
Section 2

Major MIT Initiatives

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National Policy Initiatives

MIT has had major involvement in technology policy at the national level since before World War II, with MIT faculty and administrators frequently serving as advisors to national policymakers. A more formal “policy initiative” model is relatively new, having developed over the past decade. In 2005, incoming MIT President Susan Hockfield announced that MIT would create a major cross-disciplinary, cross-school initiative around energy, which led to MIT’s first major policy initiative effort. Additional initiatives have since been created to tackle other major science and technology issues with national and, often, global policy dimensions. These are inherently cross-disciplinary, drawing on a range of MIT expertise, from science and engineering to the social sciences, economics, and management. Some, such as energy, are ongoing. Others have had more defined, shorter-term goals. Major policy initiatives to date are described here.

Energy

The MIT Energy Initiative (MITEI) was formally launched in the fall of 2006, following the recommendations of the 2006 Report of the Energy Research Council regarding new approaches to multidisciplinary research, education across school and department boundaries, energy use on campus, and outreach to the policy world through technically grounded analysis. As described on page 45, the education component of MITEI has grown rapidly through the development of new academic materials and pathways. Simultaneously, MITEI has helped energy research at MIT grow by developing strategic alliances with companies across a broad range of energy-related businesses as well as by attracting government and philanthropic support.

MITEI is recognized as the first and the foremost campus-wide energy program at a U.S. academic institution. Its policy outreach component has similarly prospered, and now includes both core MITEI activities and those under the auspices of programs with many MITEI-affiliated faculty members (such as the Center for Energy and Environmental Policy Research (CEEPR) and the Joint Program on the Science & Policy of Global Change). MITEI, CEEPR, and the Joint Program each hold workshops at least annually which address technological, economic, and political aspects of energy and climate issues.

MITEI’s best-known policy products are the in-depth, multidisciplinary “Future of ...” studies, which are designed to inform future decisions regarding energy research, technology choices, and policy development. The most recent MITEI study, *The Future of Solar Energy* was released at the National Press Club on May 8, 2015 and continues to draw national attention. Now underway is *The Utility of the Future: Preparing for a Changing Energy Sector*. Additional studies are in the planning stages.

Convergence

“Convergence” is a term for the merging of distinct technologies, integrating disciplines, into a unified whole that creates a host of new pathways and opportunities. It involves the coming together of different fields of study—particularly engineering, physical sciences, and life sciences—through collaboration among research groups and the integration of approaches that were originally viewed as distinct and potentially contradictory. Convergence at MIT implies a broad rethinking of how all scientific research can be conducted, to capitalize on a range of knowledge bases, from microbiology to computer science to engineering design. It is a new organizational model for innovation, taking the tools and approaches of one field of study and applying them to another, paving the way for advances in all fields involved. Just as engineering and physical sciences are transforming the life sciences, biological models are transforming engineering and physical science. Advances in biofuels, biomaterials, and viral self-assembly are just a few examples of the results from this reciprocal relationship at MIT. The following site documents the major convergence developments referenced below:

<http://www.convergencerevolution.net/>

MIT has been a leader in the Convergence revolution from the beginning, developing a widely cited white-paper on the topic in 2011, entitled *Third Revolution: Convergence of The Life Sciences, Physical Sciences And Engineering* led by a faculty committee named by President Susan Hockfield, and chaired by Professors Phillip Sharp and Robert Langer. In parallel to the development of the report, MIT created its Koch Institute for Integrative Cancer Research, internally adopting the convergence research model, and

organizing its latest advanced research facility to include biologists, engineers and physical scientists working in close collaboration.

Support grew for this integrated research approach following the report, with the White House featuring a section on Fostering Convergent Science in its Blueprint For Action, released in January 2013, which included advancing the convergence approach among four goals for the year. In the spring of 2013, President Obama announced the BRAIN initiative (Brain Research through Advancing Innovative Neurotechnologies), a major public-private partnership consciously utilizing a convergence research approach, with federal participation by NIH, NSF, and DARPA complemented by contributions from companies, health systems, patient advocacy organizations, philanthropists, state governments, research universities, private research institutes, and scientific societies.

