

MIT ENERGY INITIATIVE: FY 2019 HIGHLIGHTS

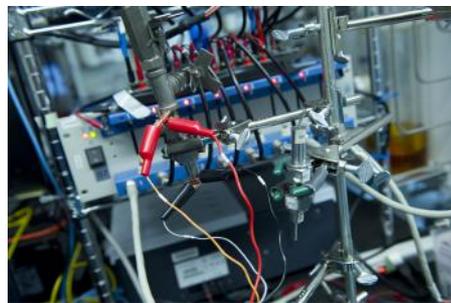
Robert C. Armstrong

Director, MIT Energy Initiative

Chevron Professor of Chemical Engineering

MITEI: ENERGY HUB OF MIT

- Deploying **~\$835 million** to date
- **~90** industry and public partners
- Support for about **900** *sponsor*-originated research/analysis projects + **hundreds of researcher-originated projects**
- More than **400** named fellows and **thousands of other graduate and undergraduate students** supported by MITEI
- Institute-wide Energy Studies Minor has graduated **100+ students** from all five schools
- MIT has spun out **more than 60 energy startups** since MITEI inception



RESEARCH PROGRAM

- MITEI awarded seven early-stage MITEI seed research projects last spring for a total of approximately **\$1 million**
- MITEI has supported **177** energy-focused seed projects with grants totaling approximately **\$23.6 million**
- These projects have covered the full spectrum of energy research areas, and have drawn from all five MIT schools and **28** departments, labs, and centers
- New Low-Carbon Energy Center launch: Mobility Systems Center launching based on sustained member interest in addressing issues such as those raised in the Mobility of the Future study

MITEI'S LOW-CARBON ENERGY CENTERS

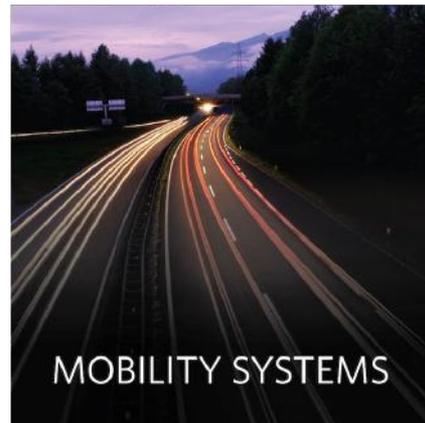
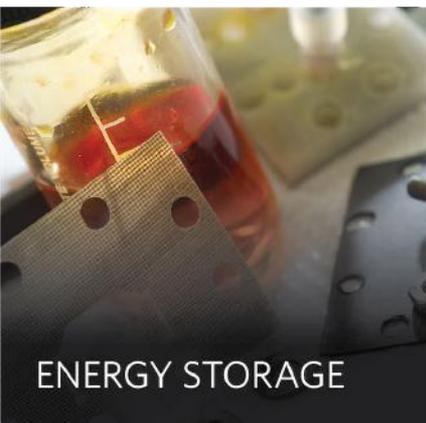
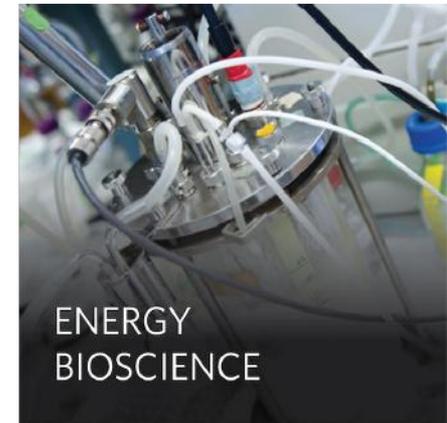
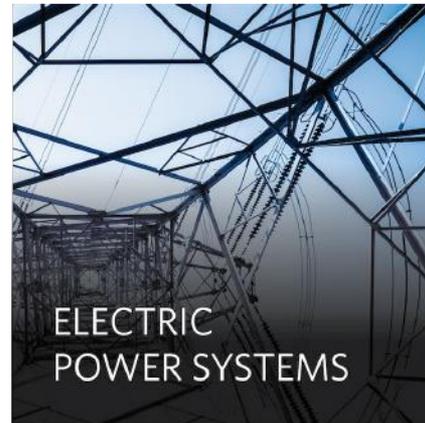
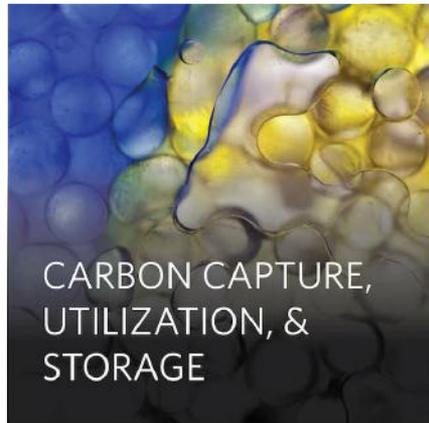
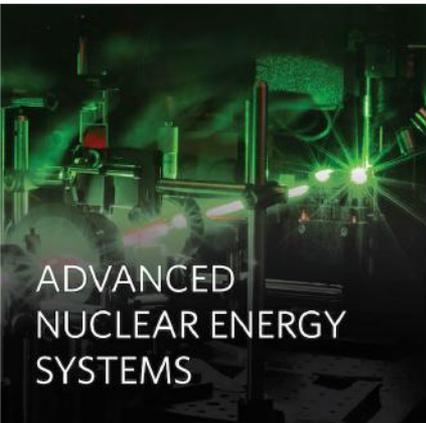
Objectives:

