information about funding for ARPA-E, see CRS Report R43986, *ARPA-E and the FY2016 Budget Request*, by Heather B. Gonzalez.

[106] H.R. 1898.

[107] H.R. 1898, §§301, 402, and 611, respectively.

Table 2. Compound Annual Growth Rate (CAGR) in Funding for NSF, NIST, and the Office of Science under H.R. 1898, as Introduced

Dollars in Millions, Rounded

Agency	FY2014	FY2015 Enacted	FY2016 Request	As Authorized Under H.R. 1898					
				FY2016	FY2017	FY2018	FY2019	FY2020	CAGR[a]
NSF (total)	$7,131.4	$7,344.2	$7,723.6	$7,723.6	$8,099.0	$8,493.6	$8,907.8	$9,342.8	4.9%
NIST (total)	$850.0	$863.9	$1,119.7	$1,119.7	$1,484.4[b]	$1,517.1[b]	$1,562.0[b]	$1,609.1[b]	13.2%[c]
Office of Science (total)	$5,070.2	$5,071.0	$5,339.8	$5,339.8	$5,606.8	$5,887.1	$6,181.5	$6,490.6	5.1%

Source: CRS analysis of H.R. 1898, as introduced, as well as the NSF, NIST, and Office of Science FY2016 congressional budget justifications.

Notes: Figures in the column titled "FY2014" are actual, enacted, or current funding levels as reported by each agency in their respective FY2016 congressional budget justifications. For the sake of comparability, Office of Science funding levels in FY2014 and FY2015 do not include changes due to rescissions, use of prior year balances, or certain small business program transfers.

a. Percentages in this column represented the CAGR in funding for each specified agency from FY2015 enacted to the final year of authorized funding under H.R. 1898 (e.g., FY2020).

b. The FY2017 to FY2020 NIST appropriations authorizations as proposed by H.R. 1898 may not be comparable to figures reported in previous America COMPETES Act-related CRS reports related to efforts to double funding for certain targeted appropriations accounts; for example, the NIST figures in Table 5 include all NIST appropriations accounts, not just targeted accounts. In addition, according to staff of the House Committee on Science, Space, and Technology, H.R. 1898 incorrectly specifies the total authorized funding levels for NIST for FY2017 to FY2020, over-reporting the total by $310 million for each year.

c. The CAGR for NIST funding between FY2015 (enacted) and FY2020 (authorized under H.R. 1898), as calculated using the lower authorization level for FY2020 discussed above in footnote a, is 8.5%.

STEM Education. H.R. 1898 contains a number of STEM education provisions that seek to address governance concerns. Examples include provisions that would establish a government-wide STEM education coordinator within the OSTP and would establish a STEM Education Advisory Panel to advise the President and other policymakers.[108] At NSF, the bill would, among other things, authorize grants (1) to institutions of higher education for undergraduate STEM education reform,[109] (2) to community colleges for advanced manufacturing education,[110] and (3) to unspecified organizations for R&D on the alignment, implementation, impact, and improvement of state-based STEM education standards.[111] Additionally, like H.R. 1806 would authorize informal education activities[112] and amend the Noyce program at NSF.[113]

Other Provisions. Other provisions in H.R. 1898 seek to broaden the participation of underrepresented groups in STEM education and employment. These include provisions directing NSF to develop written guidance for institutions of higher education on best practices for identifying cultural or institutional barriers to the recruitment, retention, and promotion of underrepresented populations in STEM degree programs and academic STEM careers.[114] H.R.

[108] H.R. 1898, §202.

[109] H.R. 1898, §323.

[110] H.R. 1898, §324.

[111] H.R. 1898, §328.

[112] H.R. 1898, §327.

[113] H.R. 1898, §326.

[114] H.R. 1898, §217.