Five MIT faculty members were invited to attend the White House event, a larger delegation than from any other university. MIT Professor Emery Brown subsequently chaired the NIH Advisory Committee to the Director's Working Group for the initiative.

At the AAAS Annual meeting in Chicago in February of 2014, Professor Phillip Sharp delivered the annual AAAS President's Lecture on Convergence to a group of over 1000 scientists. In addition, former MIT President Susan Hockfield led a multi-hour convergence workshop at the meeting. AAAS later released a report summarizing the workshop findings.

The National Academies of Science has also provided leadership in the convergence effort. Its "Key Challenges in the Implementation of Convergence," a workshop led by the Board on Life Sciences of the National Academies in September 2013 was co-chaired by former MIT President Hockfield and featured Professor Philip Sharp. A book from the National Academies Press, *Convergence—Facilitating Transdisciplinary Integration of Life Sciences, Physical Science, Engineering and Beyond*, summarizing the

workshop findings was published in May. Meanwhile, in parallel, the Defense Advanced Research Projects Agency (DARPA) has been expanding its focus on convergence model research, forming a new Biological Technologies Office with a research portfolio in areas including bio-fabrication, neuroscience, and infectious disease, and leading DARPA's participation in the BRAIN initiative. The White House has subsequently developed a new Precision Medicine Initiative, also organized on the convergence model utilizing big data and analytics to develop personalized medicine advances.

At MIT, convergence as a research model is now deeply anchored in many areas of life science advances, including work in quantum information studies of neurons, neuroscience and computing, synthetic biology, and cancer research.

Advanced Manufacturing

MIT leaders have played a major role in recent years in the design of national efforts to confront structural problems in the U.S. manufacturing sector, starting in 2011 with the MIT Production in the Innovation Economy study project. It continued until 2015 with MIT playing a strong leadership role in the President's Advanced Manufacturing Partnership (AMP) which led to the development of a network of regional institutes to promote manufacturing innovation and other programmatic efforts. On campus, these efforts helped to define an emerging campus initiative on innovation, and work on advanced manufacturing research, education, and outreach in the region.

MIT has also been participating in efforts to create new advanced manufacturing institutes, cost shared between federal and state governments and by industry. On July 26, 2015 a regional consortia including New York and Massachusetts firms and universities was competitively selected by federal officials to form an institute around integrated photonics, with MIT faculty leading technology development and workforce education segments of the project.

Production in the Innovation Economy Study

This MIT study (known as PIE) issued its final report in two volumes from MIT Press (released in September 2013 and January 2014). The report identified a major decline in the ecosystem of support for small and midsized production firms and gaps in financing for production scale-up and in workforce training, drawing lessons from production practices abroad, particularly Germany and China. The report recommended a new innovation effort around what it termed “advanced manufacturing,” to be shared across industry and universities, with new financing, workforce training and collaborative R&D efforts. The PIE report was presented at a major campus forum on September 20-21, 2014, led by MIT President Reif, including Dow Chemical CEO Andrew Liveris, who co-led the Advanced Manufacturing Partnership, and senior federal officials. The National Academy of Sciences hosted key PIE researchers at a November 1 presentation of the PIE report, in its historic Lecture Room in Washington, led by PIE Commission co-chair Suzanne Berger. They summarized the study results to a packed house of federal officials and representatives from industry, universities, and non-governmental organizations. Professor Berger subsequently testified about the PIE findings before the Senate Banking and Senate Commerce Committees, and briefed forums at think tanks and foundations, as well as the President. President Obama’s Administration drew extensively on expertise from the PIE study. The key PIE research findings were discussed on an ongoing basis as the report was developed with industry and government, including directly with President Obama and his senior officials, and had a major effect on developing national manufacturing policies, through the AMP process discussed below. In effect, the MIT initiative flowed almost seamlessly into national manufacturing policy creation at the highest levels.