- Bring institutional focus to key areas for energy system decarbonization
- Create communities of practice within MIT and a sense of *urgency*
- Build a solution-oriented research portfolio under faculty leadership informed by timely techno-economic analysis

Strategy:

- Build on existing consortia and major funded programs as much as possible
- Harness faculty and member interest in areas critical to a low-carbon future
- Appoint faculty co-directors for each center to shape research mission and regularly convene members; support co-directors with MITEI member management and recruitment capacities.

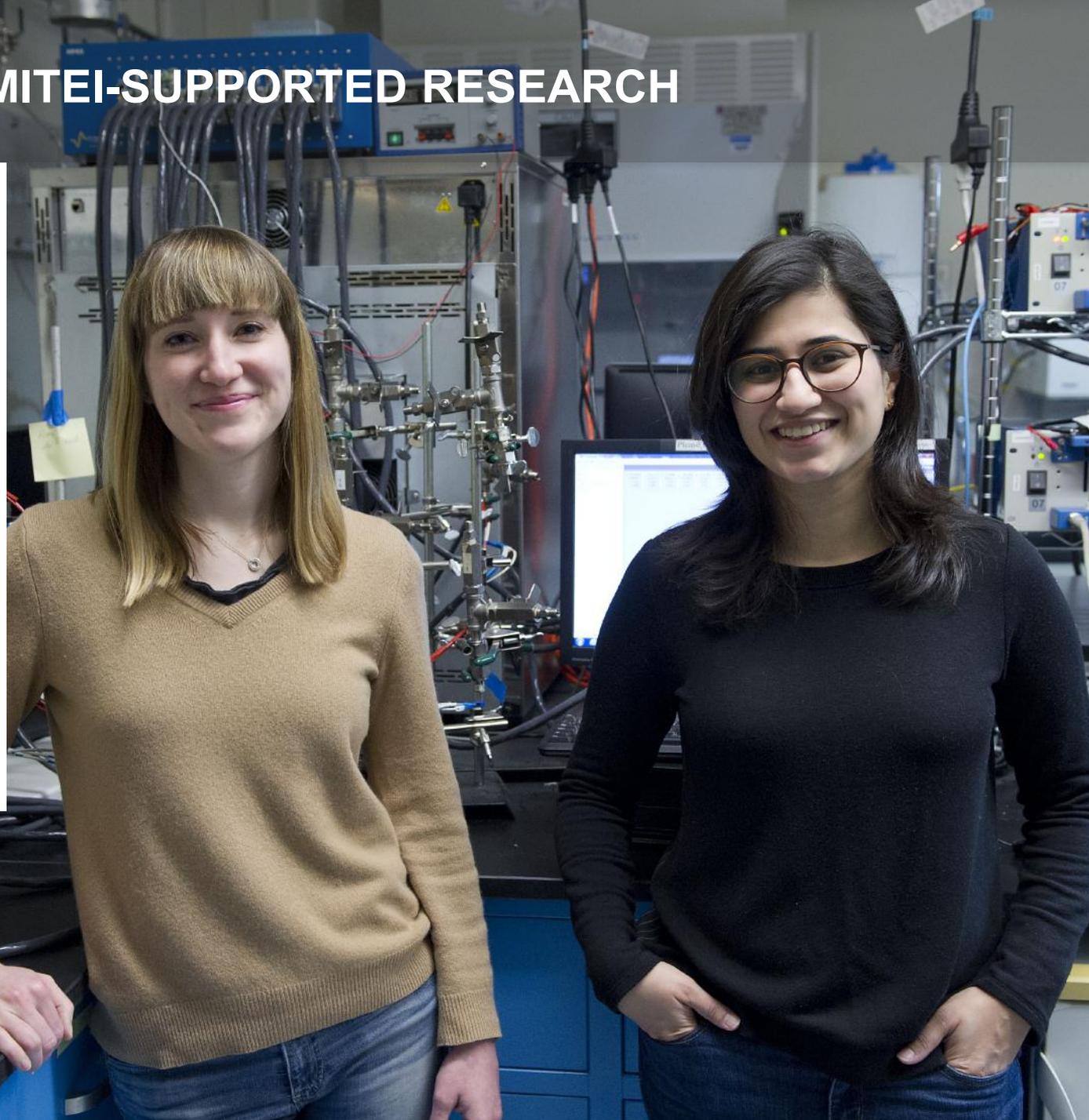
MITEI'S LOW-CARBON ENERGY CENTERS



MITEI-SUPPORTED RESEARCH

CARBON CAPTURE, UTILIZATION, & STORAGE:

Assistant Professor **Betar Gallant** (l) and graduate student **Aliza Khurram** (r) are developing a novel battery that could both remove CO₂ from power plant exhaust and convert it to a solid ready for safe disposal.