1898 also includes provisions to reauthorize the Federal Loan Guarantees for Innovative Technologies in Manufacturing program[115] and directs specified federal science agencies, to the extent practicable, to support federal employee and contractor attendance at scientific and technical conferences.[116] The bill's DOE title would authorize certain Office of Science research programs (e.g., High Energy Physics, Fusion Energy) and would reauthorize and amend the statutory authority for ARPA-E.[117] H.R. 1898, Title I, Subtitle B, would reauthorize the National Nanotechnology Initiative, while Title I, Subtitle C, would provide for a National Engineering Biology Research and Development program to "advance areas of research at the intersection of the biological, physical, and information sciences and engineering."

S. 1398

As introduced, the Energy Title of America COMPETES Reauthorization Act of 2015 (S. 1398) seeks to "extend, improve, and consolidate energy research and development programs."[118]

Doubling path policy, revised. As its title indicates, S. 1398 was not designed to be a comprehensive COMPETES reauthorization bill. Rather, it contains only energy-related provisions—including funding authorizations for the Office of Science and ARPA-E.[119] A press release and materials associated with S. 1398 described the bill as putting "us on a path to double basic energy research."[120] The materials treat FY2015 as the baseline year and would set basic energy research on a path to double at a rate of 4% a year over a period of about 18 years. The doubling path policy for basic energy research in S. 1398 includes both the Office of Science and ARPA-E.

The doubling path policy in S. 1398 represents an evolution of the doubling path policy in the COMPETES Acts. The COMPETES Acts policy focused on doubling funding for physical sciences and engineering research, while S. 1398 focuses more narrowly on basic energy research. The COMPETES Acts baseline year is FY2006, while the baseline for S. 1398 is FY2015. Additionally, the COMPETES Acts doubling path policy targeted increases at the NSF, certain NIST accounts, and the Office of Science. S. 1398 seeks increases for the Office of Science and ARPA-E.

Table 3 shows the compound annual growth rate (CAGR) for the Office of Science and ARPA-E under S. 1398, treating FY2015 enacted appropriations as the baseline and FY2020 authorized levels as the final year. The table also includes FY2014 current funding levels, FY2015 enacted levels, the Administration's FY2016 request, and FY2016 to FY2020 authorization levels under S. 1398.[121]

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[115] H.R. 1898, §502.

[116] H.R. 1898, §106.

[117] H.R. 1898, Title VI.

[118] S. 1398. Provisions from S. 1398 have also been introduced as part of the Senate Energy and Natural Resources Committee's Energy Policy Modernization Act of 2015. This bill had not received a number as of July 24, 2015, but details are available at http://www.energy.senate.gov/public/index.cfm?p=legislation&id=87D9E1CF-1B96-4815-9D05-387798EFAEA7.

[119] For more information about funding for the Office of Science and ARPA-E, see CRS Report R43963, *DOE's Office of Science and the FY2016 Budget Request*, by Heather B. Gonzalez; and CRS Report R43986, *ARPA-E and the FY2016 Budget Request*, by Heather B. Gonzalez.

[120] Sen Lamar Alexander, "Seven Senators Introduce Bipartisan Legislation to Put U.S. on Path to Double Basic Energy Research," press release, May 20, 2015, http://www.alexander.senate.gov/public/index.cfm/pressreleases?ID=eb7c6965-d5fb-465e-a8d2-34204843af2e.

[121] S. 1398, §101.

Table 3. Compound Annual Growth Rate (CAGR) in Funding for the Office of Science and ARPA-E under S. 1398, as Introduced

Dollars in Millions, Rounded

Agency	FY2014 Current	FY2015 Enacted	FY2016 Request	As Authorized Under S. 1398					
				FY2016	FY2017	FY2018	FY2019	FY2020	CAGR[a]
Office of Science (total)	$5,070.2	$5,071.0	$5,339.8	$5271.0	$5485.0	$5704.0	$5932.0	$6178.0	4.0%
ARPA-E	$280.0	$280.0	$325.0	$291.2	$303.6	$314.7	$327.3	$340.0	4.0%

Source: CRS analysis of S. 1398, as introduced, and the FY2016 Office of Science congressional budget justification.