Advanced Manufacturing Partnership

MIT Presidents Susan Hockfield and Rafael Reif were named by President Obama as successive co-chairs of the steering committee for his industry-university Advanced Manufacturing Partnership (AMP) in its two phases, from 2012 through 2014. MIT Provost Martin Schmidt and Professor Krystyn Van Vliet served as successive technical co-leads for AMP 1.0 and AMP 2.0.

The AMP 1.0 report in 2012 led to the new network of advanced manufacturing institutes, modeled on the German Fraunhofer institutes. Fifteen institutes will be stood up by the end of 2016, funded at a half billion annually, matched by higher levels of industry and state cost-sharing.

The AMP 2.0 report was released in October 2014, making new recommendations supplementing AMP 1.0 on advanced manufacturing technology development strategies, collaborative R&D efforts across leading federal agencies, apprenticeship and training programs, and policies to support financing of production scale-up for advanced manufacturing processes and technologies. In addition to President Reif’s leadership role, Professor Van Vliet co-chaired the AMP 2.0 technology development workgroup, preparing manufacturing strategies on digital manufacturing, advanced materials for manufacturing, and sensors/measurement/process control areas. President Reif and Provost Schmidt led the AMP 2.0 Steering Committee, along with DOW CEO, Andrew Liveris, and the President’s National Economic Council Director, Science Advisor, and Commerce Secretary, in 2013–2014. MIT hosted the New England AMP 2.0 regional meeting in the Stata Center with over 200 leaders from area industries and universities participating. Senator Edward Markey and senior state and federal officials also attended.

The “Future Postponed”

Federal support is the primary mainstay of U.S. science research. As federal R&D funding has stagnated, new ways of explaining to policy makers the central societal need for science is required. The MIT report *The Future Postponed: Why Declining Investment in Basic Research Threatens a U.S. Innovation Deficit*, released in April of 2015, is a new way of explaining science and is designed to be accessible to policymakers. The Future Postponed explains the critical importance of federal investment in science research to grow the economy, develop better therapies and cures, stay competitive, and solve global challenges.

The MIT Committee to Evaluate the Innovation Deficit, named in October 2014 comprised of 30 MIT faculty and researchers from across all schools at MIT, selected and wrote case studies of 15 vital areas of science and engineering from infectious disease, to batteries, Alzheimer's, cybersecurity, catalysis, economics and plant science. The report is not a list of priorities in science research, but rather a short set of illustrative examples from a much longer list of critical fields worthy of investment.

The science community has tried to tell the stories of how past investments in research have paid off in today's technologies—like GPS, MRI, and the Google search engine—but has not fully told how research cutbacks today will affect the science of tomorrow. The “Future Postponed” report explores the remarkable technology opportunities that lie ahead and the science needed to get there, all fully vetted by a faculty review board, but written in short two or three page case studies that are highly accessible to non-scientist readers. It's a vision of the future of innovation in America and a call for sustained support for research.

The report has gained national press attention in such forums as the Wall Street Journal, the New York Times, Reuters, the Los Angeles Times, and others. A group from the faculty committee, led by Professor Marc Kastner, former Dean of Science, held a forum hosted by the AAAS and briefed Congressional staff, White House staff, and other national stakeholders during a Washington DC visit on April 27th.

A second national phase of the report is now beginning, with Professor Kastner leading an advisory committee of noted scientists from outside MIT developing additional case studies. The full report is at <http://dc.mit.edu/innovation-deficit> and additional case studies are posted online at www.futurepostponed.org.

Innovation

In October 2013, President Reif announced an “innovation initiative” at MIT, which was followed by a report on the proposed project in December 2014, http://innovation.mit.edu/sites/default/files/images/MIT_Innovation_Initiative_PreliminaryReport_12-03-14.pdf. The initiative has primarily focused on MIT itself. As summarized on its website (<http://innovation.mit.edu/about>) the report emphasizes:

- **Capability-building Programs:** Growing existing education opportunities while creating a select few new programs of interest to MIT students and faculty
- **Convening Infrastructure:** Expanding maker and collaborative spaces across campus and creating digital tools that connect them into a unified campus
- **Communities:** Linking the MIT community more deeply with corporations, governments, and innovation hubs in Cambridge and around the world
- **Lab for Innovation Science and Policy:** an organized effort to develop the ‘science of innovation’ and evidence-base to inform both internal and external program design

