



Impact Report 2022

welcome

Message from MCSC Leadership

The MIT Climate & Sustainability Consortium's second year was full of growth and activity to advance our mission of helping large companies usher in, adapt to, and prosper in a decarbonized world.

In 2022, the MCSC welcomed four new member companies that enabled the expansion of our work into new industries: BBVA, Liberty Mutual, Prologis, and Vontier. The collaborations and conversations that are happening between our members demonstrate the value of working together, across sectors, and at scale.

The consortium also welcomed several new Impact Fellows, with backgrounds in environmental policy and planning, physics, finance, and anthropology. The MCSC Impact Fellows are leading and coordinating the work with MIT faculty while also engaging external organizations and communities, to advance the consortium's work in its core focus areas. These focus areas, which are detailed within this report, resonate and apply across members' climate and sustainability goals.

Working closely with our colleagues at MIT and developing new internal networks have remained priorities. In March 2022, the MCSC co-hosted a multiday workshop with the MIT-IBM Watson AI Lab and MIT Schwarzman College of Computing, which explored the climate implications of computing and communications. The consortium also partnered with the new MIT Morningside Academy for Design (MAD) by funding three Design Fellows who are working on projects with a sustainability focus.

To strengthen engagement with MIT researchers and link the economy-wide work of the consortium to ongoing and emerging climate and sustainability efforts across MIT's campus, the MCSC launched its Seed Awards program in spring 2022. The MCSC awarded 20 projects a total of \$5 million over two years, with the winning projects led by principal investigators across all five of MIT's schools. On the student side, the MCSC continues to grow its undergraduate research program, launching a new Scholars Program for MIT undergraduate students to engage in research throughout the academic year while learning about climate and sustainability topics, building off our established and growing Undergraduate Research Opportunities Program (UROP).

In October 2022, the MCSC held its annual symposium to showcase the consortium's work as well as emerging topics of interest to those working in or passionate about the climate and sustainability industries. The year also featured several focused workshops and study groups, bringing together business and science on specific topics that relate to the MCSC's focus areas.

Please read more about our second year in our Impact Report. As we reflect on the past year, we are also excited for an increased emphasis on implementation and expanding our engagement to new sectors and stakeholders moving forward. Thank you for your support.

Anantha P. Chandrakasan | Chair

Jeffrey Grossman | Co-Director

Elsa Olivetti | Co-Director

Jeremy Gregory | Executive Director

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Our Work

The MCSC is creating new collaboration opportunities that amplify and extend MIT's current efforts, while empowering the industry to usher in, adapt to, and prosper in a decarbonized economy and world. We **strategize**: link stated company goals to value chains, enhance synergy, and find blind spots; **implement**: define, design, and pilot cross-industry technology, process, and organizational change; and **educate**: embed sustainability practice throughout workforce and university education.

Current Focus Areas

TOUGH TRANSPORTATION MODES

VALUE CHAIN RESILIENCE

CIRCULARITY

NATURE-BASED SOLUTIONS

CARBON CAPTURE & STORAGE

DATA & COMPUTING

SOCIAL DIMENSIONS

CLIMATE FINANCE



Read more about our focus areas starting on page 20.

MCSC Impact Fellows collaborate in the Consortium's office space in Kendall Square, Cambridge, Mass.



Member Companies

MCSC member companies recognize industry's profound responsibility for action on climate change and its unique ability to rapidly deploy and optimize solutions. Representing the heart of global capital, they have committed not only to working with MIT but with each other, to confront climate challenges with the urgency required to realize their goals — and to be part of solving this existential threat for society.

These industry leaders can both help inspire transformative change within their own sectors and demonstrate the value of working together, across sectors, at scale.

Industry Advisory Board Members

Read more about the Industry Advisory Board [here](#).

ACCENTURE

JAN-WILLEM JANNINK
Global Sustainable Value Chain Lead

PETER LACY
Chief Responsibility Officer and
Global Sustainability Services Lead

APPLE

SARAH CHANDLER
Vice President of Environment and
Supply Chain Innovation

ALISHA JOHNSON WILDER
Director, Environment, Policy & Social Initiatives/
Racial Equity & Justice Initiative

BBVA

JAVIER RODRÍGUEZ SOLER
Global Head of Sustainability

BIOGEN

JOHANNA JOBIN
Global Head, Corporate Reputation
& Responsibility

BOEING

CHRIS RAYMOND
Chief Sustainability Officer

ELLEN EBNER

Director, Sustainability & Future Mobility

CARGILL

GREG DOWNING
Director of Sustainability

DOW

A.N. SREERAM
Senior Vice President and
Chief Technology Officer

HOLCIM

MAGALI ANDERSON
Chief Sustainability and Innovation Officer

NOLLAIG FORREST
Global Head of Communications

IBM

SOLOMON ASSEFA
Vice President at IBM Research

INDITEX

JAVIER LOSADA
Chief Sustainability Officer

LUIS COLOMA YEPES
Head of Infrastructure and Sustainability

PEPSICO, INC.

JIM ANDREW
Chief Sustainability Officer

PROLOGIS, INC.

SUSAN UTHAYAKUMAR
Chief Sustainability and Energy Officer

RAND-WHITNEY CONTAINERBOARD (RWCB), A KRAFT GROUP COMPANY

ROBYN GLASER
Senior Vice President of Business Affairs

TONY HOBSON
Senior Vice President of Strategic Planning
and Kraft Operations

LIBERTY MUTUAL INSURANCE

FRANCIS HYATT
Executive Vice President and
Chief Sustainability Officer

MATHWORKS

AKSHAY RAJHANS
Principle Research Scientist, Founding Member,
Advanced Research & Technology Office

NEXPLORE

DAVID KOCH
Chief Risk, Organization and Innovation Officer,
HOCHTIEF; CEO, Nexlore

VERIZON

JAMES GOWEN
Senior Vice President, Global Supply Chain
& Chief Sustainability Officer

ABEL LEITES
Vice President, Verizon Global Supply Chain

VONTIER

NATE STREED
Senior Global Director of Sustainability & ESG

KATIE ROWEN
Senior Vice President, Chief Legal and
Administrative Officer

18
MEMBER
COMPANIES

26
INDUSTRY ADVISORY
BOARD MEMBERS

100+
PARTICIPANTS ON TECHNICAL TEAMS

People

MCSC Leadership



ANANTHA P. CHANDRAKASAN
Chair
Dean, MIT School of Engineering
Vannevar Bush Professor of Electrical Engineering
and Computer Science



ELSA OLIVETTI
Co-Director
Esther and Harold E. Edgerton Professor
Materials Science and Engineering



JEFFREY GROSSMAN
Co-Director
Department Head, Materials Science and Engineering;
Morton and Claire Goulder and Family Professor in
Environmental Systems



JEREMY GREGORY
Executive Director

MCSC Administrative Staff



ELISE CHAMBERS
Program Manager,
Student, Postdoctoral,
and MIT Engagement



MOLLY CHASE
Communications Officer



JAY LAMOUR
Program Coordinator



MELISSA ZGOLA
Program Manager,
Member Engagement

MCSC Faculty Steering Committee

An interdisciplinary group of MIT faculty, working collaboratively with the MCSC to share their perspectives and help shape a common vision. Read more about the Faculty Steering Committee [here](#).