Notes: For the sake of comparability, Office of Science funding levels in FY2014 and FY2015 do not include changes due to rescissions, use of prior year balances, or certain small business program transfers.

a. Percentages in this column represented the CAGR in funding for the Office of Science from FY2015 enacted to the final year of authorized funding under S. 1398 (i.e., FY2020).

Amendments to ARPA-E's statutory authority in S. 1398 would require the director to ensure that (1) activities are coordinated with, and not duplicative of, other DOE efforts; and (2) funding is not provided for projects that might otherwise be independently commercially viable. Other provisions would define certain types of ARPA-E awardee information (including business plans and certain financial information) as privileged and confidential and therefore not subject to disclosure under the Freedom of Information Act (5 U.S.C. 552).[122]

STEM Education. S. 1398 includes provisions to repeal many of the remaining DOE STEM education activities authorized by the America COMPETES Act. Specifically, the bill would repeal the Nuclear Science Talent Expansion Program for Institutions of Higher Education, the Hydrocarbon Systems Science Competitiveness Grants for Institutions of Higher Education, and Discovery Science and Engineering Innovation Institutes. These programs were authorized by P.L. 110-69, Sections 5004, 5005(e), and 5008, respectively. S. 1398 would not repeal Section 5005(d) of P.L. 110-69, which authorizes Hydrocarbon Systems Science Program Expansion Grants for Institutions of Higher Education. These programs and activities do not appear to have been implemented or received funding.[123]

S. 1398 also seeks to repeal certain STEM education provisions from the Department of Energy Science Education Enhancement Act (DOE-SEEA, 42 U.S.C. 7381 et seq.). These provisions were added to the DOE-SEEA by Section 5003 of the America COMPETES Act. The America COMPETES Reauthorization Act of 2010 already repealed three of the six DOE-SEEA STEM education provisions added by that act: 42 U.S.C. 7381h, 7381j, and 7381p.[124] S. 1398 would repeal the remaining three: 42 U.S.C. 7381l, 7381n, and 7381r.[125] These programs and activities do not appear to have been implemented or received funding.[126]

[122] S. 1398, §102.

[123] See CRS Report R42779, *America COMPETES Acts: FY2008 to FY2013 Funding Tables*, by Heather B. Gonzalez.

[124] Pilot Program of Grants to Specialty Schools for Science and Mathematics (42 U.S.C. 7381h), Experiential-Based Learning Opportunities (42 U.S.C. 7381j), and National Energy Education Development (42 U.S.C 7381p).

[125] National Laboratories Centers of Excellence in Science, Technology, Engineering, and Mathematics Education (42 U.S.C. 7381l), Summer Institutes (42 U.S.C. 7381n), and Mentoring Program (42 U.S.C. 7381r).

[126] See CRS Report R42779, *America COMPETES Acts: FY2008 to FY2013 Funding Tables*, by Heather B. Gonzalez.

S. 1398 would also repeal the appropriations authorizations of three DOE STEM education programs authorized by the America COMPETES Act. (Program authority would remain.) These include the Department of Energy Early Career Awards for Science, Engineering, and Mathematics Researchers (Early Career), Protecting America's Competitive Edge (PACE) Graduate Fellowship Program, and Distinguished Scientist programs. These programs were authorized by the America COMPETES Act, P.L. 110-69, Sections 5006, 5009, and 5011, respectively. Other STEM education provisions in S. 1398 would consolidate the Early Career and Distinguished Scientist programs, provide $150 million in appropriations authorizations for the consolidated program (each fiscal year between FY2016 and FY2020), and specify that no more than 65% of total consolidated program funds may accrue to either Early Career or Distinguished Scientist activities.[127]

Concluding Observations

In addition to their stated purposes—investing in innovation and improving U.S. competitiveness—the COMPETES Acts have effectively functioned as the primary authorization acts for NIST, the Office of Science, and NSF since FY2008. The acts have also contained a variety of provisions for policy and programs at ARPA-E, OSTP, ED, NASA, the National Oceanic and Atmospheric Administration, the DOC's Economic Development Administration, and GAO. As such, the range of policy issues that may arise during congressional debate about reauthorization of the COMPETES Acts could include a wide variety of issues perceived as relating to innovation or competitiveness, or reauthorization, at any or all of these agencies. However, key questions for Congress may center on the future of the doubling path policy for PS&E research and authorized funding levels for NSF, NIST, and the Office of Science as well as on the disposition and direction of the federal STEM education effort.

