MIT ENERGY INITIATIVE

External Advisory Board Briefing Book

November 2024

MITei

MIT Energy Initiative

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Letter from the Director

Dear External Advisory Board Members,

As the newly named director of the MIT Energy Initiative (MITEI), I am grateful to my predecessor Bob Armstrong, for the strong foundation of energy work he created; to Rob Stoner, MITEI's interim director, for maintaining that momentum; to our researchers, faculty, and students who are passionately driven to advance the energy transition; and to MITEI's members, who recognize the importance of this work and make it possible.

I took this role because I strongly believe we can stop climate change. MITEI has deep expertise in energy systems, technologies, resources, policy, and distribution. We understand the complexity of the energy transition. And we recognize the urgency with which it must happen. We are already making great strides transitioning from fossil fuels to cleaner sources of energy. Still, change is not happening fast enough. And success will only be measured in how much and how quickly we reduce greenhouse gas emissions.

MIT President Sally Kornbluth has identified climate change as "the greatest scientific and societal challenge of this or any age," and has called on the MIT community to meet that challenge. MITEI, with our understanding of the science, systems, economics, and business of energy, and our relationships across academia, industry, and government, is answering that call with renewed vigor and purpose.

In order to succeed, and succeed quickly, we must all work together: universities and start-ups for innovation, government for policy, big companies for massive scale. Today, new clean technologies have difficulty competing with well-established processes powered by cheap fossil fuels, and big companies are reluctant to make major investments unless government policy reduces the risk.

Last spring, MITEI demonstrated how we can work together by bringing together the stakeholders in the energy transition for our Spring Symposium to explore the possibilities and challenges of obtaining cheap, clean hydrogen from geologic sources. This symposium exemplified what I believe is our best

chance at success in solving complex challenges—gathering experts from all sectors, clarifying what remains unknown, considering pros and cons, and building consensus around promising technologies and how to advance them quickly.

Yes, with so many stakeholders, and such complicated energy systems, this work takes time. I believe we can accelerate the process of moving climate solutions from laboratory to large-scale commercialization by bringing these stakeholders together even earlier to discuss, develop, and fund solutions. As I envision MITEI's future, I am focused on convening researchers, economists, industry, non-profits, and government to reach consensus on practical approaches to decarbonize our entire global economy as quickly as possible. Consensus reduces risk, and so encourages the massive investments needed to stop climate change.

While we develop these necessary advances, I recognize that to solve the climate problem, the entire global economy needs to change. We must all come to the table to address the challenges of every sector. With support from business and government, MITEI is searching for real climate solutions that the public will adopt, and that merit the huge investments necessary for wide deployment. Still, we must work harder and faster to transition our energy systems. For, it is by working collaboratively, and urgently, to solve these complex issues that we will successfully address the greatest threat facing humanity today.

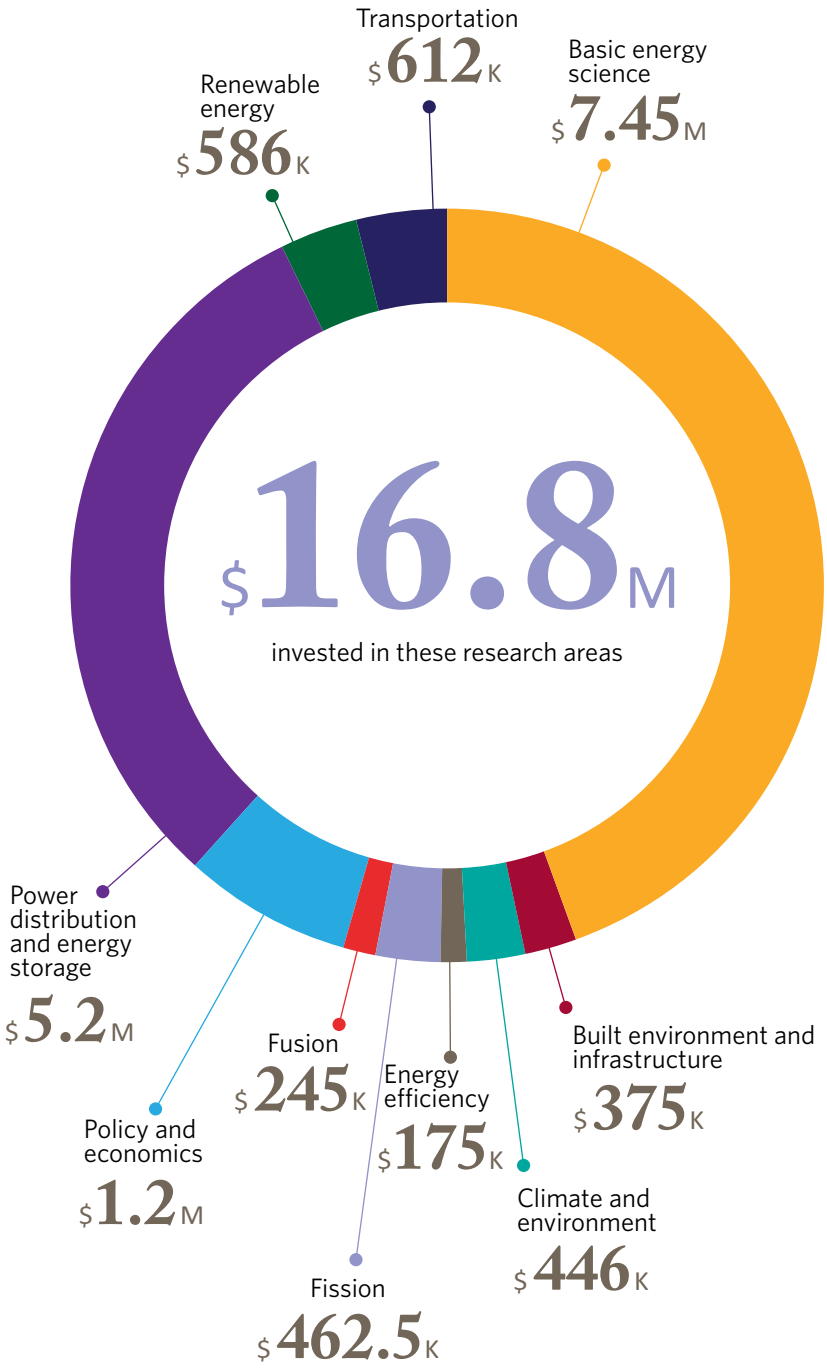
Sincerely,

William H. Green
Director, MIT Energy Initiative
Hoyt C. Hottel Professor of Chemical Engineering

MITEI by the Numbers, FY24

Research

38 MITEI members



Included in the above are 6 early-stage research projects supported with $900,000 from the MITEI Seed Fund and 10 new projects funded by the Future Energy Systems Center with $1.75 million.

Education

MITEI supported **48** student research projects through the Undergraduate Research Opportunities Program

9 new graduate fellows

12 students graduating with the Energy Studies Minor

16 students traveled on MITEI field trips, 9 to Denmark to explore renewable startups and 7 to the Netherlands to learn about offshore wind and hydrogen production

2 IAP courses offered in January 2024, one engaging students with leaders in the energy transition, and one focusing on the engineering, economics, and regulation of the electric power sector

18,776 learners took MITEI open online courses

14 graduate students and postdocs piloted a team practicum during IAP at Shell TechWorks

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Outreach

303 speakers MITEI brought to campus, who addressed topics that included energy justice for developing countries

263 attendees at Annual Research Conference

26 news articles published about MITEI research, education, and events

10 seminars hosted

26 webinars presented

Overview and Mission

The MIT Energy Initiative (MITEI), MIT's hub for energy research, education, and outreach is advancing zero- and low-carbon solutions to combat climate change and expand energy access. MITEI is a crucial rallying point for MIT researchers and educators who share our vision and commitment to dramatically reduce emissions through the development of novel technologies and delivery of science-based analysis. Together we are dedicated to decarbonizing global energy systems and building upon MIT's long tradition of working collaboratively and transparently with industry, government, and civil society.

MITEI and its member companies and organizations support hundreds of research projects across the Institute, including those awarded through the MITEI Seed Fund Program for innovative early-stage energy research projects. MITEI contributes to the goals of MIT's Climate Project through these efforts, as well as by supporting technology innovation for deep decarbonization and providing techno-economic analyses to inform the successful scaling of low- and no-carbon technologies.