In May 2015, President Rafael Reif announced a new innovation programmatic focus in a Washington Post op ed (<http://newsoffice.mit.edu/2015/reif-op-ed-washington-post-0524>). President Reif emphasized the need for regional and national policy elements to fill a gap he identified in the national innovation system. He noted that startups in non-IT fields face major challenges in scaling up to a point where their technologies are demonstrated, tested and de-risked, and placed in range of follow-on financing mechanisms. Calling for new innovation “orchards” and “accelerators,” a team at MIT is now exploring relevant models nationwide, and considering new innovation institutions to fill this gap that could be implemented by MIT and regional partners in Massachusetts.

Online Education

MIT's pioneering support for online education has been in the national spotlight since the announcement, in 2001, that the institute would make materials from all its courses freely available through OpenCourseWare (OCW). Now part of the Office of Digital Learning (ODL), OCW has delivered lecture notes, exams, and videos from over 2000 MIT courses to 175 million learners and educators. In May 2012, building off the success of OCW and extending a tradition of educational innovation as old as the institute itself, MIT joined together with Harvard University to create edX. Massively Open Online Courses are available via the edX platform to anyone with Internet access. In the first three years of operation, nearly half a million learners have received certificates of completion for courses offered by MIT and edX partners institutions, including 50+ courses to date developed and produced by ODL under the MITx nameplate.

The policy aspects of MIT's digital learning initiative came into focus with President Rafael Reif's announcement, in April 2013, of an Institute-wide *Task Force on the Future of MIT Education*, charged with capturing an integrated understanding of how online access is changing teaching and learning. The task force looked at impacts on our own campus and beyond, and began to envision how future technologies and models can spark innovation in higher education. Following the release of the task force's final report (<http://bit.ly/1JSkNJM>) in August 2014, co-chairs Professor Sanjay Sarma and Professor Karen Wilcox assumed the leadership of a study of the national policy aspects and implications of online education, with support from the Carnegie foundation. This Online Education Policy Initiative (OEPI) is exploring teaching pedagogy and efficacy,

institutional business models, and global educational engagement strategies. It is scheduled to produce a report on these issues in early 2016, which policy-makers and leaders in education can use to deepen the public discourse surrounding online learning and to encourage productive discussion about the future of higher education in the U.S. and globally. Important input to the OEPI was obtained through a May 2015 workshop, sponsored by the National Science Foundation, which brought fifty practitioners from the learning science and online learning technology communities together to discuss emerging ideas about online pedagogy.

MIT's senior leaders continued to take a national role in the education initiative in 2014–2015, as shown in the following examples. President Reif and Harvard President Drew Faust hosted an online education summit in Cambridge in April, with guests including senior officers from colleges and universities from across the country and leading academics in the field. Under-Secretary of Education Ted Mitchell joined Presidents Reif and Faust in an opening night discussion of online learning on and off campus, moderated by John Hockenberry, which was later broadcast nationally on PRI's "The Takeaway." At the December 2014 White House College Opportunity Summit, Chancellor Barnhart presented a commitment to expand the use of edX courses to help develop a cadre of high school science, technology, engineering, and mathematics teachers skilled in the use of educational technologies. These teachers can then in turn better prepare their own students to transition into college and succeed academically along the path to STEM careers.

Research Initiatives

Cybersecurity Initiatives

In 2015, MIT launched three campus-wide cybersecurity efforts aimed at addressing the technical, regulatory and managerial aspects of cybersecurity. The three initiatives: MIT Cybersecurity Policy Initiative, Cybersecurity@CSAIL, and MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)³, are intended to provide a cohesive, cross-disciplinary strategy to tackling the complex problems involved in keeping digital information safe.