[127] S. 1398, §203(b).

Appendix. Efforts to Reauthorize in the 113th Congress

At least four bills were introduced to reauthorize selected provisions from the COMPETES Acts in the 113th Congress: H.R. 4159, H.R. 4186, H.R. 4869, and S. 2757.[128] All of these bills included various policy and fiscal provisions authorizing activities and appropriations for physical sciences and engineering research, STEM education, and related programs at COMPETES Act agencies. The following sections summarize these bills and highlight some of their provisions.

H.R. 4159

The America COMPETES Reauthorization Act of 2014 (H.R. 4159) was introduced to "provide for investment in innovation through research and development and STEM education, to improve the competitiveness of the United States, and for other purposes." It would have authorized funding for NSF, NIST, and the Office of Science and would have authorized or amended various federal STEM education and innovation-related programs, policies, and activities.

Funding for the Targeted Accounts. H.R. 4159 would have authorized appropriations to NSF, NIST, and the Office of Science from FY2015 through FY2019. Explanatory materials associated with H.R. 4159 do not mention the doubling path policy or the targeted accounts; rather, they highlight provisions authorizing year-over-year increases for NSF, NIST, and the Office of Science.[129] Accordingly, **Table A-1** shows the compound annual growth rate for these agencies under H.R. 4159, treating FY2014 enacted appropriations as the baseline and FY2019 authorized levels (as per H.R. 4159) as the final year.

Table A-1. Compound Annual Growth Rate (CAGR) in Funding for NSF, NIST, and the Office of Science Under H.R. 4159, as Introduced

Dollars in Millions, Rounded

Agency	FY2014 Enacted	FY2019 Authorized	CAGR
NSF (total)	$7,171.9	$9,096.0	4.9%
NIST (total)	$850.0	$1,084.8	5.0%
Office of Science (total)	$5,066.4	$6,472.0	5.0%

Source: CRS analysis of H.R. 4159 (113th Congress).

[128] Several stand-alone bills with provisions similar to those included in the various identified COMPETES Acts reauthorization measures were also considered by the 113th Congress. In some cases, these stand-alone measures passed at least one chamber (typically the House). Such bills include H.R. 967 (Advancing America's Networking and Information Technology Research and Development Act of 2013), H.R. 2495 (American Super Computing Leadership Act), H.R. 5029 (International Science and Technology Cooperation Act of 2014), H.R. 5031 (STEM Education Act of 2014), H.R. 5035 (NIST Reauthorization Act of 2014), H.R. 5544 (Low-Dose Radiation Research Act of 2014), H.R. 5056 (Research and Development Efficiency Act), and H.R. 5120 (Department of Energy Laboratory Modernization and Technology Transfer Act of 2014).

[129] The bill and associated fact sheet, press release, video clips, as well as a list of endorsements, are available at http://democrats.science.house.gov/bill/hr-4159-america-competes-reauthorization-act-2014.

For the sake of comparison with the COMPETES Acts, under H.R. 4159, the compound annual growth rate in authorized funding for just the targeted accounts would have been 4.1% (between the FY2006 baseline and FY2019) or about a 17-year doubling period.

STEM Education. H.R. 4159 contained a number of STEM education provisions. Examples include provisions that would have (1) established a government-wide STEM education coordinator within the OSTP and (2) directed OSTP to develop guidance for federal agencies on increasing opportunities for federal scientists and engineers to participate in STEM education activities. At NSF, the bill would have, among other things, authorized grants to institutions of higher education for undergraduate STEM education reform; authorized grants to community colleges for advanced manufacturing education; and authorized grants for R&D on the alignment, implementation, impact, and improvement of state-based STEM education standards. Additionally, H.R. 4159 would have authorized informal education activities and made changes to the Robert Noyce Teacher Scholarship Program (Noyce) program at NSF.