The Future Energy Systems Center is a consortium-funded research portfolio that aims to foster and inform interdisciplinary energy research across MIT, accelerating our progress toward a net-zero carbon future. The Center is another vital component of MIT's climate action plan and MITEI's research program. Using techno-economic and life cycle analysis to examine energy pathways in different sectors, the Center enables its members to explore and develop strategic energy plans, taking into consideration technology, economics, and policy.

The Initiative also delivers comprehensive analyses for thought leaders, policy makers, and regulators, such as the "Future of" study series, the latest of which is *The Future of Energy Storage*, published in May 2022. This report, the ninth in the series, focuses on the role of energy storage in getting electricity systems to net-zero by mid-century by making them cleaner, more efficient, and more affordable. Another series of reports, which includes *Insights into Future Mobility* (2019) and *Utility of the Future* (2016), examines rapidly changing segments of the energy sector.

MITEI leads Institute energy education efforts and has engaged with thousands of students through sponsored research opportunities and other programs—preparing the next generation of innovators, entrepreneurs, and policy makers to collaborate on solutions to global energy challenges. Energy education programs include the Energy Studies Minor, Undergraduate Research Opportunities Program in energy, short modules during the Independent Activities Period, an energy-focused first-year pre-orientation program, the graduate Society of Energy Fellows, and online energy classes open to a global audience. 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 efforts foster dialogue within the research community and across the academic, industry, and government sectors and provide the public with context on current energy issues. In addition to informing public policy through research reports, MITEI facilitates this exchange of information by hosting and sponsoring events and by supporting faculty and staff participation in external events. The MITEI communications team also develops content to highlight MIT energy researchers, students, and their work across print and digital platforms, such as MITEI's website, podcasts and audio articles, and social media, as well as through media outreach.

FY24 Highlights

MIT researchers are exploring a promising plan to use clean-burning hydrogen in place of the diesel fuel now used in most freight-transport trucks—a change that would significantly reduce their greenhouse gas emissions. *Photo: Gretchen Ertl*

A team of MIT researchers and researchers from several other institutions has revealed ways to optimize efficiency and better control degradation by engineering the nanoscale structure of perovskite devices. Team members include Madeleine Laitz, left, and lead author Dane deQuilettes. *Photo courtesy of the resesarchers.*

Research & Analysis

MITEI's research portfolio reflects its primary objective of decarbonizing the global economy with zero- and low-carbon technologies and integrated energy systems supported by effective policy. We are guided by the use of advanced system modeling and analysis techniques to understand the climate as well as financial, economic, and social impacts of available pathways against the complex backdrop of the energy system as a whole.

MITEI raised more than $53 million in FY24 related to multi-year commitments from new and renewing members. Research projects launched by MITEI in FY24 totaled $16.8 million. The areas that garnered the most new research support this year were basic energy science at $7.45 million and power distribution and energy storage at $5.2 million. The balance of this year's research funding was allocated to support a range of other energy topics, including renewable energy, policy and economics, and built environment and infrastructure.

With support from its Members, as well as numerous foundations, donors, various government entities (state and federal), and university partners, MITEI has supported more than 1,050 projects through FY24.

The Future Energy Systems Center

The Future Energy Systems Center launched in the fall of 2021 as part of MIT's Climate Action Plan for the Decade. The Center was created to examine the accelerating energy transition as technologies, policies, demographics, and economics impact energy supply and demand. It conducts an integrated energy system analysis, providing insights into the complex multisectoral transformations that will alter the power and transportation systems, industry, and the built environment. Our work draws upon MIT research in traditional energy-related disciplines, as well as from cross-disciplinary fields such as energy and environmental policy, climate science, carbon management, energy economics, behavioral science, cybersecurity, information technology, and artificial intelligence. The Center's integrative analysis examines the three major energy-consuming sectors, transportation, buildings, and industry; and how

the three decarbonization strategies, electrification, low-carbon fuels/storage, and carbon management, can be applied across these sectors to support and accelerate the energy transition.

There are 37 Future Energy Systems Center members. The member companies span four continents and are involved in many industries, including energy, utilities, automotive, semiconductors, mining/metals, chemicals, telecommunications, infrastructure, insurance, and engineering/construction. We are in discussions with a number of prospective members.

MITEI Research Program Highlights

- **Funding for early-stage research:** One of MITEI's core tenets is supporting promising energy research across a wide range of disciplines. In FY24, six early-stage research projects submitted during the annual MITEI Seed Fund call were funded for a total of $900,000. MITEI has supported more than 220 energy-focused seed projects with grants totaling more than $28.8 million.
- **Systems modeling tools:** MITEI's internal research team has made substantial progress toward further developing a unique and powerful set of energy system analysis and optimization tools. The Sustainable Energy System Analysis Modeling Environment (SESAME) is a web application incorporating a growing number of features and capabilities for modeling energy system emissions and cost scenarios. SESAME is being used and expanded in projects funded by the Future Energy Systems Center and by industry. In 2023, the climate tech software startup Sesame Sustainability was spun out of MITEI, leveraging SESAME's unique platform for techno-economic and life cycle analysis to accurately evaluate industrial decarbonization solutions at scale. GenX, our state-of-the-art electricity system capacity expansion model for investment planning in the power sector, was released as an open-source tool in June 2021. It is being used in a number of Future Energy Systems Center projects, and by researchers and companies around the world. A multi-sector expansion of the GenX model, the Decision Optimization of Low-carbon Power-HYdrogen Network (DOLPHYN), was also released as open-source software in January 2022. DOLPHYN is capable of co-optimizing electricity, hydrogen, biofuel, synthetic and fossil fuel, natural gas, and CO_2 investments and operations. This model enables analysis of economy-wide decarbonization pathways and of how new technologies, policies, and investments in each sector affects the others.
- **Future Energy Systems Center projects:** The Future Energy Systems Center recently finished its fifth call for project outlines. From these submissions, the Center awarded funding for ten new projects, bringing the number of system modeling and analysis projects being carried out within the Center to 43. The topics range from the hurdles of small modular reactors for industrial settings to the interplay between H_2 production and renewable fuel synthesis. MITEI will kick-off meetings for each of these new projects at the Center's November 2024 Workshop. Our next call for project outlines will be sent to MIT's 1,300 Principal Investigators in June 2024 and a new cohort of projects will be selected in the fall.
- **Future Energy Systems Center meetings and workshops:** In May, the Future Energy Systems Center held its spring workshop to address pressing topics, including the role of bioenergy in the energy transition, decarbonizing buildings in cold climates, and the potential for nuclear power to play a significant role in the energy transition. It also held its advisory committee meeting and a student presentation and poster session.

- **Future Energy Systems Center webinars:** This series of webinars has provided an opportunity to share information about emerging technologies, policies, and sustainability issues from MIT professors across departments. The webinars also provide a venue for sharing the latest updates on the Center-supported projects.

Faculty Research Highlights

TRANSPORTATION

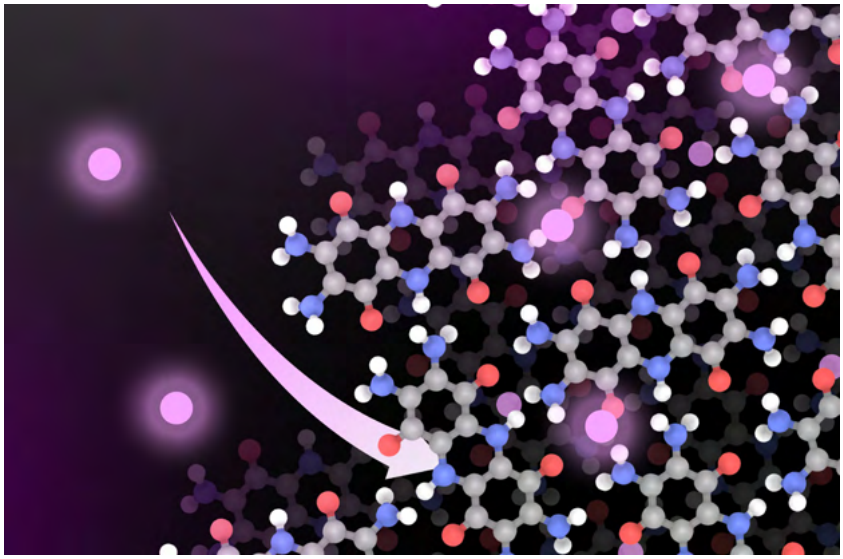
- Reducing carbon emissions from long-haul trucking
  MIT researchers led by William Green (Chemical Engineering) are exploring a promising plan to use clean-burning hydrogen in place of the diesel fuel now used in most freight-transport trucks—a change that would significantly reduce their greenhouse gas emissions.
- Cobalt-free batteries could power cars of the future
  Led by Mircea Dincă (Chemistry), MIT chemists developed a lithium-ion battery with a cathode based on organic materials—rather than scarce metals—decreasing the battery's social and environmental costs.
- Has remote work changed how people travel in the U.S.?
  New research suggests that the prevalence of remote work since the start of the Covid-19 pandemic has significantly changed urban transportation patterns, with significant variation across U.S. states. These changes have potential long-term implications for the environment and mass transit.