STEVEN BARRETT
Professor, Aeronautics and Astronautics
School of Engineering



HEATHER J. KULIK
Associate Professor,
Chemical Engineering
School of Engineering



ROBERTO RIGOBON
Society of Sloan Fellows Professor
Professor, Applied Economics
Sloan School of Management



MEGAN A. BLACK
Associate Professor of History
School of Humanities,
Arts, and Social Sciences



CHAKANETSA MAVHUNGA
Associate Professor, Science,
Technology, and Society
School of Humanities, Arts,
and Social Sciences



MARIA YANG
Associate Dean
Gail E. Kendall (1978) Professor,
Mechanical Engineering
School of Engineering



STEFANIE JEGELKA
Associate Professor, Electrical
Engineering & Computer Science
School of Engineering



DAVID MCGEE
Associate Professor,
Earth, Atmospheric and
Planetary Sciences
School of Science



SIQI ZHENG
Samuel Tak Lee Champion Professor
Professor, Urban and Real Estate
Sustainability
School of Architecture and Planning



JEREMIAH JOHNSON
Professor, Chemistry
School of Science



DAVID PERREAULT
Joseph F. and Nancy P. Keithley Professor
in Electrical Engineering
School of Engineering



YANCHONG (KAREN) ZHENG
George Maverick Bunker
Professor of Management
Associate Professor, Operations Management
Sloan School of Management



DAVID HSU
Associate Professor,
Urban and Environmental Planning
School of Architecture and Planning



DESIREE PLATA
Gilbert W. Winslow Career Development
Professor in Civil Engineering
Associate Professor, Civil and
Environmental Engineering
School of Engineering

MCSC Impact Fellows

This program is a postdoctoral opportunity for individuals who want to transcend academia and industry to apply their expertise to near-term change for a more sustainable future. Impact Fellows work with MIT researchers and consortium industry members—in collaboration with external organizations and communities—to implement solutions needed for global economic transformation to address the global climate change and sustainability crisis. Read more about the MCSC Impact Fellows [here](#).



JUNGWOO CHUN



EVAN COLEMAN



PALOMA GONZALEZ-ROJAS



GLEN JUNOR



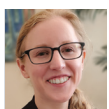
DANIKA MACDONELL



POUSHALI MAJI



LAURA FRYE-LEVINE



SYDNEY SROKA



ANEIL TRIPATHY

MCSC Student Council

MEMBERS FOR THE 2022-2023 ACADEMIC YEAR

TESS BUCHANAN
School of Engineering

ALAYNA JOHNSON
School of Science

LAUREN SHRACK
School of Engineering

ANUSHREE CHAUDHURY
School of Architecture and Planning/
School of Humanities, Arts, and
Social Sciences

AMENA KHATUN
School of Engineering

DUHA SYAR
School of Engineering

YEJI CHO
School of Engineering

QINGYANG (ANNE) LIU
Schwarzman College of Computing

PAIGE YEUNG
School of Science

PAUL IRVINE
School of Engineering/School of
Humanities, Arts, and Social Sciences

SANDHYA MAHADEVAN
Sloan School of Management

DHWANI MEHTA
School of Architecture and Planning

MCSC Climate & Sustainability Scholars

LOUISE ANDERFAAS
School of Engineering

EINAT GAVISH
School of Science/School of
Engineering

REBECCA LIZARDE
School of Engineering

ANUSHREE CHAUDHURI
School of Architecture and Planning/
School of Humanities, Arts, and
Social Sciences

M. GEOGDZHAYEVA
School of Science

HELENA MCDONALD
School of Science

JADE CHONGSATHAPORNPONG
School of Science

GRACE HARRINGTON
School of Engineering

DELIGHT NWENKA
School of Engineering

AMELIA DOGAN
School of Architecture and Planning/
School of Engineering

AVIVA INTVELD
School of Science

TRINITY STALLINS
School of Architecture and Planning

DAHLIA DRY
School of Science/School of Engi-
neering

PAUL IRVINE
School of Engineering/School of
Humanities, Arts, and Social Sciences

MELISSA STOK
School of Engineering

PAMELA DUKE
Sloan School of Management

CLAIRE KIM
School of Engineering

DUHA SYAR
School of Engineering

SHIVANI KONDURU
School of Engineering/School of
Humanities, Arts, and Social Sciences

The MCSC welcomed new Impact Fellows with backgrounds in environmental policy & planning, physics, finance, and anthropology. Welcome Jungwoo Chun, Evan Coleman, Danika MacDonell, and Aneil Tripathy!



“The greatest thing about being part of the MCSC has been the collaboration with other companies, and really thinking about how can we solve the problem together as an ecosystem.”

Susan Uthayakumar

Chief Sustainability and Energy Officer, Prologis, Inc.
MCSC Industry Advisory Board Member



“Having the support from all these companies and people that have the engagement and the expertise to help you guide the way is extremely valuable.”

Beatriz Roa Tejero

Sustainable Solutions Director, BBVA



“It’s really interesting to see what’s happening here at MIT, which is typically a few years ahead of what we see in the corporate world and what we see that our clients are asking for.”

Jan-Willem Jannink

Global Sustainable Value Chain Lead, Accenture
MCSC Industry Advisory Board Member

“The MCSC creates a tremendous amount of value for us in that it brings together a diverse group of stakeholders, including other industry partners and the academic community, to challenge the way that we think about problems and bring fresh and different perspectives.”

Susannah Calvin

Senior Manager, Environment & Supply Chain Innovation, Apple



Strategize

Member Meetings Connect Work Across Focus Areas

In October 2022, MCSC members met with MIT researchers for a series of workshops and conversations led by MCSC Impact Fellows on topics linking work across focus areas and cross-cutting themes. These brief synopses highlight the key themes of each session.

Cross-Industry Perspective on Circularity Challenges

This session focused on a collection of written perspectives on circularity challenges, developed by participating MCSC member companies, with the aim to produce and circulate a publishable cross-industry piece in 2023. One discussion point that emerged from the conversation included the realization that an accelerated transition to a circular economy needs a systemic shift and consideration of multidimensional impact. Other key points centered on the importance of creating opportunities to educate governing bodies, providing a voice to business coalitions, and setting examples for how policy could be designed to enable productive circularity and incentive alignment.

FOCUS AREAS

- Circularity

Biomass Feedstock Allocation and Tipping Points

This session provided an opportunity to articulate and reconcile assumptions around biomass use and availability, in light of demand for low-carbon biomass feedstocks increasing. Industry participants contributed to coupling strategies and practices along the supply chain toward finding opportunities for cross-sector synergies, aligning with the notion that biomass as a resource is best used through cross-sector coordination. Greater transparency of the current biomass system, as well as increased measurement and data collection, will be needed to ensure that supply is established in a way that minimizes carbon emissions and supports biodiversity.

FOCUS AREAS

- Circularity
- Tough transportation modes

Reuse of Structural Components in the Built Environment

In this session, MIT Professor Caitilin Mueller's research team demonstrated their structural concrete design innovation, PixelFrame. PixelFrame uses discretized reusable concrete elements designed for material efficiency and adaptability, holding potential solutions to the high carbon-intensity and recycling challenges of conventional concrete structures. The optimized PixelFrame design is estimated to result in a 60% reduction in carbon footprint, relative to a conventional structural element. To emphasize the themes of circularity, reuse, and modularity within a collaborative framework, participants worked together to build multiple structures using provided parts, reinforcing the idea that future buildings can be produced using existing materials.

FOCUS AREAS

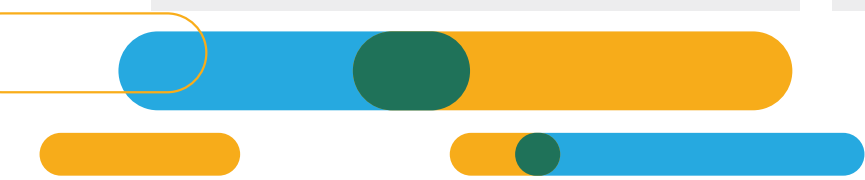
- Circularity

Soil Carbon Measurement Methodology

This session focused on ways MCSC efforts can enhance data and methodology capability toward improved assessment of soil carbon removal potentials and support clear and sensible standards to apply against member assets, including carbon accrual monitoring and measuring based on interventions and investments. With similar scales of science and technology requirements, MCSC member companies have significant opportunities to collaborate in this sphere and collectively identify interventions with permanent and quantifiable impact.

FOCUS AREAS

- Nature-based solutions
- Data & computing





A.N. Sreeram, Senior Vice President and Chief Technology Officer for Dow, collaborates with the MIT community, MCSC Symposium 2022.