Other Provisions. Other provisions in H.R. 4159 sought to broaden the participation of underrepresented groups in STEM education and employment. For example, Section 217 would have directed NSF to develop written guidance for institutions of higher education on best practices for identifying cultural or institutional barriers to the recruitment, retention, and promotion of underrepresented populations in STEM degree programs and academic STEM careers. H.R. 4159 also included provisions to reauthorize the Regional Innovation Program and Federal Loan Guarantees for Innovative Technologies in Manufacturing, which were established by the America COMPETES Reauthorization Act of 2010. The bill's DOE title would have authorized certain Office of Science research programs (e.g., High Energy Physics, Fusion Energy) and would have reauthorized and amended ARPA-E. Section 204 would have created a new Advanced Research Projects Agency-Education (ARPA-ED) at the Department of Education.

Legislative Disposition. H.R. 4159 was referred to both the House Committee on Education and the Workforce, as well as the House Committee on Science, Space, and Technology. It was not marked up or enacted. The bill was sponsored by the ranking minority Member of the House Committee on Science, Space, and Technology and co-sponsored by all of the minority Members of that committee.[130] It had no House majority Members as co-sponsors.

H.R. 4186

The Frontiers in Innovation, Research, Science, and Technology Act of 2014 (H.R. 4186, FIRST Act) was introduced "to provide for investment in innovation through scientific research and development, to improve the competitiveness of the United States, and for other purposes." The act included provisions that would have authorized funding for NSF and NIST, as well as those that would have authorized or amended various federal STEM education and innovation-related programs, policies, and activities.

Funding for the Targeted Accounts. The FIRST Act would have authorized appropriations to NSF and NIST for FY2014 and FY2015.[131] In his statement during full committee markup of

[130] As included in the House Committee on Science, Space, and Technology's 113th Congress committee roster.

[131] For NSF and NIST appropriations authorizations, see H.R. 4186, §§101 and 401, respectively. An amendment to §101 adopted during the May 20, 2014, House Committee on Science, Space and Technology full committee mark-up reduced total FY2015 funding for the NSF by $50 million. The same amendment also reduced authorized funding levels for certain major NSF sub-accounts. See Amendment 028 at http://science.house.gov/sites/republicans.science.house.gov/files/documents/Rohrabachersbe.pdf.

H.R. 4186, the Chairman of the House Committee on Science, Space, and Technology did not mention the doubling path policy or targeted accounts, but rather said

> In a time of tight budgets, this bill authorizes small overall funding increases for the National Science Foundation (NSF) and the National Institute of Standards and Technology (NIST) in Fiscal Year 2015.[132]

Accordingly, **Table A-2** shows the compound annual growth rate in authorized appropriations for NSF and NIST under the FIRST Act, treating FY2013 actual appropriations as the baseline and FY2015 authorized levels (as per H.R. 4186) as the final year.[133]

Table A-2. Compound Annual Growth Rate (CAGR) in Funding for NSF and NIST Under the FIRST Act (H.R. 4186), as Amended

Dollars in Millions, Rounded

Agency	FY2013 Actual	FY2015 Authorized	CAGR
NSF (total)	$6,901.9	$7,227.3	2.3%
NIST (total)	$769.4	$855.8	5.5%

Source: CRS analysis of H.R. 4186 (113th Congress).

H.R. 4186 would not have authorized funding for the Office of Science. As such, it is not possible to calculate a growth rate for the targeted accounts under H.R. 4186 that would be comparable to the growth rate in funding for the targeted accounts as authorized under the COMPETES Acts' doubling path policy.

STEM Education. The FIRST Act included many STEM education provisions, several of which sought to address governance concerns about the federal effort. In particular, the bill would have established a STEM Education Advisory Panel to advise the President and other policymakers on STEM education-related topics.[134] In addition, the bill would have created a federal government-wide STEM Education Coordinating Office at the NSF.[135] Other STEM education provisions in H.R. 4186 would have authorized informal STEM education activities—and made changes to the Noyce program—at NSF.[136] Section 2 of H.R. 4186 would have clarified that the definition of the term "STEM education" included computer science (for the purposes of the act).