BUILT ENVIRONMENT

- AI pilot programs look to reduce energy use and emissions on MIT campus
  A cross-departmental team at MIT is utilizing machine learning to increase efficiency in heating and cooling of MIT's buildings and reduce on-campus energy consumption.
- Climate action, here and now
  David Hsu (Urban Studies and Planning) has been working to develop practical and concrete steps for climate action locally and at MIT: "I try to figure out how we can have cleaner and healthier cities that will be more sustainable, equitable, and more just."

INDUSTRIAL PROCESSES

- Microbes could help reduce the need for chemical fertilizers
  MIT researchers—led by Ariel Furst (Chemical Engineering)—developed a method for reducing the greenhouse gas emissions of chemical fertilizers by incorporating bacteria.
- With just a little electricity, MIT researchers boost common catalytic reactions
  MIT researchers have found that applying a small voltage to a catalyst could boost the efficiency of key chemical processing reactions, by up to a factor of 100,000.



A new MIT battery material could offer a more sustainable way to power electric cars. Instead of cobalt or nickel, the new lithium-ion battery includes a cathode based on organic materials. In this image, lithium molecules are shown in glowing pink. *Image: Courtesy of the researchers. Edited by MIT News.*

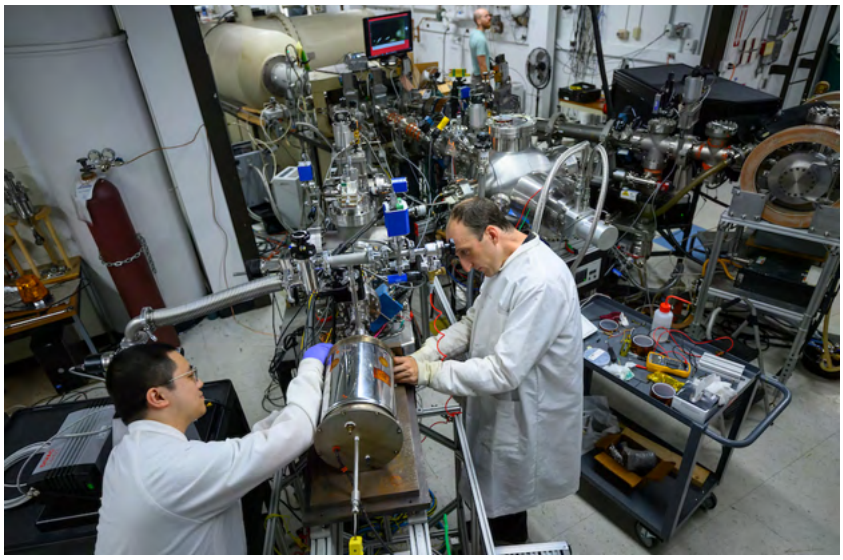
ELECTRIC POWER

- Future nuclear power reactors could rely on molten salts—but what about corrosion?
  MIT researchers show that using the right metals could alleviate the corrosion problem in these promising new reactor designs.
- Embracing the future we need
  MIT Sloan Professor Andy Sun is working to improve the electricity grid so it can better use renewable energy.
- Fast-tracking fusion energy's arrival with AI and accessibility
  By integrating fusion data into a system that can be read by AI-powered tools, MIT's Plasma Science and Fusion Center aims to improve access to fusion data and encourage diverse participation in fusion and data science.
- New study shows how universities are critical to emerging fusion industry
  A new study—co-authored by Dennis Whyte (Plasma Science and Fusion Center)—suggests that academia plays an essential role in supporting the growth and success of high-tech industries, like fusion.
- Study unlocks nanoscale secrets for designing next-generation solar cells
  Researchers have engineered the nanoscale structure of perovskite devices, revealing ways to improve their efficiency and better control degradation.

- Tests show high-temperature superconducting magnets are ready for fusion
  New superconducting magnets have met all criteria for building an economic, compact fusion power plant, finds a recent study from MIT's Plasma Science and Fusion Center and MIT spinout Commonwealth Fusion Systems.

ENERGY STORAGE & LOW-CARBON FUELS

- MIT engineers create an energy-storing supercapacitor from ancient materials
  MIT engineers have created a "supercapacitator"—made with cement, carbon black, and water—that could provide cheap and scalable storage for renewable energy.
- Pixel-by-pixel analysis yields insights into lithium-ion batteries
  MIT researchers have used X-ray images to observe the reactivity of lithium-ion phosphate, a material used in rechargeable batteries. These findings could lead to improvements in the efficiency of charging and discharging batteries.
- MIT design would harness 40 percent of the sun's heat to produce clean hydrogen fuel
  MIT engineers have developed a system of reactors for producing hydrogen fuel using solar energy instead of fossil fuels.
- Engineers develop an efficient process to make fuel from carbon dioxide
  Engineers from MIT and Harvard have developed a method for directly converting greenhouse gas into a stable fuel that can power fuel cells and generate electricity.



Postdoc Weiyue Zhou (left) and Associate Professor Michael Short attach a novel test chamber containing a metal sample and salt to the end of a proton accelerator. Experiments to date show that proton irradiation decreases the rate of corrosion in certain metal alloys. *Photo: Gretchen Ertl*

- Team engineers nanoparticles using ion irradiation to advance clean energy and fuel conversion
  MIT researchers—led by Bilge Yildiz (Nuclear Science and Engineering)—have found a way to precisely control the size, composition, and other aspects of nanoparticles, which could advance clean energy and environmental technologies.
- Extracting hydrogen from rocks
  Iwnetim Abate (Materials Science and Engineering) is researching ideal conditions for underground hydrogen production, unlocking a new path for cost-effective, carbon-free energy.

CARBON MANAGEMENT

- Study suggests energy-efficient route to capturing and converting CO_2
  The findings, based on a single electrochemical process, could help cut emissions from the hardest-to-decarbonize industries, such as steel and cement.
- Engineers find a new way to convert carbon dioxide into useful products
  By using DNA, MIT chemical engineers have devised an efficient way to convert carbon dioxide to carbon monoxide, a chemical precursor that can be used to generate useful products such as ethanol and other fuels.

POLICY

- Cutting carbon emissions on the U.S. power grid
  An online model enables users to calculate the least-cost strategy for a specific regional grid under various assumptions; outcomes vary widely from region to region.
- To improve solar and other clean energy tech, look beyond hardware
  An MIT study finds system deployment processes have been slow to improve over time—but must be addressed to lower clean energy costs in the future.
- Tracking U.S. progress on the path to a decarbonized economy
  The Clean Investment Monitor database, developed by the MIT Center for Energy and Environmental Policy Research and the Rhodium Group, monitors clean technology and infrastructure investments to assess the efficacy of policies encouraging investments for climate change.
- Improving U.S. air quality, equitably
  A study from researchers at MIT and Stanford University has found that climate policy alone cannot address the racial and economic disparities in air pollution exposure.
- MIT researchers map the energy transition's effects on jobs
  A new analysis—co-authored by Christopher Knittel (Sloan School of Management)—shows areas in the United States with the highest concentration of jobs that may be most impacted by the renewable energy transition.

Reports and Studies

A selection of MITEI-supported reports and studies published in FY24.

Maryam Alghannam, et al. "Fluid-injection control on energy partitioning during the earthquake cycle." *Journal of the Mechanics and Physics of Solids*. May 2024.
bit.ly/eab24-earthquake
Analyzes fluid-injection-induced earthquakes and the impact of fluid injection on energy partitioning during induced and triggered earthquakes. The partitioning of energy gives an indication of an earthquake's overall size and its potential damage to man-made structures.