Integrated Map of Infrastructure, Energy Mix, and CO₂ Emissions

This session introduced the latest iteration of a mapping prototype developed to support business decisions related to decarbonization and resilience. The interactive tool allows users to filter and visualize collective datasets compiled from over 30 public sources, more comprehensively addressing cross-sectoral needs than existing mapping tools. Participants provided feedback on questions of specific interest to MCSC member companies, which will be addressed in an updated version.

FOCUS AREAS

- Carbon capture & storage
- Value chain resilience
- Data & computing

Electrification and Cross-sector Coupling of Transportation

This session addressed cross-sector knowledge gaps in accelerating decarbonization of tough-to-decarbonize transportation, highlighting industry concerns in fleet and fuel choice. The conversation was structured around the electrification of long-haul trucking, and focused on activities that would support electrification and cross-sector coupling of transportation. The discussion included a range of topics and ideas for cross-industry collaboration across multiple stakeholders from customers to manufacturers.

FOCUS AREAS

- Tough transportation modes

Data and Machine Learning Challenges in Climate and Sustainability

This session surveyed key challenges related to climate change and sustainability, and presented opportunities where machine learning can be leveraged to fill data gaps and accelerate solutions. A subset of these opportunities was highlighted through lightning talks by domain experts, which framed a brainstorming session in which participants identified further opportunities for research and collaboration on data-driven sustainability problems. Examples include: eco-diversity near cities, robust dynamic optimization for renewable energy integration, contrail mapping including atmospheric dynamics, and design of sustainable concrete.

FOCUS AREAS

- Data & computing
- Nature-based solutions
- Value chain resilience
- Tough transportation modes
- Circularity

Creating Value in Social Dimensions of Sustainable Solutions

This session explored how systemic innovation for sustainability requires pioneering beyond the technical to involve environmental, social, and governance (ESG) frameworks that account for human well-being, diverse contexts and goals, and intersections across metrics. The workshop explored the complexities of what and who is considered in measuring sustainability, and participants discussed metrics of social impact that will allow for benchmarking and designing equitable value chains. A more holistic understanding of supply chains, which involves understanding climate forecasting in conjunction with value streams, is needed to create corporate investment pathways that equitably dialogue with communities.

FOCUS AREAS

- Social dimensions
- Data

Strategize

Sparking Cross-industry and Interdisciplinary Collaborations to Drive Innovations in Climate Change

At the MCSC's second annual symposium in October 2022, over 100 community members and industry representatives explored emerging topics of interest in the climate and sustainability spheres, culminating in a poster session with more than 50 posters on the MCSC focus areas, newly launched seed projects, and student projects.



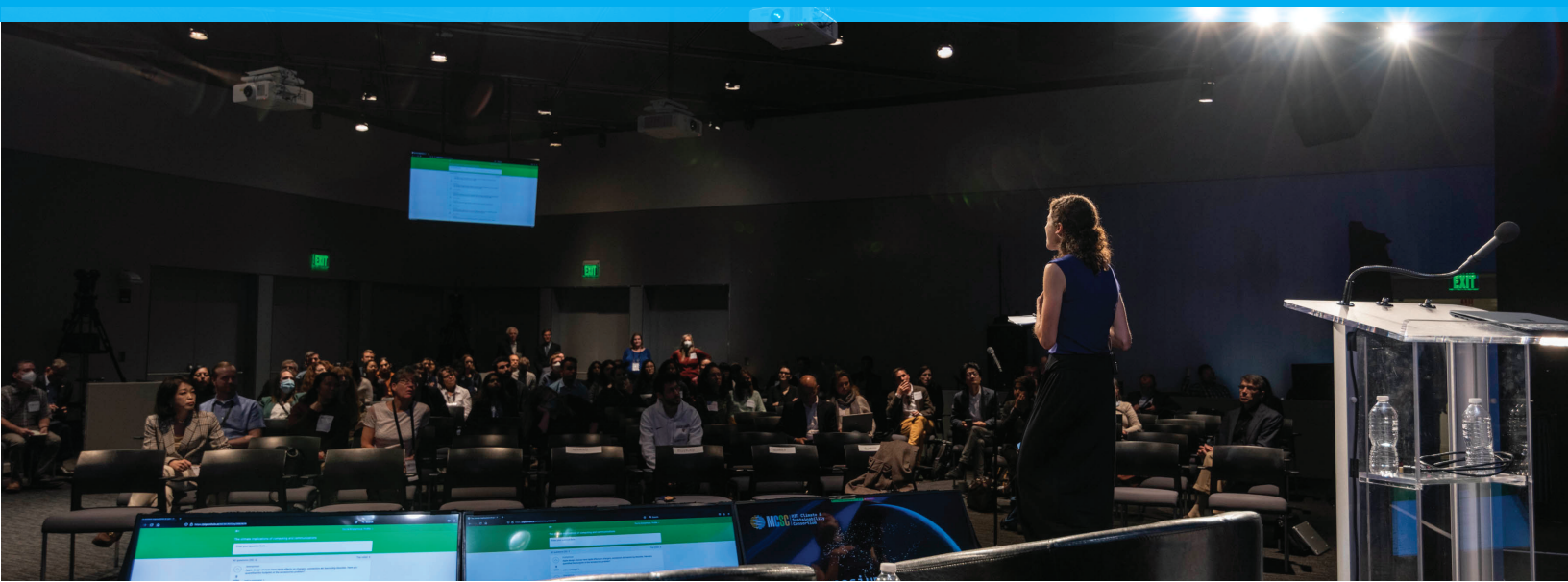
The computing and communications session addressed next steps and available opportunities for the types of cross-cutting work and collaboration needed to tackle current and emerging climate problems, with moderator **Elsa Olivetti** (left) and panelists representing MIT and major industry partners (from left to right of Olivetti): **Susannah Calvin**, Senior Manager, Environment & Supply Chain Innovation at Apple; **Carole-Jean Wu**, Research Scientist and Technical Lead Manager at Meta AI; and **Jesús del Alamo**, Donner Professor of Science, Department of Electrical Engineering and Computer Science, MIT.

Delving into the MCSC's newest crosscutting theme of climate finance, panelists representing a range of financial interests discussed ways in which finance can accelerate the adoption of climate solutions. Panelists included moderator **Jason Jay** (left) and (from left to right of Jay): **Elizabeth Teague**, Director of the Climate Resilience Initiative at Root Capital; **Heike Reichelt**, Head of Investor Relations and Sustainable Finance at World Bank; **Beatriz Roa Tejero**, Sustainable Solutions Director at BBVA; and **Susie Boshoff**, Sustainability Director of ESG Reporting at PepsiCo.



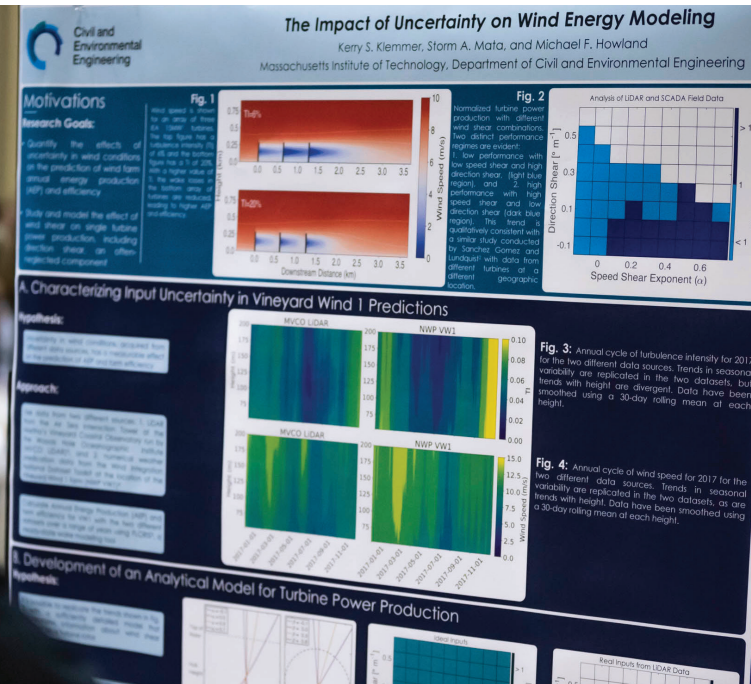
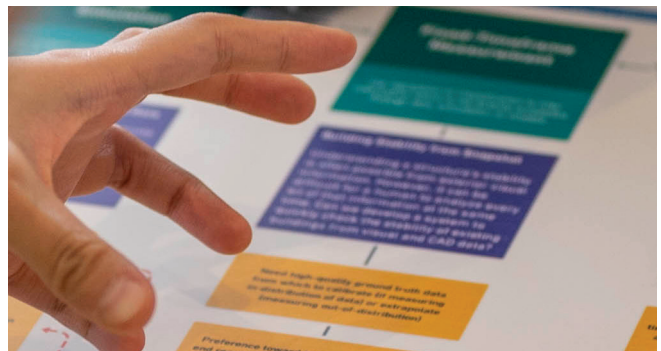
The session on entrepreneurship delivered a unique take on pitch competitions, with a panel of mixed experts representing primary stakeholder groups responding to pitches by three startups that align with MCSC's focus areas. Panelists were (from left to right): **Christopher A. Schuh**, POSCO Professor of Materials Science and Engineering at MIT; **Jan-Willem Jannink**, Global Responsible Value Chain Lead at Accenture; **Maureen Stancik Boyce**, Managing Partner at Good Growth Capital; and **Matthew M. Nordan**, General Partner at Azolla Ventures.