MIT Cybersecurity Policy Initiative

MIT Cybersecurity Policy Initiative's goal is to create a new field that will help governments and other responsible institutions create public policy frameworks that will increase the trustworthiness of the interconnected digital systems that will be the foundation of the future flourishing of our societies and on which we are already inexorably dependent. This campus wide initiative, housed in CSAIL, has already produced important research results contributing to current debates on the security of new electronic surveillance proposals. Working with colleagues from around the world, the initiative produced a paper, that has been widely cited at several legislative hearings in the U.S. Senate and reported in the world press. This paper analyzes security risks of new wiretapping proposals propounded by law enforcement agencies in the United States and the United Kingdom. Additionally, as part of the Initiative's mission to train a new generation of technology policy leaders, in the spring of 2015, Initiative leaders ran an experimental course jointly with Georgetown Law School on privacy technology and legislation. The course gave students a high intensity introduction to privacy law and associated computer systems design questions. In 2015–16, initiative faculty are planning to organize a series of workshops on topics such as critical infrastructure security threats, cyberwar norms, global electronic surveillance technical and human rights risks, and cyber insurance markets.

Cybersecurity@CSAIL

Cybersecurity@CSAIL launched in 2015 with 5 founding industrial partners, the goal of CyberSecurity@CSAIL is to identify and develop technologies to address the most significant security issues confronting organizations in the next decade. Presently, approaches to system security do not give overall security guarantees, but rather attacks are fought individually—"patch and pray" style. CyberSecurity@CSAIL aims to provide an integrated and formal approach to the security of systems, combining design and analysis methods from cryptography, software and hardware. Cybersecurity@CSAIL's approach includes three key elements: collaborate closely with industry for input to shape real-world applications and drive impact; approach the problem from a multi-disciplinary perspective; and create a test-bed for our industry partners to implement and test our tools as well as have our researchers test tools developed by our partners.

MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)³

MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity (IC)³ addresses the important strategic, managerial and operational issues related to cybersecurity of the nation's critical infrastructure, ranging from energy and healthcare to financial services. An MIT cross disciplinary team lead by Sloan, along with industry partners (such as: ExxonMobil, Schneider Electric, State Street Bank), looks to address issues, such as cyber risk analysis, return on cybersecurity investment, application of cybersafety models, incentives for more effective information sharing, establishing a better organizational cybersecurity culture, methods for disrupting the cybercrime ecosystem, and metrics and models to better protect organizations.

<http://ic3.mit.edu>

Environmental Solutions Initiative

The Environmental Solutions Initiative (ESI) is designed to leverage the traditionally open atmosphere at MIT, which fosters interactions among people working in very different fields of study. That spirit of collaboration, and the possibilities it unleashes, are very powerful. ESI is designed to advance new interdisciplinary approaches spanning natural and social sciences, engineering, management, policy, and the humanities to help drive the kind of progress required in time to make a difference.

MIT is already a powerhouse of environmentally oriented research, education, and innovation. ESI is building on this vibrant foundation using seed grants to encourage new, cross-disciplinary research partnerships that advance progress and solutions on issues of environmental significance to humanity. A total of 59 teams of faculty, research staff and students responded to the first call for proposals, from which nine winners were announced on March 13, 2015. Projects launch in September.

Education—both curricular and experiential—is integral to ESI’s mission. Understanding the complexity of human and natural systems and the essential relationship between environmental quality and human welfare is increasingly important for professionals and scholars in a diverse array of fields. ESI’s educational role is to provide integrative, multi-disciplinary opportunities for MIT students to develop their capacity as leaders in environment and sustainability. ESI’s Education Committee, composed of faculty, staff and students, is already at work advancing this agenda. A five-year grant from the Dirk (’75) and Charlene (’79) Kabcenell Foundation is supporting the development of a new Institute Minor in Environment and Sustainability.