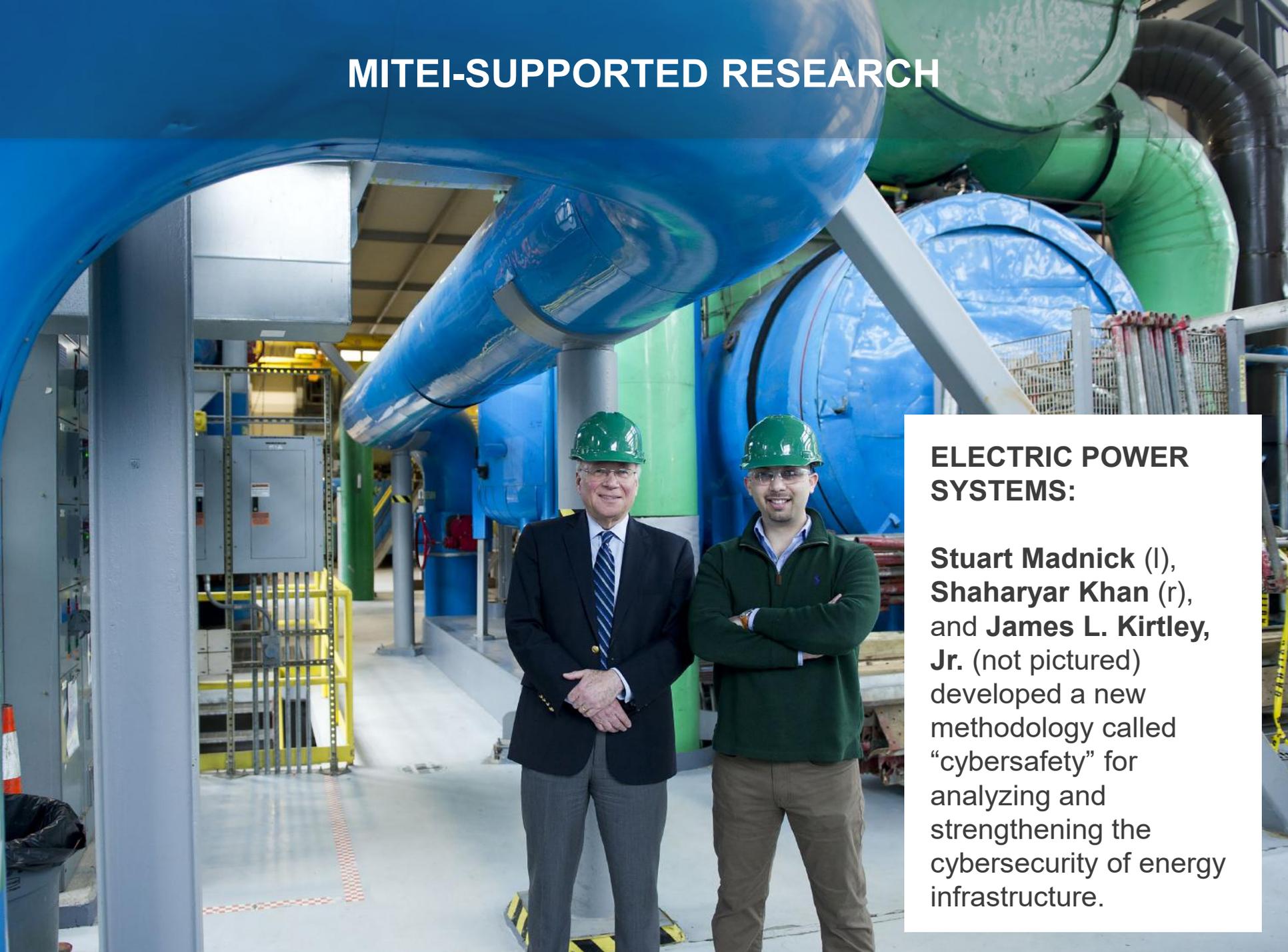
MITEI-SUPPORTED RESEARCH



MACHINE LEARNING:

Associate Professor **Heather Kulik** (c) and graduate student **Jon Paul Janet** (r) are using neural networks coupled with genetic algorithms to examine huge databases of transition metal compounds for potential use in practical devices. With this technique, graduate student **Aditya Nandy** (l) is designing better catalysts for methane conversion reactions.

MITEI-SUPPORTED RESEARCH

A photograph of two men standing in a large industrial facility. The man on the left is wearing a dark suit, a blue striped tie, and a green hard hat. The man on the right is wearing a green jacket, brown pants, and a green hard hat. They are standing in front of large blue and green pipes and machinery. The background shows a complex network of pipes and structural elements, with a yellow safety fence visible on the left.

ELECTRIC POWER SYSTEMS:

Stuart Madnick (l), Shaharyar Khan (r), and James L. Kirtley, Jr. (not pictured) developed a new methodology called “cybersafety” for analyzing and strengthening the cybersecurity of energy infrastructure.

MITEI-SUPPORTED RESEARCH

A photograph of two men standing in front of a red Peterbilt truck. The man on the left is wearing a blue jacket and glasses. The man on the right has a white beard and is wearing a striped sweater. The truck has 'Peterbilt' and 'SARRIS TRUCK EQUIPMENT WALTHAM 781-922-1111' written on it. In the background, there is a modern building and a bus stop.

TRANSPORTATION:

Daniel Cohn (l), a MITEI research scientist, and **Leslie Bromberg** (r), a principal research engineer at MIT's Plasma Science and Fusion Center, propose a plug-in hybrid electric truck with an internal combustion engine that can burn either gasoline, ethanol or methanol.