Leaders from across MIT's various climate and sustainability initiatives addressed symposium attendees, including Associate Provost **Richard Lester** (pictured left), Co-Leader of the Climate Grand Challenges; **Rob Stoner**, Deputy Director of the MIT Energy Initiative; **Desiree Plata**, representing the MIT Environmental Solutions Initiative; **Jason Jay**, Director of the Sloan Sustainability Initiative; and **Jinhua Zhao**, Founder and Faculty Director of the MIT Mobility Initiative. The MCSC is excited to be working closely with these entities and what they aim to achieve.

An emergent theme through the range of panels is that the best – or only – way for various sectors to reach sustainability goals is to leverage the strengths of each and work together. The 2022 symposium demonstrated how the MCSC continues to connect individuals and entities across industry and academia, creating opportunities to collaborate for lasting impact.



PHOTOS BY CHRISTOPHER HARTING

Strategize

Study Groups and Workshops

Focused “Study Groups” Enhance Specificity

The MCSC launched focused “study groups” that bring together member companies and MIT experts to explore a specific facet or opportunity. Study groups in 2022 included Phase Change CO₂ Capture, a lecture and collaborative discussion led by Glen Junor (MCSC Impact Fellow), and Establishing CO₂ as an Asset Class in Voluntary Carbon Markets, a panel discussion led by Sydney Sroka (MCSC Impact Fellow). Panelists included Beatriz Roa Tejero (BBVA), Janelle Knox-Hayes (MIT), and Roberto Rigobon (MIT).

Reducing the Carbon Footprint of Global Computing

A workshop hosted by the MCSC, MIT-IBM Watson AI Lab, and the MIT Schwarzman College of Computing highlighted how new approaches to computing can save energy and help the planet. The virtual event featured rich discussions and highlighted opportunities for collaboration among an interdisciplinary group of MIT faculty and researchers and industry leaders across multiple sectors — underscoring the power of academia and industry coming together. The workshop presentations explored a host of energy-efficiency options, including specialized chip design, data center architecture, better algorithms, hardware modifications, and changes in consumer behavior. Panel topics ranged from “Custom hardware for efficient computing” to “Hardware for new architectures” to “Algorithms for efficient computing,” among others. Leading up to this event, the MCSC hosted two other computing-related workshops: AI to Support Climate Mitigation & Adaptation and Carbon footprinting in ICT.

“If we continue with the existing trajectory of compute energy, by 2040, we are supposed to hit the world’s energy production capacity. The increase in compute energy and demand has been increasing at a much faster rate than the world energy production capacity increase.”

Bilge Yildiz, the Breene M. Kerr Professor in the MIT Departments of Nuclear Science and Engineering and Materials Science and Engineering

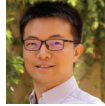
Thank you MIT faculty speakers who participated in the Climate Implications of Computing & Communications workshop!



JESÚS DEL ALAMO



JOEL EMER



SONG HAN



MURIEL MEDARD



DAVID PERREAULT

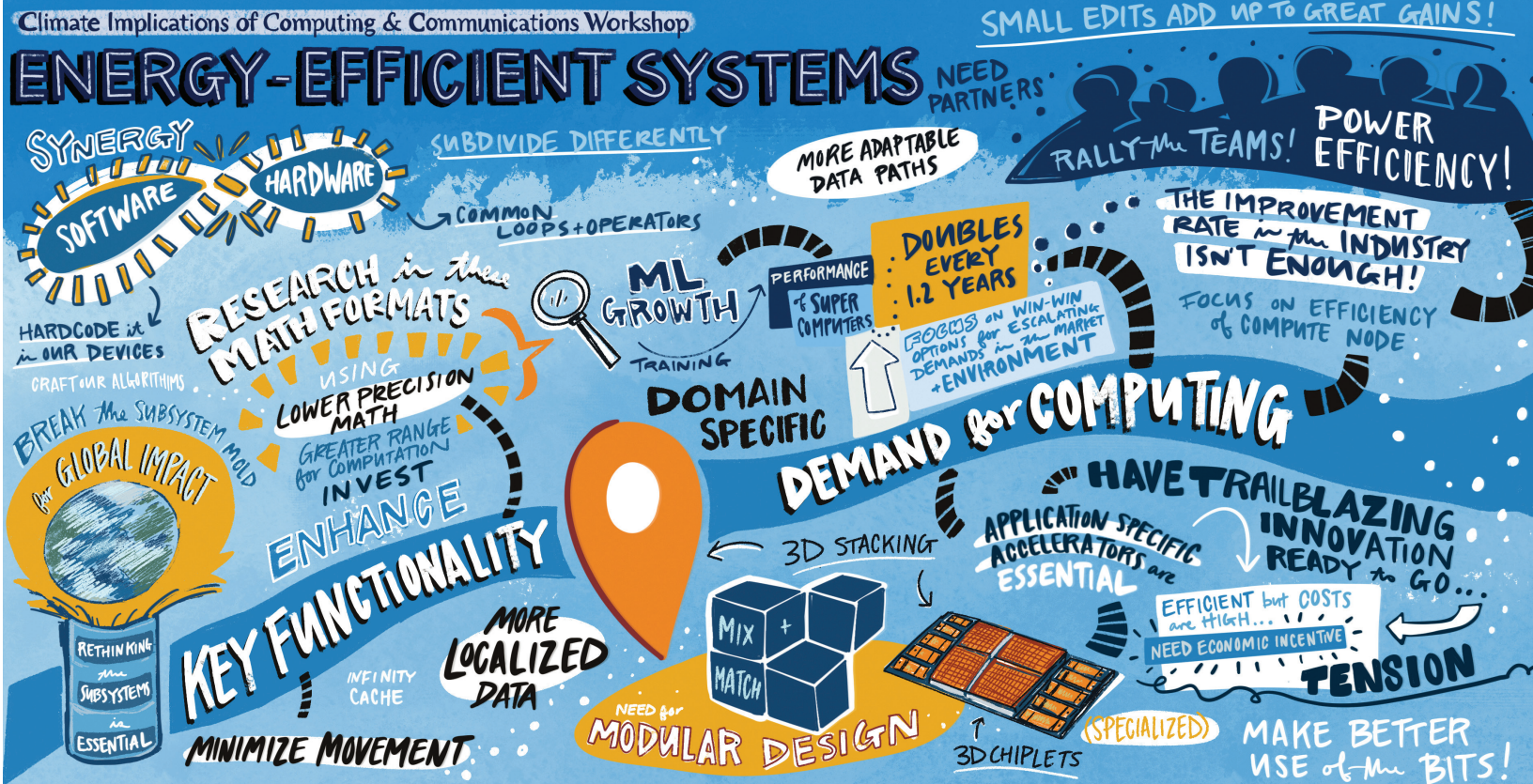


VIVIENNE SZE



BILGE YILDIZ

SMALL EDITS ADD UP TO GREAT GAINS!