Yu Qian Ang, et al. "Smart meter-based archetypes for socioeconomically sensitive urban building energy modeling." *Building and Environment*. December 2023.
bit.ly/eab24-ubem
Developed a novel method to incorporate socioeconomic indicators in urban building energy modeling. The method presented is scalable and applicable to cities and municipalities worldwide (large or small) and elucidates the importance of accounting for demographic and socioeconomic indicators to reflect lived realities accurately. Supported in part by Exelon Corporation through the MIT Energy Initiative.

Kali Benavides, et al. "Mitigating emissions in the global steel industry: Representing CCS and hydrogen technologies in integrated assessment modeling." *International Journal of Greenhouse Gas Control*. January 2024.
bit.ly/eab24-steel
Conducts a techno-economic assessment of two low-emissions steel production technologies and evaluates their deployment in emissions mitigation scenarios utilizing the MIT Economic Projection and Policy Analysis (EPPA) model. Supported by the MIT Joint Program on the Science and Policy of Global Change, and by ExxonMobil through the MIT Energy Initiative.

Ilya Charaev, et al. "Single-photon detection using large-scale high-temperature MgB_2 sensors at 20 K." *Nature Communications*. May 2024.
go.nature.com/3XOgi39
Demonstrates magnesium diboride (MgB_2) thin-film superconducting microwires capable of single-photon detection at 1.55 μm optical wavelength. This research provides possibilities for breaking the operating temperature limit and maximum single-pixel count rate, expanding the detector area, and raises inquiries about the fundamental mechanisms of single-photon detection in high-critical-temperature superconductors.

A.R. Devitre, et al. "A facility for cryogenic ion irradiation and in situ characterization of rare-earth barium copper oxide superconducting tapes." *Review of Scientific Instruments*. June 2024.
bit.ly/eab24-REBCO
Presents a new ion-beam facility that enables simultaneous cryogenic irradiation and in situ characterization of commercial rare earth barium copper oxide (REBCO) tapes. This facility is used to study the performance of REBCO magnets in high radiation environments, such as fusion power plants, particle colliders, and space exploration.

Gang Fan, et al. "Highly efficient carbon dioxide electroreduction via DNA-directed catalyst immobilization." *JACS Au*. March 2024.
bit.ly/eab24-DNA
Applies DNA as a molecular-scale "Velcro" to investigate the tethering of three porphyrin-based catalysts to electrodes to enable the electrochemical reduction of carbon dioxide. This tethering improves the stability of the catalysts and their Faradaic efficiencies, demonstrating its potential as a strategy for catalyst immobilization.

Zi Hao Foo, et al. "Harnessing dimethyl ether with ultra-low-grade heat for scaling-resistant brine concentration and fractional crystallization." *Chemical Engineering Journal*. June 2024.
bit.ly/eab24-brine
Analyzes the technoeconomic viability of a novel solvent-driven water extraction system employing dimethyl ether and ultra-low-grade heat for brine concentration and fractional crystallization. Solvent-driven separations may enable scalable concentration of hypersaline brines, supporting a circular resource economy from the extraction of lithium and rare earth elements from spent battery and magnet leachates. Supported in part through MITEI's Energy Fellowship program.

Zi Hao Foo, et al. "Sustainable lithium recovery from hypersaline salt-lakes by selective electrodialysis: Transport and thermodynamics." *Environmental Science and Technology*. September 2023.
bit.ly/eab24-recovery
Quantifies the influence of the solution composition, salinity, and acidity on the counterion selectivity and thermodynamic efficiency of electrodialysis for sustainable lithium extraction, leveraging 1,250 original measurements with salt-lake brines that span four feed salinities, three pH levels, and five current densities. Supported in part by MITEI's Energy UROP.

Weiran Gao, et al. "Modeling the impact of electrolyte flow on heat management in a Li-ion convection cell." *Journal of the Electrochemical Society*. September 2023.
bit.ly/eab24-electrolyte
In response to challenges in the thermal management of lithium-ion batteries, this paper investigates the concept of circulating electrolyte through the porous electrodes and separator to facilitate effective, uniform, and real-time temperature regulation. Supported by ExxonMobil through the MIT Energy Initiative.

Michael A. Giovanniello, et al. "The influence of additionality and time-matching requirements on the emissions from grid-connected hydrogen production." *Nature Energy*. January 2024.
go.nature.com/3MOBq37
Analyzes energy system policies to clarify conflicting guidelines on appropriate time-matching requirements for qualifying hydrogen as "low carbon." These findings argue for annual time-matching in the near term for the attribution of hydrogen U.S. production tax credits, followed by phase-in and then phase-out of hourly time-matching requirements as the grid decarbonizes. This research was funded by MITEI's Future Energy Systems Center.

Zachary S. Hartwig, et al. "The SPARC Toroidal Field Model Coil Program." *IEEE Transactions of Applied Superconductivity*. November 2023.
bit.ly/eab24-SPARC
Presents a high-level technical and programmatic overview of the entire Toroidal Field Model Coil Program, including a summary of the high-field path to fusion energy and a brief history of large-scale superconducting fusion magnet development programs.

Wei He, et al. "Flexible batch electrodialysis for low-cost solar-powered brackish water desalination." *Nature Water*. March 2024.
go.nature.com/3BjWzzo
Develops and field validates a time-variant electrodialysis reversal (EDR) technology that flexibly uses available solar energy for the desalination of brackish groundwater. This desalination system can vary pumping and EDR power to match the intermittency of solar power, maximizing the desalination rate.

Rob Jones, et al. "Realistic U.S. long-haul drive cycle for vehicle simulations, costing, and emissions analysis." *Transportation Research Record Journal of the Transportation Research Board*. January 2024.
bit.ly/eab24-truck
Creates a representative drive cycle for U.S. long-haul truck operations for the modeling and simulation of alternative powertrains. Benchmarks are presented for fuel consumption, well-to-wheel emissions, and total cost to society under different scenarios (present-day, mid-term, and long-term). This research was funded by MITEI's Mobility Systems Center.

Paul Joskow. "The expansion of incentive (performance-based) regulation of electricity distribution and transmission in the United States." *Review of Industrial Organization*. June 2024.
bit.ly/eab24-electricity
Examines developments in the application of performance-based regulation to electricity distribution and transmission in the United States.

Rahman Khorramfar, et al. "Electric-gas infrastructure planning for deep decarbonization of energy systems." *Applied Energy*. January 2024.
bit.ly/eab24-planning
Develops a least-cost investment and operations model for joint planning of electricity and natural gas infrastructures that considers a wide range of available and emerging technology options. This modeling framework will be used to evaluate outcomes for the U.S. New England region under different technology, decarbonization goals, and demand scenarios. This research was partially funded by MITEI's Future Energy Systems Center.

So Yeon Kim, et al. "Demonstration of Helide formation for fusion structural materials as natural lattice sinks for helium." *Acta Materialia*. March 2024.
bit.ly/eab24-helide
Addresses the embrittlement of polycrystalline materials in fusion reactors caused by helium. Incorporating nanodispersoids with constitutional vacancy-like atomic-scale free volume, which can securely store helium within their bulk lattices, could help delay critical damage that may lead to premature failure of reactors.

Kerry S. Klemmer, et al. "Evaluation of wind resource uncertainty on energy production estimates for offshore wind farms." *AIP Publishing*. January 2024.
bit.ly/eab24-wind
Identifies and quantifies sources of uncertainty in wind energy resource stemming from the level of description of the relevant meteorological variables and the source of the data, considering numerical weather predictions and in situ observations. These findings can inform wind farm siting and design and can improve energy output predictions.

Yongli Lu, et al. "Rational design of a chemical bath deposition-based tin oxide electron-transport layer for perovskite photovoltaics." *Advanced Materials*. July 2023.
bit.ly/eab24-tin
Chemical bath deposition (CBD) is widely used to deposit tin oxide (SnOx) as an electron-transport layer in perovskite solar cells (PSCs). This research introduces volatile oxalic acid as an alternative to thioglycolic acid to facilitate attachments of tin oxide particles onto the substrate in a chemical bath to improve PSC stability. Supported in part by Eni S.p.A. through the MIT Energy Initiative.