Other Provisions. Other provisions in the FIRST Act would have authorized and amended certain Networking and Information Technology R&D (NITRD) program provisions,[137] provided

[132] Statement of Chairman Lamar Smith, in U.S. Congress, House Committee on Science, Space, and Technology, *Full Committee Markup—S. 1254, H.R. 4186*, hearing on S. 1254 and H.R. 4186, 113th Cong., 2nd sess., May 21, 2014, http://science.house.gov/markup/full-committee-markup-s-1254-hr-4186.

[133] These calculations treat FY2013 as the baseline year because it precedes FY2014, the first year authorized under H.R. 4186. However, in FY2013, many federal agencies experienced reductions under the process commonly referred to as sequestration and under the rescissions contained in the Consolidated and Continuing Appropriations Act, 2013 (P.L. 113-6). Both NSF and the Office of Science received less funding in FY2013 than they did in FY2012 under these reductions. NIST received a 2.5% ($18.6 million) increase.

[134] H.R. 4186, §202.

[135] H.R. 4186, §204.

[136] H.R. 4186, §§205 and 125, respectively. §205 was added to H.R. 4186 during the May 20, 2014, House Committee on Science, Space, and Technology full committee mark-up. See amendment 047 at http://science.house.gov/sites/republicans.science.house.gov/files/documents/LIPINS_047_xml%20-%20Informal%20Science%20Education.pdf.

[137] H.R. 4186, Title V. For more information, see CRS Report RL33586, *The Federal Networking and Information*

for coordination of international science and technology partnerships,[138] and provided for public access to federally funded research and data.[139] The bill also included provisions from the Transfer Act of 2013 (H.R. 2981), which would have amended the Small Business Act to revise and expand (to certain other agencies) an existing proof-of-concept pilot program at the National Institutes of Health.[140] Some of the more intensely debated provisions of the FIRST Act would have provided defined appropriations to NSF by directorate (e.g., $742.9 million for Biological Sciences in FY2014, $150.0 million for Social, Behavioral, and Economic Sciences in FY2015)[141] and would have required NSF to determine (and describe in writing) how each grant it issues serves certain enumerated national interests.[142]

Legislative Disposition. H.R. 4186 was not enacted. It was marked up and ordered reported by voice vote from the House Committee on Science, Space, and Technology on May 28, 2014. The bill was sponsored by the Chairman of the Subcommittee on Research and Technology, House Committee on Science, Space, and Technology. It was co-sponsored by Members of the majority (including the chairman of the full committee)[143] and opposed by the ranking minority Member of the full committee.[144] It had no House minority co-sponsors.

H.R. 4869

The Department of Energy Research and Development Act of 2014 (H.R. 4869, DOE-RDA), would have authorized funding for the Office of Science and other Department of Energy programs in FY2014 and FY2015.[145]

Funding for Targeted Accounts. DOE-RDA would have authorized appropriations for the Office of Science in FY2014 and FY2015. In a statement about the bill, the sponsor said funding levels for the Office of Science were "true to the intent of the COMPETES Act legacy."[146] Under

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Technology Research and Development Program: Background, Funding, and Activities, by Patricia Moloney Figliola.

[138] H.R. 4186, §305.

[139] H.R. 4186, §303, as amended. §303 was amended during the May 20, 2014, House Committee on Science, Space, and Technology full committee mark-up. See Amendment 027 at http://science.house.gov/sites/republicans.science.house.gov/files/documents/sensenbrennerlofgren.pdf.

[140] H.R. 4186, §421.

[141] H.R. 4186, §101. Enacted appropriations authorizations for NSF since FY2000 have typically provided specific, defined funding levels for major accounts (e.g., Research and Related Activities) and selected programs (e.g., EPSCoR), but not for NSF research directorates. However, between FY1977 and FY1999, NSF authorization acts often included defined appropriations authorizations for NSF's research directorates (e.g., Mathematics and Physical Sciences).