Implementation

MCSC Seed Awards Link Member Priorities with MIT Researchers to Develop Scalable Climate Solutions

In May 2022, the MCSC awarded 20 projects more than \$5 million over two years in its first-ever MCSC Seed Awards program. The winning projects are led by principal investigators across all five of MIT's schools.

The goal of the MCSC Seed Awards is to engage MIT researchers and link the economy-wide work of the consortium to ongoing and emerging climate and sustainability efforts across campus. The program offers further opportunity to build networks among the awarded projects to deepen the impact of each and ensure the total is greater than the sum of its parts.

For example, to drive progress under the awards category Circularity and Materials, the MCSC can facilitate connections between the technologists at MIT who are developing recovery approaches for metals, plastics, and fiber; the social scientists who are uncovering barriers to reuse; and the engineers, who will look for efficiency opportunities in reverse supply chains.

PROJECT TITLES AND RESEARCH LEADS ARE LISTED BELOW, CATEGORIZED BY MCSC FOCUS AREA.

DECARBONIZED AND RESILIENT VALUE CHAINS

“Collaborative community mapping toolkit for resilience planning,” led by Miho Mazereeuw, associate professor of architecture and urbanism in the Department of Architecture, and Nicholas de Monchaux, professor and department head in the Department of Architecture

“CP4All: Fast and local climate projections with scientific machine learning — towards accessibility for all of humanity,” led by Chris Hill, principal research scientist in the Department of Earth, Atmospheric and Planetary Sciences, and Dava Newman, director of the MIT Media Lab and the Apollo Program Professor in the Department of Aeronautics and Astronautics

“Emissions reductions and productivity in U.S. manufacturing,” led by Mert Demirer, assistant professor of applied economics at the MIT Sloan School of Management, and Jing Li, assistant professor in the MIT Sloan School of Management

“Logistics electrification through scalable and inter-operable charging infrastructure: operations, planning, and policy,” led by Alex Jacquilat, the 1942 Career Development Professor and assistant professor of operations research and statistics in the MIT Sloan School of Management

“Powertrain and system design for LOHC-powered long-haul trucking,” led by William Green, the Hoyt Hottel Professor in Chemical Engineering in the Department of Chemical Engineering, and Wai K. Cheng, professor in the Department of Mechanical Engineering

“Sustainable Separation and Purification of Biochemicals and Biofuels using Membranes,” led by John Lienhard, the Abdul Latif Jameel Professor of Water in the Department of Mechanical Engineering, and Nicolas Hadjiconstantinou, professor in the Department of Mechanical Engineering

“Toolkit for assessing the vulnerability of industry infrastructure siting to climate change,” led by Michael Howland, assistant professor in the Department of Civil and Environmental Engineering

[→ Read the MIT News story](#)

CIRCULARITY AND MATERIALS

“Colorimetric Sulfidation for Aluminum Recycling,” led by Antoine Allanore, associate professor of metallurgy in the Department of Materials Science and Engineering

“Double Loop Circularity in Materials Design Demonstrated on Polyurethanes,” led by Brad Olsen, the Alexander and I. Michael Kasser (1960) Professor in the Department of Chemical Engineering, and Kristala Prather, the Arthur Dehon Little Professor in the Department of Chemical Engineering

“Engineering of a microbial consortium to degrade and valorize plastic waste,” led by Otto Cordero, associate professor in the Department of Civil and Environmental Engineering, and Desiree Plata, the Gilbert W. Winslow (1937) Career Development Professor in Civil Engineering and associate professor in the Department of Civil and Environmental Engineering

“Fruit-peel-inspired, biodegradable packaging platform with multifunctional barrier properties,” led by Kripa Varanasi, professor in the Department of Mechanical Engineering

100+

PARTICIPANTS FROM
BOTH MIT AND
INDUSTRY, AT SEED
AWARD PROJECT
MEETINGS

20

AWARDS OF
UP TO \$250K
OVER TWO
YEARS

\$5.4

MILLION
TOTAL
AWARDED

PIs FROM

5

MIT SCHOOLS

“High Throughput Screening of Sustainable Polyesters for Fibers,” led by Gregory Rutledge, the Lamot du Pont Professor in the Department of Chemical Engineering, and Brad Olsen, Alexander and I. Michael Kasser (1960) Professor in the Department of Chemical Engineering

“Short-term and long-term efficiency gains in reverse supply chains,” led by Yossi Sheffi, the Elisha Gray II Professor of Engineering Systems and professor in the Department of Civil and Environmental Engineering

“The costs and benefits of circularity in building construction,” led by Siqi Zheng, the STL Champion Professor of Urban and Real Estate Sustainability at the MIT Center for Real Estate and Department of Urban Studies and Planning, and Randolph Kirchain, principal research scientist and co-director of MIT Concrete Sustainability Hub

NATURE-BASED SOLUTIONS

“Carbon sequestration through sustainable practices by smallholder farmers,” led by Joann de Zegher, the Maurice F. Strong Career Development Professor and assistant professor of operations management in the MIT Sloan School of Management, and Karen Zheng, the George M. Bunker Professor and associate professor of operations management in the MIT Sloan School of Management

“Coatings to protect and enhance diverse microbes for improved soil health and crop yields,” led by Ariel Furst, the Raymond A. (1921) and Helen E. St. Laurent Career Development Professor of Chemical Engineering in the Department of Chemical Engineering, and Mary Gehring, associate professor of biology in the Department of Biology

“ECO-LENS: Mainstreaming biodiversity data through AI,” led by John Fernández, professor of building technology in the Department of Architecture

“Growing season length, productivity, and carbon balance of global ecosystems under climate change,” led by Charles Harvey, professor in the Department of Civil and Environmental Engineering, and César Terrer, assistant professor in the Department of Civil and Environmental Engineering

SOCIAL DIMENSIONS AND ADAPTATION

“Anthro-engineering decarbonization at the million-person scale,” led by Manduhai Buyandelger, professor in the Anthropology Section, and Michael Short, the Class of '42 Associate Professor of Nuclear Science and Engineering in the Department of Nuclear Science and Engineering

“Sustainable solutions for climate change adaptation: weaving traditional ecological knowledge and STEAM,” led by Janelle Knox-Hayes, the Lister Brothers Associate Professor of Economic Geography and Planning, and Miho Mazereeuw, associate professor of architecture and urbanism in the Department of Architecture (a research lead on a Climate Grand Challenges flagship project)

“The MCSC Seed Awards are designed to complement actions previously outlined in Fast Forward: MIT’s Climate Action Plan for the Decade and, more specifically, the Climate Grand Challenges. In collaboration with seed award recipients and MCSC industry members, we are eager to engage in interdisciplinary exploration and propel urgent advancements in climate and sustainability.”

Anantha P. Chandrakasan,
Dean of the MIT School of Engineering,
Vannevar Bush Professor of Electrical
Engineering and Computer Science, and
chair of the MIT Climate and Sustainability
Consortium

The MCSC's Innovation Ecosystem

Fundamental to the MCSC's innovation and progress is a community of experts from across a range of diverse departments, labs, and centers at MIT and our member companies, which span across industries. Our focus areas provide direction, but are linked by cross-cutting themes that provide potential points of acceleration as well as important nuance and clarity to our work.