ENERGY EDUCATION

- Educate future energy innovators
- Provide a robust educational portfolio to MIT students and others around the world who want to contribute to the energy transition
 - **Undergraduate research:** Energy Studies Minor and Energy Undergraduate Research Opportunities Program (UROP)
 - **Graduate research:** Fellowships, mentoring, research and teaching assistantships
 - **Master's-level online courses**
 - Integration of **content from the Low-Carbon Energy Centers** into MITEI's education ecosystem
 - Exposure to **career opportunities and perspectives** from industry and policy leaders
 - **SDM** masters degree for energy executives



ENERGY EDUCATION

FY 2019 highlights:

- Revised Energy Studies Minor curriculum published in August 2019; changes add flexibility to the minor and increases number of advisors
- Supported 56 projects through the Undergraduate Research Opportunities Program, bringing total to 531, including Tata Center
- 26 new graduate students and postdocs named to Society of Energy Fellows with support from six MITEI member companies
- Ran special programs including April 2019 “Working the Energy Transition” career forum and June 2019 energy field trip class to Denmark and Germany
- 15 students participated in First-Year Energy Pre-Orientation Program
- Online energy courses: A new series of online energy courses will be launched on MIT’s edX platform; the first is Professor Christoph Reinhart’s 4.464 Sustainable Building Design, projected to launch in early 2020

OUTREACH

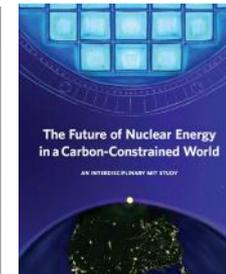
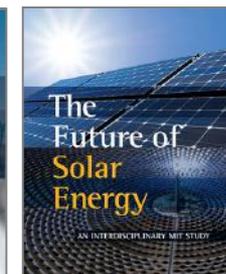
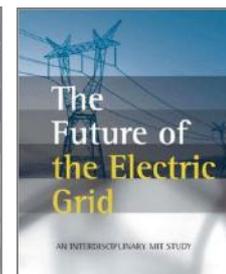
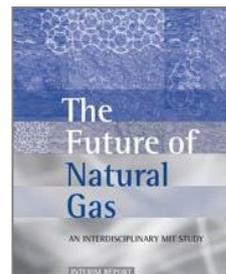
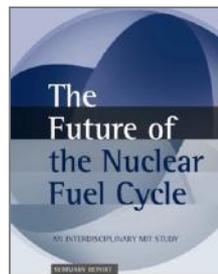
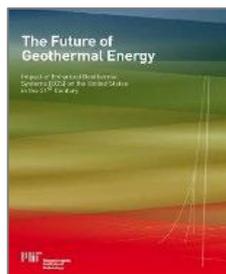
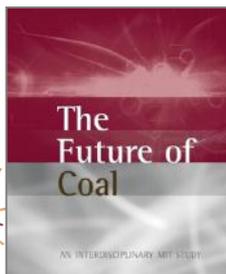
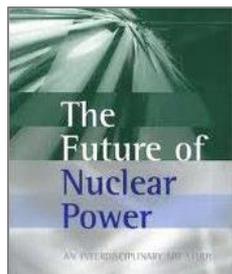
- Multi-disciplinary studies
 - *Insights into Future Mobility* will be published in November 2019 with events in Washington, DC, and Cambridge
 - *Future of Energy Storage* study is underway and contains outreach-specific grant
- Guest speakers to broaden perspectives of MIT community
 - FY 2019 speakers included Naomi Hirose (Tokyo Electric Power Company), Frances Beinecke (past president, Natural Resources Defense Council), and Asegun Henry (Atomic Simulation and Energy Research Group), IHS-MITEI Seminar Series
- Technology & policy symposia
 - Included 2018 C3E Women in Clean Energy Symposium, hosted by Stanford Energy in collaboration with MITEI, U.S. DOE, and Texas A&M Energy Institute, Hydrogen Symposium
- MIT Climate Symposia:
 - MITEI is providing strategic and operational support for the series; many MITEI-affiliated faculty and staff members are speaking at the events
- Outreach through various communications channels
 - Communicating our work through articles, media outreach, podcast, *Energy Futures* magazine, and participation in public forums

MULTI-DISCIPLINARY STUDIES: POLICY IMPACT

MITEI *Future of...* studies: fact-based analyses exploring the roles of key energy technologies in a carbon-constrained future

- Future of Energy Storage (2021)
- Future of Nuclear Power (2003, 2009, 2018)
- Future of Solar Energy (2015)
- Future of Natural Gas (2011)
- Future of the Electric Grid (2011)
- Future of the Nuclear Fuel Cycle (2010)
- Future of Geothermal (2008)
- Future of Coal (2007)