[142] H.R. 4186, §106.

[143] In this instance, the term "full committee" refers to the House Committee on Science, Space, and Technology as constituted in the 113th Congress.

[144] In her opening statement during full committee mark-up of H.R. 4186, Ranking Member Eddie Bernice Johnson stated, "Unless there are significant changes made to the FIRST Act, I will have to oppose the bill and encourage others to do the same." Statement of Ranking Member Eddie Bernice Johnson, in U.S. Congress, House Committee on Science, Space, and Technology, *Full Committee Markup—S. 1254, H.R. 4186*, hearing on S. 1254 and H.R. 4186, 113th Cong., 2nd sess., May 21, 2014, http://democrats.science.house.gov/sites/democrats.science.house.gov/files/documents/Ranking%20Member%20Johnson%20FIRST%20Opening%20Statement.pdf.

[145] For Office of Science appropriations authorizations, see H.R. 4869, §119.

[146] Statement of Subcommittee Chairman Cynthia Lummis, in U.S. Congress, House Committee on Science, Space, and Technology, *Subcommittee on Energy Markup – Committee Print of H.R.___, the "Department of Energy Research and Development Act of 2014*," hearing on Committee Print of H.R.___, "The Department of Energy Research and Development Act of 2014," 113th Cong., 2nd sess., June 11, 2014, http://science.house.gov/markup/subcommitee-energy-markup-committee-print-hr-department-energy-research-and-development-act.

DOE-RDA, the compound annual growth rate in authorized appropriations for the Office of Science would have been 7.3%, treating FY2013 actual appropriations as the baseline and FY2015 authorized levels (as per H.R. 4869) as the final year.[147]

Because DOE-RDA would not have authorized appropriations for the other targeted accounts (e.g., NSF, as well as NIST's STRS and CRF), it is not possible to calculate a growth rate for the targeted accounts under H.R. 4869 that would be comparable to the growth rate in funding for the targeted accounts as authorized under the COMPETES Acts' doubling path policy.

Other Provisions. In addition to authorizing overall appropriations for DOE's Office of Science, H.R. 4869 would have authorized certain Office of Science research programs (e.g., High Energy Physics, Fusion Energy);[148] addressed various issues at the national laboratories (e.g., technology transfer, early-stage technology demonstration, etc.);[149] and amended the ARPA-E statute.[150] Additionally, the bill would have authorized certain DOE activities in crosscutting R&D, nuclear energy R&D, energy efficiency and renewable R&D, and fossil energy R&D.[151]

Legislation Disposition. H.R. 4869 was not enacted. The Subcommittee on Energy, House Science, Space, and Technology Committee sought to mark up a committee print of DOE-RDA on June 11, 2014; however, the markup was adjourned before full consideration after some of the minority Members expressed concern about process. H.R. 4869 was formally introduced two days later, on June 13, 2014. H.R. 4869 was sponsored by the Chairman of the Subcommittee on Energy, House Committee on Science, Space, and Technology and co-sponsored by Members of the majority, including the chairman of the full committee.[152] It had no House minority co-sponsors.

S. 2757

The America COMPETES Reauthorization Act of 2014 (S. 2757) was introduced "to invest in innovation through research and development, to improve the competitiveness of the United States, and for other purposes." S. 2757 differs from the House bill of the same name (H.R. 4159). For example, unlike H.R. 4159, S. 2757 does not include Office of Science or other Department of Energy provisions. However, both bills would have authorized funding for NSF and NIST and would have authorized or amended various (in some cases, differing) federal STEM education and innovation-related programs, policies, and activities.