CARBON CAPTURE & STORAGE

Engineering: Chemical, Material
Science, Mechanical
MIT Energy Initiative

Cargill
Dow
Holcim
IBM



NATURE-BASED SOLUTIONS

Architecture
Biology
Engineering: Chemical,
Civil and Environmental,
Climate Grand Challenges
Environmental Solutions Initiative
Management
Science, Technology and Society

Accenture
Apple
BBVA
Cargill
Dow
Holcim
IBM
Inditex
MathWorks
Nexplora
PepsiCo
Rand-Whitney
Verizon

Accenture
Apple
BBVA
Boeing
Cargill
Dow
Holcim
IBM

Inditex
MathWorks
Nexplora
PepsiCo
Prilogis
Rand-Whitney
Verizon
Vontier



CIRCULARITY

Architecture
Chemistry
Concrete Sustainability Hub
Engineering: Chemical, Civil and Environmental,
Material Science, Mechanical
Materials Research Laboratory
Urban Studies and Planning

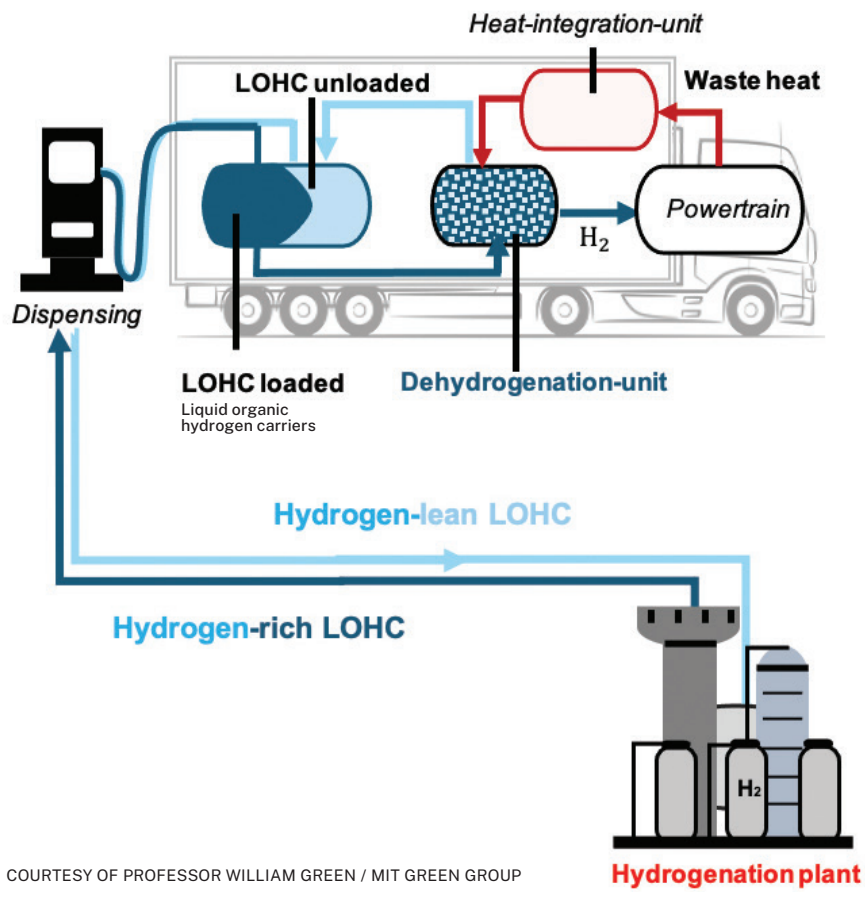


Implement:



TOUGH TRANSPORTATION MODES

Transportation of goods forms the basis of today's globally distributed supply chains. However, maritime shipping, air transportation, and heavy-duty trucking together emit between 2 and 4 billion metric tons (Gt) of CO₂ today. These modes of transportation are inherently tough to decarbonize and may have local emissions that impact communities. Without significant action, these emissions have the potential to quadruple by 2050, potentially making this sector one of the largest emitters of greenhouse gases. One approach to decarbonize this sector is through the use of bioenergy, a nature-based method of sequestering carbon.



COURTESY OF PROFESSOR WILLIAM GREEN / MIT GREEN GROUP

SELECTED HIGHLIGHTS

An analysis of biomass availability catalyzed through discussions with Dow, Boeing, and Cargill found that while overall primary bioenergy potential ranges from 55-300 Exajoules per year by 2050, residue bioenergy is restricted to <56 EJ/yr in 2050.

The MCSC team pursued further discussions with member companies around the availability of agriculture residues for bioenergy, where uncertainties in estimates are driven by unknowns in crop and residue production, alternative uses, and sustainable and economic collection rates.

Collaborations with MCSC researchers, PepsiCo, Vontier, and Holcim examined the economic feasibility of electrified long-haul trucking to show that for many scenarios electrification is approaching cost parity relative to conventional diesel combustion engines. Member companies such as Apple and Vontier are working to expand this analysis.

MCSC LEADS

- DANIKA MACDONELL
MCSC Impact Fellow
- KATIE DAEHN
Postdoctoral Researcher
- FLORIAN ALLROGGEN
Research Scientist

→ How can infrastructure, fuels, and powertrains be transformed now and in the coming decades to decarbonize tough transportation modes? What conditions are needed to enable widespread adoption of low-carbon solutions by fleet owners and operators?

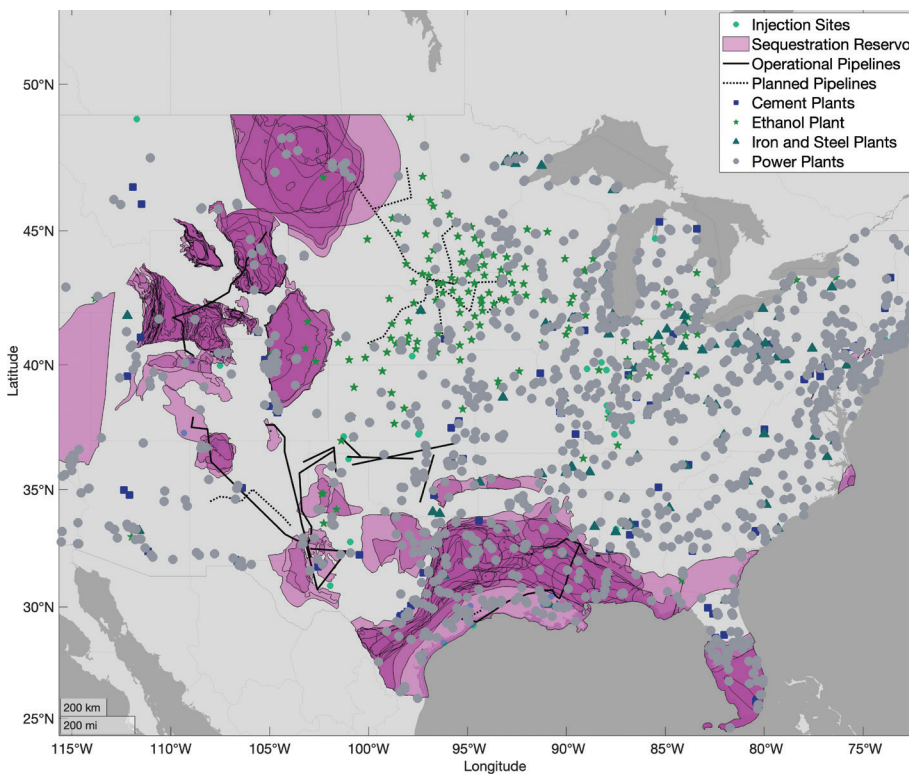


Focus Areas



VALUE CHAIN RESILIENCE

The objective of the Value Chain Resilience focus area is to accelerate the rate at which climate risk and resilience planning becomes sufficiently widespread to meet this need by addressing technical challenges that inhibit progress toward this goal. The MCSC is addressing three main challenges: how to improve projections of environmental risk levels, how to improve the estimate of the impact a given natural hazard would have on the value chain with and without adaptation, and how to design and evaluate adaptation strategies against each other.



SELECTED HIGHLIGHTS

Collaborations among MCSC member companies, including Cargill, Dow, and Holcim, launched the development of a geospatial mapping tool for carbon capture infrastructure scenario analysis. The discussions that led to the tool centered on decarbonizing value chains via point source carbon capture and identified a common data gap that could be bridged by integrating data on CO₂ sources, pipelines, and sinks.

Working with the MCSC, Accenture, IBM, and Liberty Mutual collaboratively extended the geospatial mapping tool's ability to support broader value chain resilience decisions. MathWorks suggested using MATLAB's App Designer and Mapping Toolbox to make it interactive and provided technical support at key milestones in meetings with other MCSC member companies.