Study participants have briefed trade associations, NGOs, elected officials and their staffs, administration officials; have testified on study results at Congressional hearings; and have spoken in scores of venues in the US and around the world, including Norway, Cyprus, Abu Dhabi, Hungary, Japan, Peru, Australia, Turkey, Monaco, Spain, Brazil, Colombia, Ecuador, and other countries



MOBILITY OF THE FUTURE

- Study focus areas: Fuels, powertrains, policies, business models, and disruptive technologies
- Final report, *Insights into Future Mobility*, to be issued in November 2019
- Study supported by consortium of energy, automotive, and infrastructure companies
- Mobility Systems Center, MITeI's newest Low-Carbon Energy Center, created in response to industry interest



THE FUTURE OF ENERGY STORAGE

- Launched in the summer of 2018
- Focuses on the role of storage in making electricity systems cleaner and more efficient
- Considers storage technologies; economics of storage; practical transformation pathways for industry, and possible government roles in market design, regulation, research, and deployment support for storage in the near (2030) and long-term (2050) timeframes
- Research is underway; the report is expected to be published in 2021

TATA CENTER FOR TECHNOLOGY AND DESIGN



- Training engineers and entrepreneurs to tackle challenges of resource-constrained communities in the developing world
- Research locations include India, Nepal, Kenya, Nigeria, Tanzania, Uganda, Rwanda, Brazil, Colombia, and Venezuela
- During the 2018-19 academic year, supported 40 master's and PhD students
- Center-funded projects have led to close to 45 patent filings, with several projects transitioning into commercialization and policy programs
- Many projects have attracted follow-on funding from government agencies and commercial sponsors
- Research fields: energy, water, the environment, housing, health, and agriculture

GLOBAL COMMISSION TO END ENERGY POVERTY

- New effort to develop a viable pathway for providing electricity services to hundreds of millions of under-served homes more quickly and cost effectively than the current trajectory
- Commission led by The Rockefeller Foundation and co-chaired by Ernest Moniz, special advisor to the MIT President and former U.S. Secretary of Energy; Dr. Rajiv Shah, president of the Rockefeller Foundation; and Akinwande Adesin, president of the African Development Bank
- MITEI's Robert Stoner and Ignacio Perez-Arriaga lead the research team
- Commission convened for first time in September 2019 and will publish its findings and recommendations at the United Nations General Assembly in 2020
- Commission's leaders hope to define an actionable long-term agenda underpinned by commitments from the major development banks, private firms and investors, governments, and national utilities that will make universal electrification a reality by 2030

MITEI MEMBERS

Founding Members



ExxonMobil



Sustaining Members



Startup Members

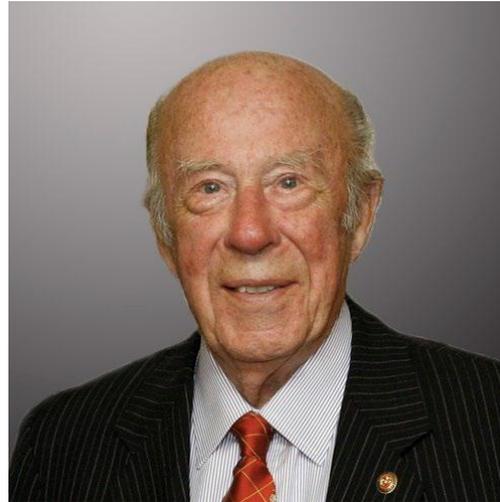


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THANK YOU, SECRETARY SHULTZ



for your many years of service as a valued advisor and friend.



INCOMING BOARD CHAIR: NORM AUGUSTINE



Previous roles have included:

- Chairman and CEO at Lockheed Martin Corp.
- Acting Secretary and Under Secretary of the U.S. Army
- Chairman and Principal Officer of the American Red Cross
- Chairman of the National Academy of Engineering
- Chairman of the NIH Scientific Management Review Board
- Member of the U.S. Department of Energy's Advisory Board
- ...and many more!

THANK YOU

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