<http://environmentalsolutions.mit.edu/>

Abdul Latif Jameel World Water and Food Security Lab

The new Abdul Latif Jameel World Water and Food Security Lab (J-WAFS) serves to organize and promote food and water research around campus, emphasizing innovation and deployment of effective technologies, programs, and policies in order to have measurable impact as humankind adapts to a rapidly changing planet and combats water and food-supply scarcity. The lab addresses the collective pressures of population growth, urbanization, development, and climate change—factors that endanger food and water systems in developing and developed countries alike. To accomplish this, the lab develops broad-based approaches employing MIT’s interdisciplinary strengths and expertise in science, engineering and technology, climate and hydrology, energy and urban design, business, social science, and policy. J-WAFS, as an interdepartmental lab reporting to the Vice President for Research, spearheads the efforts of MIT’s faculty, labs, and centers to work towards solutions for water and food security that are environmentally benign and energy-efficient, including the development of transformative water and food technologies. These efforts are supported in part through seed grants distributed competitively to MIT researchers from J-WAFS’ endowment, established in 2014 through a generous gift by alumnus Mohammed Abdul Latif Jameel ‘78.

J-WAFS also seeks to partner with other institutions, foundations, industry, philanthropists, and governments to develop regionally appropriate solutions and innovations, whether for fast-growing megacities or for the rural developing world. Water supply in urban settings, for example, may benefit from conservation policies and infrastructure-scale systems, whereas rural populations may need small-scale, locally powered water purifiers. Ensuring stable food supplies requires a similarly varied approach that engages technology, biological and environment science, policy, and business innovation. J-WAFS also supports graduate student-driven food and water research and business communities on campus, through fellowships, conference sponsorship, and other mentoring and assistance.

<http://web.mit.edu/jwafs/>

MIT Energy Initiative

The MIT Energy Initiative (MITEI) plays an important catalytic role in accelerating responses to the many challenges facing our global energy system. MITEI supports energy research teams across the Institute by bringing them together with government and industry to analyze challenges and develop solutions. MITEI also leads Institute energy education efforts and delivers comprehensive analyses for policy makers. Its accomplishments are enabled through the investment of member companies, government sponsors, and donors. From these funding sources, MITEI has raised more than \$585 million to date to support MIT and MITEI Research, Education, and Outreach programs.

MITEI is an Institute-wide initiative that, in its depth and breadth, is without peer at U.S. academic institutions. MITEI-sponsored researchers are developing cutting-edge solutions and bringing new technologies to the marketplace. MITEI 2015 accomplishments include the acquisition of eight new members, the launch of two new consortia, and the release of *The Future of Solar Energy*, the newest in the series of “The Future of...” studies.

MITEI members have sponsored more than 800 projects, many involving collaborations between MIT researchers and member researchers. Nearly 30 percent of the MIT faculty is engaged with MITEI’s programs.

The MITEI Seed Fund Program supports innovative early-stage research projects that address energy and related environmental issues. Including 2015 grants, the MITEI Seed Fund Program has supported a total of 140 energy-focused research projects representing nearly \$17.4 million in funding over the past eight years. The program encourages researchers from throughout MIT’s five schools to collaborate in exploring new energy-related ideas, and attracts a mix of established energy faculty as well as many who are new to the field or to MIT.

More than two-thirds of MITEI’s research portfolio reflects its core mission of enabling the low-carbon economy of the future through the adoption of renewable energy, energy efficiency, and carbon management technologies. The largest single area of funded research is solar energy technology and policy. Much of the remainder of the portfolio is concerned with meeting contemporary energy needs through the efficient use of conventional energy sources.

This year, MITEI funded nine undergraduate energy curriculum projects through a grant from the S.D. Bechtel, Jr. Foundation. It has awarded nearly 350 graduate fellowships in energy and supported well over 200 Undergraduate Research Opportunities Program (UROP) students since 2008. In 2015, with the graduation of 19 Energy Studies Minor students, the Minor achieved a milestone: 108 students have graduated since the Minor began in 2009. Faculty associated with MITEI help shape energy education at both the undergraduate and graduate levels, by teaching, advising, and developing new curricula.

MITEI’s outreach program promotes and disseminates energy research findings to the MIT community, as well as to policy makers, industry leaders, and other stakeholders. Through colloquia, symposia, and seminars, MITEI introduces energy thought leaders from across the energy value chain to the local audience, which includes the MIT community, students and faculty at nearby colleges and universities, as well as Boston and Cambridge area politicians, energy industry personnel, and interested residents.

<http://mitei.mit.edu/>