Dharik Mallapragada, et al. "Electricity pricing challenges in future renewables-dominated power systems." *Energy Economics*. September 2023.
bit.ly/eab24-wholesale
Assesses wholesale electricity price distributions in low-carbon power grids under various scenarios. Supported in part by the MIT Energy Initiative's Future of Energy Storage study.

Michael P. Nitzsche, et al. "Capture and electrochemical reduction of CO_2 using molten alkali metal borates." *ACS Sustainable Chemistry & Engineering*. July 2023.
bit.ly/eab24-borates
Demonstrates that generation of carbonates upon CO_2 capture by molten alkali metal borates can enable their use as electrolytic media for carbon nanotube (CNT) synthesis by CO_2 splitting. The authors determine the operating conditions and catalyst materials necessary for synthesis of valuable multiwalled CNTs by CO_2 capture and conversion as a sustainable alternative to conventional carbon-intensive CNT synthesis techniques.

Mohammad Ostadi, et al. "Enhancing biomass-to-liquid conversion through synergistic integration of natural gas pyrolysis: Process options and environmental implications." *Energy Conversion and Management*. February 2024.
bit.ly/eab24-biomass
Develops a framework for integrating pyrolytic hydrogen with the biomass gasification to methanol process, improving the carbon conversion efficiency of biomass to fuel. This process shows substantial promise for generating low-carbon liquid fuel, which is necessary for reducing the greenhouse gas emissions in difficult to electrify sectors.

Tim Schittekatte, et al. "Electricity retail rate design in a decarbonizing economy: An analysis of time-of-use and critical peak pricing." *The Energy Journal*. November 2023.
bit.ly/eab24-retailrate
Analyzes the design of electricity rates to best account for the increased prominence of intermittent renewable resources and flexible loads. Coupling time-of-use rates and critical peak pricing can balance signaling to consumers the value of power changes over time and keeping prices significantly predictable and stable. This research was supported by MITEI's Future Energy Systems Center.

Wei Lun Toh, et al. "The role of ionic blockades in controlling the efficiency of energy recovery in forward bias bipolar membranes." ***Nature Energy*****. December 2023.**
go.nature.com/3B9MW6F
Develops a mechanistic model explaining the forward bias polarization behavior of bipolar membranes in mixed electrolytes with different acidities/basicities and demonstrates the utility of this model for fuel cells and redox flow batteries. Supported in part by Undergraduate Research Opportunities Program (UROP) awards from the MIT Energy Initiative.

Morteza Vahid-Ghavidel, et al. "Integrated energy demand-supply modeling for low-carbon neighborhood planning." ***Applied Energy*****. March 2024.**
bit.ly/eab24-buildings
Combines urban building energy modeling and local planning of renewables, using an optimization framework, to minimize the investment and operational cost of meeting the energy needs of a group of buildings. This research was supported by MITEI's Seed Fund.

Guiyan Zang, et al. "H_2 production through natural gas reforming and carbon capture: A techno-economic and life cycle analysis comparison." ***International Journal of Hydrogen Energy*****. January 2024.**
bit.ly/eab24-h2
Conducts techno-economic analysis and life cycle analysis of five hydrogen production cases, focusing on characterizing emissions and costs of varying carbon capture and storage (CCS) schemes for hydrogen production with CCS. This research was funded by MITEI's Future Energy Systems Center.

Joy S. Zeng, et al. "Nonidealities in CO_2 electroreduction mechanisms revealed by automation-assisted kinetic analysis." ***American Chemical Society (ACS) Central Science*****. June 2024.**
bit.ly/eab24-electroreduction
Improves the workflow for collecting electrochemical rate data by using a robotic system to automate sequential testing of up to 10 electrochemical cells. This system is used to investigate the mechanism of carbon dioxide electroreduction to carbon monoxide at several immobilized metal tetrapyrroles.

Yunhan Zheng, et al. "Examining the interactions between working from home, travel behavior, and change in car ownership due to the impact of Covid-19." ***Travel Behaviour and Society*****. July 2023.**
bit.ly/eab24-covid19
Explores changes in travel behavior due to Covid-19 and investigates the underlying factors contributing to these changes. Supported in part by the MIT Energy Initiative's Mobility of the Future study.

Yuntong Zhu, et al. "Highly disordered amorphous Li-battery electrolytes." ***Matter*****. February 2024.**
bit.ly/eab24-Li
Resolves the local structure of amorphous Li garnet and examines their impact on Li dynamics. These findings provide guidelines for the structure and phase design for amorphous Li garnets and their integration in next-generation batteries.

Yuntong Zhu, et al. "Uncovering the network modifier for highly disordered amorphous Li-garnet glass-ceramics." ***Advanced Materials*****. January 2024.**
bit.ly/eab24-batteries
Examines a new class of electrolyte separators that can serve as protective layers for hybrid or all-solid-state batteries due to its grain-boundary-free nature and wide electrochemical stability window. The use of these separators can enable low-cost, more-sustainable energy storage.

Global Commission to End Energy Poverty

The Global Commission to End Energy Poverty is a collaboration between MITEI and the Rockefeller Foundation initiated in late 2018 to bring electricity to the remaining billion people across the globe who currently live without it. The Commission is led by Robert Stoner, founding director of the Tata Center for Technology and Design; and co-chaired by Ernest Moniz, special advisor to the MIT President, professor emeritus, and former U.S. Secretary of Energy; Dr. Rajiv Shah, president of the Rockefeller Foundation; and Akinwumi Adesina, president of the African Development Bank. The MITEI team's "Energy Poverty Index," which measures the capacity of countries with substantial energy poverty to achieve universal electricity access by 2030, is now being considered by the World Bank as part of its overall energy poverty tracking process. The African School of Regulation has been launched at the recommendation of the Commission to help build electricity system regulatory capacity across Africa and is under the interim leadership of Ignacio Pérez-Arriaga, a former visiting professor at the MIT Sloan School of Management from Comillas Pontifical University in Madrid, Spain. The school is based temporarily at the Florence School of Regulation in Italy and opened points of presence in six African nations over the course of 2023.

Tata Center for Technology and Design

Entering its twelfth year, the Tata Center for Technology and Design is supporting researchers at the master's and PhD level to conduct energy research in developing countries. Their experiences abroad inform their ongoing research with the goal of catalyzing positive social impact in the form of policy support and affordable products and services. Through support for these students, the Tata Center, which is led by Tata Center Founding Director Robert Stoner, advances its mission of bringing technical talent and experience to bear on the challenges of the developing world. Ongoing projects focus on the social and financial impacts of ongoing fuel price shocks in vulnerable countries, the greenhouse gas and social impact of lithium-ion battery manufacturing in Indonesia, and the potential of retrofitting coal plants in India as thermal batteries to support renewables deployment while also reducing greenhouse gas emissions.

With a double major in mathematics and electrical engineering and computer science, MIT senior Elaine Siyu Liu is exploring the ways in which renewable energy and electric vehicles impact the power grid.
Photo: Gretchen Ertl

As part of a MITEI-sponsored field trip to the Netherlands to experience the country's approach to sustainable energy, students received a tour of EnTranCe, a facility dedicated to researching hydrogen usage within the energy grid, at Hanze University in Groningen.
Photo courtesy of MITEI.

Education

MITEI's role as an educator of future energy change agents is critical to its mission as a catalyst for tomorrow's low-carbon energy solutions. Through its various programs, MITEI provides a robust educational toolkit to MIT graduate and undergraduate students, global online learners, and high school students who want to contribute to the energy transition. These programs allow students to take classes; conduct research in diverse areas, from energy science and social science to technology and engineering; practice their skills; become leaders; and network with peers and professionals. MITEI's education team serves on various climate-related committees to shape the Institute's climate response and work with MIT faculty members to develop curricula and act as advisors to aspiring and current energy students.

Students interested in energy at MIT can start as soon as they step onto campus: MITEI runs the Discover Energy First-Year Pre-Orientation Program at the end of the summer, before classes begin. The journey continues in the classroom, where undergrads take interdisciplinary courses through the Energy Studies Minor and participate in laboratory research through the MITEI Undergraduate Research Opportunities Program (UROP). We also offer a first-year discovery class, SP.254 Low-Carbon Energy in Research and Application, and collaborate on SP.257 MISTI Career Connections: Energy. After completing their first year at MIT, students have the opportunity to attend a 10-day field trip, led by MITEI, to experience practical examples related to the energy transition through visits to energy companies, demonstration projects, and research facilities.