Funding for the Targeted Accounts. S. 2757 would have authorized appropriations to the NSF and NIST from FY2015 through FY2019.[153] In a press release, the bill's sponsor stated that S. 2757 "builds on the goals and successes" of the COMPETES Acts and that it would authorize "stable and sustained increases" in funding for the NSF and NIST. The press release does not

[147] This calculation treats FY2013 as the baseline year because it precedes FY2014, the first year authorized under H.R. 4869. However, in FY2013, many federal agencies experienced reductions under the process commonly referred to as sequestration and under the rescissions contained in the Consolidated and Continuing Appropriations Act, 2013 (P.L. 113-6). Both NSF and the Office of Science received less funding in FY2013 than they did in FY2012 under these reductions. NIST received a 2.5% ($18.6 million) increase.

[148] H.R. 4869, Subtitle A.

[149] For examples, see H.R. 4869, Title I, Subtitle B.

[150] H.R. 4869, §281.

[151] See H.R. 4869, Title II.

[152] In this instance, the term "full committee" refers to the House Committee on Science, Space, and Technology as constituted in the 113th Congress.

[153] S. 2757, §§502 and 401, respectively.

mention the doubling path policy.[154] Accordingly, **Table A-3** shows the compound annual growth rate in authorized appropriations for NSF and NIST under S. 2757, treating FY2014 enacted appropriations as the baseline and FY2019 authorized levels as the final year.

Table A-3. Compound Annual Growth Rate (CAGR) in Funding for NSF and NIST Under S. 2757, as Introduced

Dollars in Millions, Rounded

Agency	FY2014 Enacted	FY2019 Authorized	CAGR
NSF (total)	$7,171.9	$9,908.1	6.7%
NIST (total)	$850.0	$1,182.7	6.8%

Source: CRS analysis of S. 2757 (113th Congress).

S. 2757 would not have authorized funding for the Office of Science. As such, it is not possible to calculate a growth rate for the targeted accounts under S. 2757 that would be comparable to the growth rate in funding for the targeted accounts as authorized under the COMPETES Acts' doubling path policy.

STEM Education. Examples of STEM education provisions in the Senate version of the America COMPETES Reauthorization Act of 2014 include Section 102, which would have directed the NSTC Subcommittee on STEM Education to encourage comments from certain stakeholders (e.g., state education agencies, nonprofits) when updating the five-year federal strategic STEM education plan; to consider cross-agency efforts to improve STEM career awareness when implementing and updating the five-year plan; and to develop guidance and best practices for federal agencies on encouraging informal STEM education, among other things. Other STEM education provisions in S. 2757 would have authorized a program for STEM secondary schools at NSF[155] and would have amended and reauthorized the informal STEM education and Noyce programs at NSF.[156] Section 202 directs the National Aeronautics and Space Administration (NASA) to continue providing STEM education and outreach activities and to consider the long-term research and workforce needs of the mission directorates before finalizing any reorganization of NASA education programs.

Other Provisions. Other provisions in S. 2757 would have directed OSTP to evaluate "family-responsive" federal science agency programs and policies and to provide guidance to federal science agencies on such policies.[157] Section 511 would have allowed NSF to establish a prize program for educational practices that broaden participation in STEM fields. Other provisions would have directed NSF to maintain its intellectual merit and broader impacts criteria as the basis for evaluating grant proposals[158] and would have authorized the expansion of NSF's Innovation Corps (I-Corps) program to other federal agencies.[159] Section 611 would have reauthorized the Regional Innovation Program at the Department of Commerce; Title IV, Subtitle B would have reauthorized the National Nanotechnology Initiative.

[154] U.S. Senate Committee on Commerce, Science, and Transportation, "Featured Legislation: America COMPETES Reauthorization Act," press release, July 31, 2014, p. 1.

[155] S. 2757, §522.

[156] S, 2757, §§609 and 507, respectively.

[157] S. 2757, §106.

[158] S. 2757, §504.

[159] S. 2757, §513.

Legislative Disposition. S. 2757 was not enacted. It was referred to the Senate Committee on Commerce, Science, and Transportation but was not marked up. S. 2757 was sponsored by the (then retiring) chairman of the Senate Committee on Commerce, Science, and Transportation. It had six Senate majority (and no Senate minority) co-sponsors.

Author Information

Heather B. Gonzalez
Specialist in Science and Technology Policy

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