Through the October 2022 annual symposium and other workshops, 10 MCSC member companies have used the tool, provided feedback on how it could support value chain decarbonization and resilience decision-making, and identified how remaining data gaps could be collaboratively bridged.

MCSC LEAD

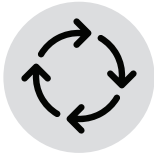
• SYDNEY SROKA
MCSC Impact Fellow



What are the barriers inhibiting decarbonization and resilience planning and how can we use data to help address them in a comprehensive way?

Crossovers



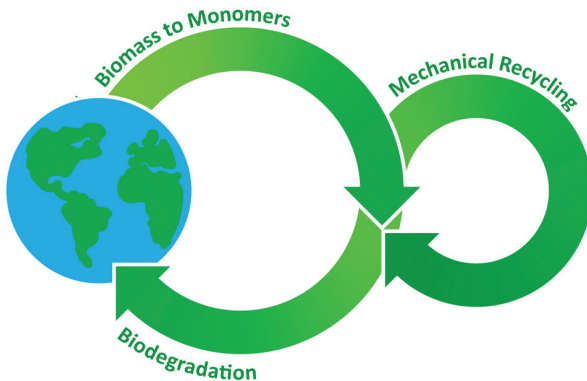


CIRCULARITY

Circularity strategies aim to reduce the material footprint of products through material recovery and efficient material use. Materials and products that go unrecovered represent missed opportunities in deriving more value from supply chains by transforming design, manufacturing, and post-consumer materials management processes. Linking circularity strategies to social, economic, and environmental analysis is crucial to estimating the benefits of resource recovery and reuse strategies, and informing which strategies to invest in to meet sustainability goals. The objective of the Circularity focus area is to understand the reasons for existing limits to circularity and provide rigorous research and analyses on materials and technologies as well as techno-economic and policy aspects of material recovery.



Where should companies invest in materials and product circularity to effectively achieve multiple sustainability benefits?



Assembling the demountable PixelFrame cross section.

COURTESY OF MUELLER GROUP

SELECTED HIGHLIGHTS

Materials production is responsible for more than 30% of greenhouse gas emissions from industry and focused MCSC efforts with Accenture, Apple, Dow, Holcim, Inditex and PepsiCo have emphasized that circular economy strategies could have a more significant role to play in reducing this impact.

Materials recovery remains low across material streams (e.g., highest circularity rate of 20% in aluminum) and MCSC member companies are keen to address roadblocks to circularity. Based on inspiration from Holcim, the MCSC team has co-authored a written perspective across the member companies outlining common barriers to circularity across diverse industry sectors and highlighting opportunities for industry collaboration to enable faster transitions to a circular economy.

The MCSC, in collaboration with member companies such as Holcim and Prologis, is piloting a reusable concrete project led by MIT researchers. The project involves design and fabrication of reusable building components, with data infrastructure in partnership with Nexlore, business case development, assessment of barriers, and tools for public interaction.

MIT seed awardees are developing an expansive biodegradation dataset to detect polymer biofragmentation and relevant polymer-degrading bacteria. This work is of interest to member companies, particularly as it links to seed award research on mechanical recycling, novel chemistry development, and screening methods for microbial communities.

MCSC LEAD

• **POUSHALI MAJI**
MCSC Impact Fellow

Crossovers





NATURE-BASED SOLUTIONS

This focus area bridges scientific and technological gaps which currently inhibit the scaling of nature-based methods for atmospheric carbon sequestration. Nature-based climate solutions offer a viable opportunity to reduce or reverse emissions impacts because of their low estimated cost and their relative ease of deployment. Processes which enhance natural carbon sinks take a variety of forms, and may induce an even more diverse set of community and ecological co-benefits, including the protection of water resources, soil health, biodiversity, and farmer livelihoods. Such solutions are variegated, and involve different strategic pathways, such as afforestation and regenerative agriculture. Opportunities for collaborative action emerge in the scalable quantification of carbon in soils and biomass, both of which play distinct and critical roles in global ecosystems. MCSC member companies have expressed interest in practice optimization guidance, in the measurement and verification of carbon sequestration through natural systems, and in elucidating the factors which impact the permanence of such solutions.

SELECTED HIGHLIGHTS

In collaboration with Apple, Cargill, and PepsiCo, MIT researchers in Civil and Environmental Engineering analyzed the global potential to sequester atmospheric carbon in soils, both on farms and in natural ecosystems. The team estimated a total of 5.9 Gt CO₂e/yr of high-impact climate change mitigation capacity, using just under 5% of land on Earth.

An MCSC-hosted study group described the challenges and potentials of nature-based climate solutions and sustainable agricultural practices. Experts from MIT, Cargill, IBM, Dow, Rand-Whitney, and Verizon participated in a panel discussion, and communicated shared challenges surrounding practice validation and farmer engagement.

Inditex worked with MCSC seed project awardees to explore testing of resilient seed coatings and understand the potential for biodiversity metrics development within their supply chains. Dow and Cargill also provided scaling guidance for this seed award.

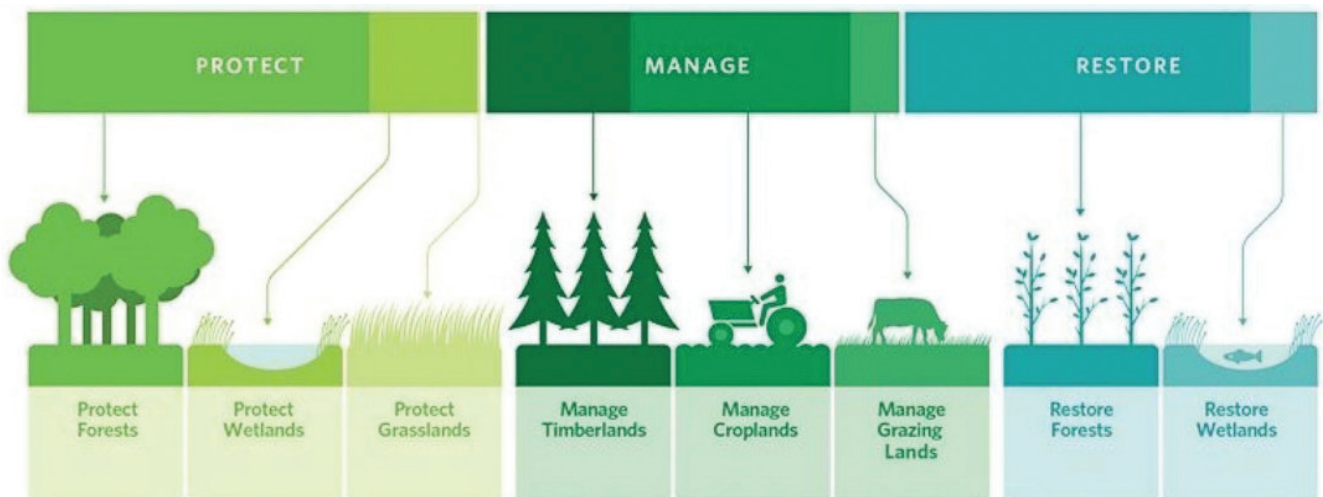
MCSC seed awardees and experts within Liberty Mutual and Accenture are guiding efforts to quantify how enhancing and strengthening biodiversity is complementary to mitigating and adapting to climate change.



How much bioenergy could be made available globally to support the energy transition to a decarbonized world?