Graduate students and postdoctoral associates receive funding from MITEI through the member education fund. In addition to contributing their own research to MITEI's areas of inquiry and collaborating with researchers on white papers and studies, graduate students mentor UROP students and contribute to the development of the Energy Studies Minor curriculum. Through the Society of Energy Fellows, MITEI hosts activities for graduate student fellows, including dinner meetings with sponsors at MITEI's Annual Research Conference, energy talks, and a range of informational gatherings and networking events. MITEI has collaborated with MIT faculty and researchers to develop five graduate-level energy courses for MITx, with a sixth currently in development.

MITEI Education Program Highlights

- **Graduate Fellows:** MITEI welcomed 9 new graduate students and postdocs to the Society of Energy Fellows in 2023-2024. The Energy Fellows network now totals more than 560 current and former graduate students and postdoctoral fellows, spanning 20 departments and divisions at MIT's five schools and college. This year's fellowships were supported by MITEI member companies Chevron, Eni, ExxonMobil, and Shell.
- **Collaboration with GradEL:** During the spring semester, MITEI Education Director Antje Danielson co-taught the class 6.S640, "How will my research matter? Optimizing projects towards impact," as part of the Riccio Graduate Engineering Leadership Program (GradEL). In weekly interactive sessions, 14 graduate students from across campus were challenged to clarify how their work has potential impact and how best to communicate this. 100% of the survey respondents agreed that they are better able to talk about their research to different audiences after taking the class.
- **Energy Systems Team Practicum:** MITEI piloted the first team practicum at Shell TechWorks in Boston during IAP 2024. For one month, 14 MIT graduate students and postdocs from 10 disciplines worked on four climate- and energy-related projects, relevant to Shell's future energy portfolio. They were supervised by MITEI and Shell staff with input from MIT faculty and researchers.
- **Online energy courses:** To train global professionals, policy makers, and students in research methods and tools to support and accelerate the energy transition, the MITEI education team has developed a series of open online courses (MOOCs) based on interdisciplinary residential MIT subjects. These courses are free and available in almost every country and have attracted more than 115,000 students. They engage critical aspects of future energy systems: load and demand-side management; economics and regulation; production, distribution, and transmission; and mobility. The courses include Sustainable Building Design; Sustainable Energy; Principles of Modeling, Simulation, and Control for Electric Energy Systems; Energy Economics and Policy; and Transformative Living Labs in Mobility.
- **IAP courses:** MITEI offered two IAP courses in January 2024. "Leading the Energy Transition" invites energy leaders to share their strategies in accelerating the change to a net-zero carbon world. "Computational modeling for clean, reliable, and affordable electricity" offers a hands-on learning experience introducing analysis techniques to model and understand the role of electric power systems within a carbon-constrained economy.
- **First-Year Pre-Orientation Program:** MITEI's summer 2023 energy pre-orientation program welcomed 19 new first-year students to the MIT community. Activities included a visit to a wind turbine testing facility, tours of MIT's Nuclear Reactor Lab and the Plasma Science and Fusion Center, a visit to a nearby sustainable farm, and sailing on the Charles (the original wind energy!).
- **Energy Studies Minor:** The Energy Studies Minor allows undergraduate MIT students to gain an integrative understanding of energy and develop the skills required of tomorrow's energy professionals, leaders, and innovators in research, industry, policy, management, and governance. Over 200 students have graduated with the Energy Studies Minor, including 12 graduating in 2024.
- **Undergraduate energy research:** MITEI supported 48 student projects through the MITEI Undergraduate Research Opportunities Program during the 2023-2024 academic year, bringing its total of sponsored projects to 975.

- **Field trip to Europe:** In August 2023, MITEI Education Director Antje Danielson took 9 undergraduate and graduate students to Denmark to explore renewable energy startups and visit the Danish Tech University in Copenhagen. In June 2024, she took 7 students to the Netherlands, visiting the Ports of Eemshaven and Rotterdam, Hanze University of Applied Science's Center of Expertise Energy, Groningen University, and a number of companies involved in offshore wind and hydrogen production.
- **High school curriculum:** MITEI Deputy Director for Policy Christopher Knittel (MIT Sloan) has developed the Climate Action Through Education (CATE) program and associated interdisciplinary high school climate curriculum with the MITEI Education team in a supportive advisory group role. Read more in **Affiliated Groups, CEEPR section**.
- **MIT–University of Groningen faculty workshop:** The MITEI education team collaborated with the MIT Catalyst Program on a faculty workshop in the broad areas of energy transition and healthy aging. The workshop was held on September 10–12, with nine MIT and 10 Dutch faculty, connecting with their peers, participating in structured experiences following the Catalyst/Impact methodology, and finding opportunities to work with one another.
- **Course support:** MITEI provided support for teaching assistants in the following subjects: IDS.521[J]: Energy Systems for Climate Change Mitigation, 22.081: Sustainable Energy, 11.165: Urban Energy Systems and Policy, EC.711: Introduction to Energy in Global Development, and EC.712[J]: Applications of Energy in Global Development. MITEI also provided course development funds for 11.S188/11.S3953 - Indigenous Water and Energy Planning.

Energy Education Task Force

MITEI's Energy Education Task Force guides the development of energy education at MIT. The task force meets regularly throughout the academic year and includes MIT faculty from all five schools and one college, as well as graduate and undergraduate student representatives. MITEI's education team members support the task force by implementing energy education programs.

ENERGY EDUCATION TASK FORCE FACULTY MEMBERS FY24

Chair: Oliver Jagoutz, Professor of Geology

Martin Bazant, Professor of Chemical Engineering and Mathematics
Matthew Evans, MathWorks Professor of Physics
Michael Howland, Esther and Harold E. Edgerton Assistant Professor
David Hsu, Associate Professor of Urban Studies and Planning
Juejun Hu, John F. Elliott Professor of Materials Science and Engineering
Robert Jaffe, Jane and Otto Morningstar Professor of Physics
Christopher Knittel, Associate Dean for Climate and Sustainability; George P. Shultz Professor of Energy Economics; Director, Center for Energy and Environmental Policy Research
Janelle Knox-Hayes, Professor of Economic Geography and Planning
Steven Leeb, Professor of Electrical Engineering and Computer Science
Michael Short, Class of '42 Associate Professor of Nuclear Science and Engineering
Kate Trimble, Senior Associate Dean and Director
Amos Winter, Associate Professor

MIT Student Energy Groups

MITEI provides financial and staff support for a number of student groups throughout the year.

The **MIT Solar Electric Vehicle Team** is dedicated to promoting clean energy and alternatively powered vehicles. Members participate in seminars, lectures, museum displays, conferences dedicated to alternative energy, and numerous Earth Day and ecological fairs.

MIT's **Electric Vehicle Team** has a strong pedigree of racing, as well as research contributions to the field of electric vehicles. It is a student team with industry partners, with a home in MIT's Edgerton Center.

StartLabs is a hub of undergraduate entrepreneurship activity at MIT. StartLabs host community events for student entrepreneurs to meet one another and find co-founders or early hires, and large, campus-wide events to increase student interest in entrepreneurship.

MIT Spokes is an annual student-organized program where a group of MIT students spend their summer cycling across America to host STEAM (Science, Technology, Engineering, Arts, and Math) learning festivals for under-resourced areas.

MIT Motorsports is a dedicated group of 65+ students that strives to engineer a Formula SAE car of the highest caliber. Made up of undergraduate and graduate students, the team builds an electric racecar each season for the Formula Hybrid and Formula SAE Electric Competition.

The **MIT Policy Hackathon** provides data-driven solutions to real-world policy challenges from government, non-profit, and industry. The hackathon is hosted by students from MIT's Technology & Policy Program and the Institute for Data, Systems, & Society.

The **MIT Energy and Climate Hack** brings students together to apply AI to solutions for climate change—a massive, complex challenge. It requires the processing and management of large-scale data and systems—problems that Artificial Intelligence is best suited to tackle. Simply put, AI has the potential to supercharge our solutions and help combat global warming.

Using an on-board logging computer, Electric Vehicle Team members (left to right) Anand John, Rachel Mohammed, and Aditya Mehrotra check data on the bike's performance, battery levels, and hydrogen tank levels to calculate the range of the vehicle. *Photo: Adam Glanzman*

Paula R. Glover, the president of Alliance to Save Energy, speaks at the twelfth annual Clean Energy, Education, and Empowerment (C3E) Women in Clean Energy Symposium and Awards on a panel discussing how to strengthen existing policies and implement new ones to accelerate decarbonization. *Photo: Gretchen Ertl*

At MITEI's Earth Day Colloquium, World Resources Institute President and CEO Ani Dasgupta stressed that systemic change is needed to bring carbon emissions in line with long-term climate goals. "It's not one thing that needs to change," he said. "The whole system needs to change." *Photo: Kelley Travers*

Outreach

MITEI's fact-based analysis of current energy topics informs public policy, fosters dialogue within the academic research community, and provides the public with context on vital issues. Convening events throughout the year, MITEI hosts thought leaders from across the energy value chain. MITEI staff, faculty affiliates, and graduate students share their research and perspectives at domestic and international events. Staff members also participate in Institute-wide efforts on addressing climate change. MITEI's communications team highlights the research and achievements of faculty and students through articles, media outreach, social media, podcasts, and other digital and print platforms.

Outreach Program Highlights

- **Guest speakers:** Leaders in policy, academia, and industry gave talks at MITEI-hosted events. Speakers included Yuri Sebregts, executive vice president of technology and chief technology officer at Shell; Praveer Sinha, CEO and managing director at the Tata Power Company Limited; Jeremiah Johnson, associate professor at North Carolina State University; Julie McNamara MS '14, deputy policy director of climate & energy at the Union of Concerned Scientists; and more.
- **Spring Symposium:** In May 2024, MITEI held its Spring Symposium bringing together researchers, industry leaders, and academic experts to address the potential of geologic hydrogen as an energy source for the future. Speakers included Mary Haas, venture partner at Breakthrough Energy Ventures; Dirk Smit, independent consultant and scientist; and Avon McIntyre, executive director of HyTerra, Ltd.
- **Earth Day Colloquium:** As part of MIT's celebration of Earth Week, MITEI hosted World Resources Institute President and CEO Ani Dasgupta to discuss how a just energy transition in key countries can lead to a global tipping point for a more resilient, equitable world.
- **Annual Research Conference 2023:** The event brought together energy researchers, policy makers, and industry members to explore policies and technologies that are shaping today's energy

system and its future. This year's conference highlighted strategies for implementing large-scale reductions in the world's greenhouse gas emissions. Students from the Undergraduate Research Opportunities Program participated in a slam, presenting their research to MITEI Members and conference attendees. Three of the conference sessions were open to the MIT community. These sessions discussed how large established companies will lead the massive energy transformation and generational perspectives on the energy transition, as well as a keynote on enabling commercial liftoff for clean energy technologies presented by Jonah Wagner, chief strategist in the Loan Programs Office at the U.S. Department of Energy.

- **C3E 2023 Women in Clean Energy Symposium:** In September 2023, the twelfth annual Clean Energy, Education, and Empowerment (C3E) Women in Clean Energy Symposium and Awards was hosted by MITEI in collaboration with the U.S. Department of Energy (DOE), Texas A&M Energy Institute, and Stanford Energy. The conference featured award presentations, as well as diverse speakers—including the former White House national climate advisor and Environmental Protection Agency administrator Gina McCarthy, Janelle Knox-Hayes (Urban Studies and Planning), Amy Glasmeier (Urban Studies and Planning), and Elsa Olivetti (Materials Science and Engineering)—and rich conversations on pursuing sustainable clean energy goals. The U.S. C3E Initiative advances clean energy by closing the gender gap and increasing the participation, leadership, and success of women in clean energy fields.
- ***Energy Futures* magazine:** After 32 editions, MITEI published its final issue of *Energy Futures* magazine in Winter 2024 and pivoted to a digital-first editorial strategy. Since 2008, this magazine was published twice a year, featuring energy research and other energy activities at MIT. This work will continue on MITEI's website on an ongoing basis.
- **Audio articles:** MITEI produced and released a series of audio articles on the future of energy at MIT. Topics include new startups, novel energy research, event coverage, and alumni profiles.

Events

MITEI SEMINARS AND COLLOQUIA, AND MITEI-SPONSORED EVENTS, 2023-2024 ACADEMIC YEAR

September 14, 2023:	MITEI Annual Research Conference: "Decarbonization at Scale" Sessions open to the MIT community included: "How will large established companies lead the massive energy transformation?" "Generational priorities for energy transition" "Keynote address: Enabling commercial liftoff for clean energy technologies" Jonah Wagner, Chief Strategist, Loan Programs Office, U.S. Department of Energy
September 18, 2023:	Energy, Education, and Excellence: A symposium honoring Robert C. Armstrong co-hosted with MIT Department of Chemical Engineering
September 20, 2023:	MITEI Special Seminar: "Turnaround of Odisha Discoms in India: Public private partnership" Praveer Sinha, CEO and Managing Director, The Tata Power Company Limited

September 21, 2023: MITEI Special Seminar: "Tata power renewable microgrid: Transformation of rural India's power supply enabled by clean, affordable, reliable & green electricity from microgrids"
Praveer Sinha, CEO and Managing Director, The Tata Power Company Limited

September 22, 2023: MITEI Special Seminar: "Energy transition: Global and Indian perspective on renewable energy and supply chain challenges of minerals and metals"
Praveer Sinha, CEO and Managing Director, The Tata Power Company Limited

September 27-28, 2023: U.S. C3E Women in Clean Energy Symposium & Awards co-hosted with U.S. Department of Energy, Stanford University's Precourt Institute for Energy, and Texas A&M Energy Institute

October 23, 2023: MITEI Special Seminar: "Diverse decarbonization pathways under near cost-optimal futures"
Jeremiah Johnson, Associate Professor, North Carolina State University

November 1, 2023: MITEI Fall Colloquium: "Gearing up for winter: A European perspective on the energy trilemma"
Yuri Sebregts, Executive Vice President of Technology and Chief Technology Officer, Shell

November 2, 2023: U.S. C3E Women in Clean Energy webinar: "Building the energy-gender-climate nexus: The role of decentralized renewable energy access"

December 5, 2023: MITEI Special Seminar: "The role and value of interregional transmission in a decarbonized U.S. electricity system"
Patrick Brown, Former Postdoctoral Associate, MIT Energy Initiative; Researcher IV, National Renewable Energy Laboratory

January 18, 2024: U.S. C3E Women in Clean Energy webinar: "Four clean energy career journeys from 2023 C3E awardees"

March 11-12, 2024: MIT Energy Conference hosted by the MIT Energy and Climate Club

March 27, 2024: U.S. C3E Women in Clean Energy webinar: "Leveraging data and digitalization to make the grid more visible, resilient, and clean"

April 9, 2023: MITEI Spring Symposium: "Geologic hydrogen: Are orange and gold the new green?"

April 22, 2023: MITEI Earth Day Seminar: "Energizing the global transition"
Ani Dasgupta, President and CEO, World Resources Institute

July 11, 2024: U.S. C3E Women in Clean Energy webinar: "Advanced nuclear energy"

Governance

MITEI Leadership Team

During FY24, Interim Director Robert Stoner led MITEI's leadership team to build on the Initiative's strong foundation and multidisciplinary approach to deliver global energy solutions, broadening MITEI's membership base, bringing in new member companies, increasing opportunities for faculty research, strengthening operations, and playing a lead role in energy education and outreach at MIT. On April 1, 2024, William H. Green, the Hoyt C. Hottel Professor at MIT, began his tenure as MITEI Director.

William H. Green, Director
Leia Amarra, Manager of Financial Operations
Morgan Andreae, Executive Director, Future Energy Systems Center
Martha Broad, Executive Director
Antje Danielson, Director, Education
Randall Field, Director, Research
J.J. Laukaitis, Director, Member Services
Heather Leet, Development Officer
Sarah Peterson, Human Resources Manager
Tom Witkowski, Director, Communications

External Advisory Board

The MITEI External Advisory Board composed of industry, academic, nonprofit, and public sector leaders—chaired by Norman Augustine, retired chairman and CEO of Lockheed Martin—provides oversight to the Initiative. The views and guidance of the board assist MITEI in maximizing its impact in helping to meet the world's energy needs, reduce the environmental impacts of energy production and consumption, and inform public discourse on energy and the environment. The board meets each fall.

Energy Education Task Force

The Energy Education Task Force, composed of faculty members and students from all five of MIT's schools and one college, oversees the Initiative's Education program. Task Force members develop new directions and support activities in this realm at MIT.

MITEI Energy Council

The Energy Council helps shape MITEI's research, education, and outreach directions. The Council includes faculty from MIT's five schools and one college, in addition to MITEI executive leadership.

Steven R.H. Barrett, Department Head, Aeronautics and Astronautics; H. N. Slater Professor of Aeronautics and Astronautics
John Deutch, emeritus Institute Professor
Bradford Hager, Associate Director, Earth Resources Laboratory; Cecil and Ida Green Professor of Earth Sciences
Christopher Knittel, Associate Dean for Climate and Sustainability; George P. Shultz Professor of Energy Economics; Director, MIT Center for Energy and Environmental Policy Research
Caitlin Mueller, Associate Professor of Architecture; Associate Professor of Civil and Environmental Engineering
Elsa A. Olivetti, Jerry McAfee (1940) Professor in Engineering, MacVicar Faculty Fellow
Christoph Reinhart, Professor of Architecture; Director, Building Technology Program
Bettina Stoetzer, Associate Professor of Anthropology
Yogesh Surendranath, Donner Professor of Science; Professor of Chemistry
Catherine Wolfram, William Barton Rogers Professor in Energy
Jinhua Zhao, Professor of City and Transportation Planning; Director, JTL Urban Mobility Lab; Director, MIT Transit Lab

MITEI Members

MITEI's corporate member program facilitates collaborations between industry and MIT to research, develop, and accelerate low- and zero-carbon solutions for the energy transition. MITEI's member roster is reflective of MITEI's mission to work across the broad industrial spectrum of energy production, conversion, delivery, and usage. Along with financial support for research, analyses, and education, industry members contribute valuable perspectives and detailed knowledge of real-world conditions for practical scaling-up, deployment, and integration of decarbonization solutions.

MITEI draws on MIT's research capabilities, innovation, expertise, and experience to create successful industry collaborations to meet its research partners' key strategic objectives. A multi-tiered membership structure enables diverse private-sector partners to sponsor multidisciplinary "flagship" research programs with MIT faculty; contribute to energy-focused labs, programs, and centers at MIT; fund critical energy fellowships; support innovative energy concepts from proposals solicited across the campus; and participate in MITEI's seminars, lectures, and colloquia.

MEMBER HIGHLIGHTS

- Overall, during FY24, MITEI's net membership roster grew from 36 to 38 members. As evidence of our efforts to diversify across the energy spectrum, we welcomed several key new members, including Vale, Liberty Mutual, and Taiwan Power Company.
- One of the key activities for FY24 was renewing the memberships of MITEI's major members, including founding member Eni and sustaining members Chevron and Equinor. In addition, MITEI welcomed Petronas as a new sustaining member and Type One Energy as a new startup member.
- Building on MITEI's mission as a hub for education, we facilitated a student field trip to ExxonMobil's massive Baytown, TX, complex. Nineteen undergraduate and graduate students from across MIT toured this facility—one of the largest integrated petrochemical, ethylene, and advanced recycling plants in the world—and see their carbon capture pilot plant in operation. They received an in-depth presentation and discussion on ExxonMobil's plans for decarbonizing the complex via hydrogen power and carbon capture.
- Leveraging our power as a convener of multiple energy stakeholders, we dedicated one of our sessions during our Annual Research Conference to hearing from students about their concerns and priorities for the energy transition. The students were also invited to attend the other parts of our conference to observe MITEI's interaction with corporations and directly speak with industry on important—and sometimes controversial—energy transition topics.
- As members' research organizations recover from Covid-19-related disruptions, they are expanding their sponsored research portfolios and we anticipate continued growth.
- In collaboration with the EPOCH Foundation, MITEI launched Taiwan's Innovative Green Economy Roadmap (TIGER) Consortium in FY23. The program focuses on engaging Taiwan's industry leaders and MIT experts in developing a long-term robust roadmap for Taiwan in its transition to a green economy based on innovative low-carbon technologies. In FY24, two new members joined TIGER.

A list of members is available on the MITEI website.

Affiliated Groups

MITEI collaborates on research and education activities with faculty members from many MIT centers, departments, and laboratories pursuing interdisciplinary energy and environmental activities. In particular, researchers from both the Center for Energy and Environmental Policy Research and the Joint Program on the Science and Policy of Global Change are working with MITEI researchers to support the work of the Future Energy Systems Center.

Center for Energy and Environmental Policy Research

Established in 1977, the Center for Energy and Environmental Policy Research (CEEPR) promotes research on energy and environmental policy to support improved decision-making by government and industry. It is directed by Christopher Knittel (MIT Sloan) and jointly sponsored by MITEI, the Department of Economics, and the MIT Sloan School of Management.

CEEPR carries out rigorous and objective research for improved decision-making in government and the private sector, and closely cooperates with government and industry partners from around the globe. Affiliated faculty and research staff as well as external research affiliates contribute to the empirical study of a wide range of policy issues related to energy supply and demand and the environment. A legacy of excellence in energy economics, enhanced with interdisciplinary cooperation across MIT's schools and departments, informs pioneering research on pressing challenges in energy and environmental policy.

CEEPR produces working papers, policy briefs, and research input to larger, interdisciplinary studies, and hosts two annual research workshops at MIT. CEEPR has extensive previous and current international collaborations and has co-organized a series of international energy policy conferences, including partnerships with the Energy Policy Research Group at the University of Cambridge, UK, the Technical University of Denmark, and the Copenhagen Business School.

CEEPR houses the Roosevelt Project, a research initiative which takes a multidisciplinary approach to examining the transitional challenges associated with deep decarbonization of the U.S. economy. The project was initiated by former U.S. Secretary of Energy and Cecil and Ida Green Professor of Physics and Engineering Systems emeritus Ernest J. Moniz and engages a breadth of MIT and Harvard faculty and researchers across academic domains including economics, engineering, sociology, urban studies and planning, and political science. Phases One and Two are complete. Phase Three is currently underway and includes studies on long-distance electric transmission, strategic metals and minerals, and low-carbon steel in the United States.

CEEPR is also host to MIT Institute Innovation Fellow Brian Deese and his team. Over the past year they focused their efforts on launching the Clean Investment Monitor (CIM), which tracks public and private investments in climate technologies in the United States. Through this data and analysis, the CIM provides insights into investment trends, the effects of federal and state policies, and on-the-ground progress in the United States towards net-zero greenhouse gas emissions. It has already been cited multiple times in several high-profile media stories and used by the wider public in analyses and assessments of the Inflation Reduction Act.

Through the Climate Action Through Education (CATE) program, CEEPR has continued ongoing work to develop an interdisciplinary, solutions-focused climate curriculum for high schools. This has included: the second annual Climate Professional Development Workshop for 26 high school educators; J-WEL funding for a design-thinking x climate impacts project; welcoming 200+ educators and high school students to the second annual Climate Action and Education Conference; becoming a steering member of the Massachusetts Climate Resilient Schools Coalition and a member of the MIT Off-Campus Climate Education Working Group; and launching the free, 23-piece high school climate curriculum.

Joint Program on the Science and Policy of Global Change

Nations, regions, cities, and the public and private sectors face increasing pressures to confront critical challenges in future food, water, energy, climate, and other areas. Led by director Ronald G. Prinn (EAPS), the Joint Program's team of natural and social scientists produces comprehensive global and regional change projections under different environmental, economic, and policy scenarios. These projections enable decision makers to better assess impacts and the associated costs and benefits of potential courses of action.

In August 2024, the MIT School of Science launched a new center called the MIT Center for Sustainability Science and Strategy (CS3), incorporating and succeeding both the Joint Program on the Science and Policy of Global Change and the Center for Global Change Science. While adding new capabilities, CS3 aims to produce leading-edge research to help guide societal transitions toward a more sustainable future. Drawing on the long history of MIT's efforts to address global change and its integrated environmental and human dimensions, CS3 is well-positioned to lead burgeoning global efforts to advance the field of sustainability science, which seeks to understand nature-society systems in their full complexity.

STAY CONNECTED

Keep up with MITEI's latest research, news, and events:

To sign up for MITEI's weekly newsletter, visit: energy.mit.edu/subscribe

Events calendar: energy.mit.edu/events

"Future of" studies: energy.mit.edu/futureof

Latest MITEI publications: energy.mit.edu/publications

Podcast: energy.mit.edu/podcasts

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