MCSC LEAD

• EVAN COLEMAN
MCSC Impact Fellow



PROTECT, MANAGE, RESTORE A graphic illustrating the framework of natural climate solutions © Nature United

Crossovers





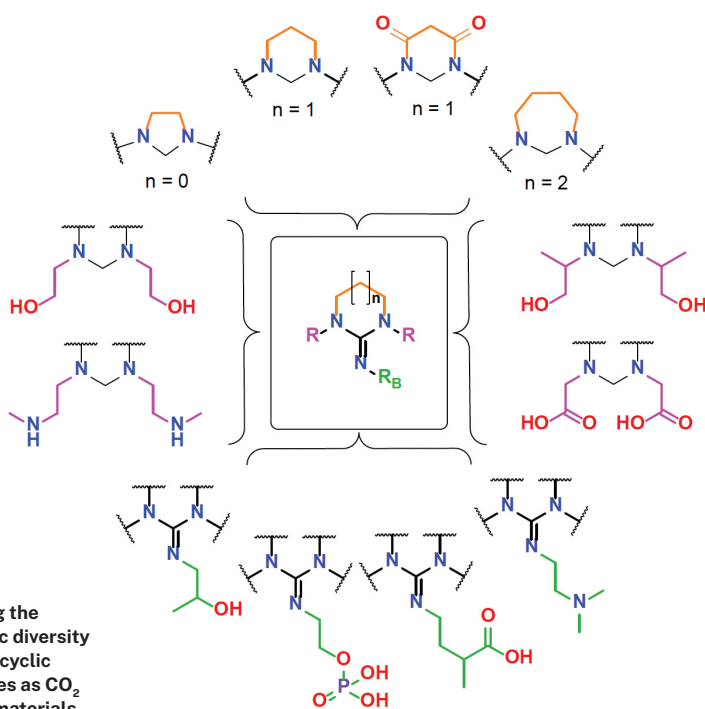
CARBON CAPTURE & STORAGE (CCS)

When it comes to technological barriers of CCS, the state of the art for CO₂ capture is amine solvents. However, even after many years of optimization, commercial amine capture systems still demand 2 GJ or more per ton CO₂, several times larger than required by thermodynamics. Furthermore, amines are susceptible to degradation in oxygen-rich post-combustion scenarios like cement production and coal or natural gas power plants. Thus, advances that reduce the energy penalty as well as the degradation rate of capture materials are necessary.

From a logistical perspective, even where mature technologies are directly applicable, projects are often near \$1 billion. Forming the right partnerships, taking advantage of government incentives, and cooperating with other industries to build necessary infrastructure are major challenges.



How do we design ideal materials for capture of industrial emissions rather than relying on serendipitous discovery?



Exploring the electronic diversity of heterocyclic guanidines as CO₂ capture materials.

SELECTED HIGHLIGHTS

MIT researchers across materials science, chemical, and mechanical engineering are building a chemical development strategy for accelerated development of capture chemicals.

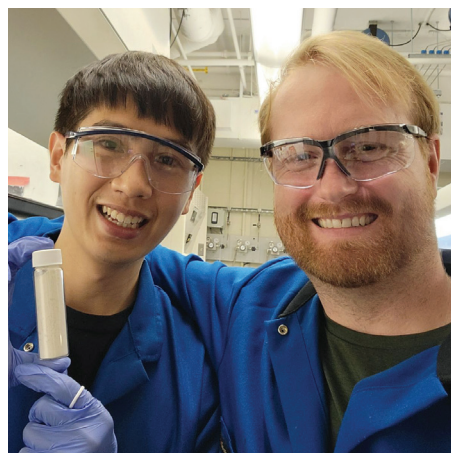
MCSC members Cargill, Dow, Holcim, and IBM provided integrated performance metrics for capture chemical design that include degradation rates, energy requirements, and compatibility with alternative energy transfer mechanisms.

MCSC researchers are constructing design principles that inform modular assembly of high-performance capture chemicals which include detailed kinetic models of oxidation and thermal degradation under capture conditions, testing of base molecules to validate predicted trends in structure-property relationships for CO₂ capture, and high-throughput synthesis for discovery of process-relevant conditions for scaled candidate synthesis.

MCSC LEAD

• GLEN JUNOR
MCSC Impact Fellow

MIT Chemical Engineering PhD student Fang-Yu Kuo (left) and MCSC Impact Fellow Glen Junor (right) working to develop the next generation of carbon capture materials based on heterocyclic scaffolds.



Crossovers



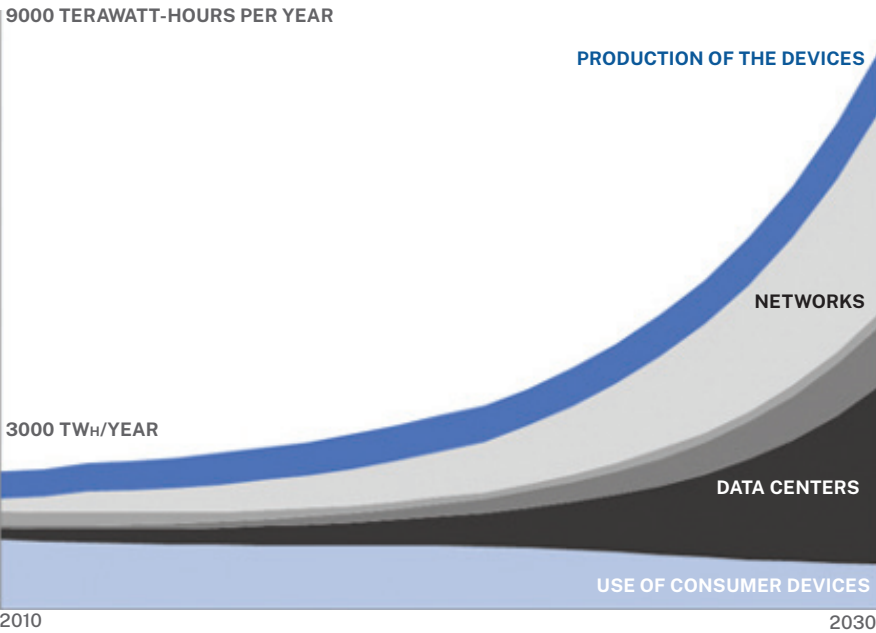


DATA & COMPUTING

Data & Computing are cross-cutting MCSC focus areas. Our data focus revolves around the opportunity found in data to manage and develop climate and sustainability solutions. Researchers from all fields are encouraged to contribute to a collaborative data environment where data can be easily discovered and enhanced by modern data fusion and hybrid computing methods and techniques. A mixture of data pools and data warehouse architecture can enable flexibility at scale for heterogeneous datasets.

On the computing side, critical framing to our work is that within the next decade computing and communications is predicted to consume more than 20% of the world's electricity coupled with significant impact on materials and chemical use, as well as waste generation. This burden is juxtaposed with the tremendous benefits from computing capability that will be critical to rapidly and broadly decarbonizing energy use and mitigating pressures on planetary boundaries.

→ **How does computing and communication lead to energy use and GHG emissions? And what are people doing about it?**



COURTESY OF ANDRAE, A. & EDLER, T. (2015).

SELECTED HIGHLIGHTS DATA

Data-driven material flow analysis by MCSC researchers has identified that building net-zero power infrastructure by 2050 is achievable in terms of material and energy demands, particularly if the mining and materials industry can co-evolve with the changing energy supply.

The resource-intensity and feasibility of the electrification transition depends on whether the renewable electricity equipment and infrastructure can be effectively updated and adapted over time, which requires design for modularity today. The MCSC is applying data-driven modular approaches to reuse within infrastructure driven by the circularity focus area.

COMPUTING

Collaborative efforts can be fully leveraged to address key industry needs through improving data center efficiency, developing networks and edge device innovation, and drawing important links between hardware, software, and data center systems, to name a few.

The MCSC has co-hosted several solutions-oriented events on this topic, with MIT entities such as the Computer Science and Artificial Intelligence Laboratory (CSAIL), MIT-IBM Watson Lab, Schwarzman College of Computing, and the School of Engineering, which have fostered community, dialogue, ideas, and a strong desire for action.

MCSC LEAD

- **EMRE GENÇER**
Principal Research Scientist
- **KATIE DAEHN**
Postdoctoral Researcher





SOCIAL DIMENSIONS

This cross-cutting theme involves considering human, social, policy, and governance factors in technical solution-building. This scope of interest includes social dimensions — equity and agent-centered design, behavior and markets, transparency and accountability, and policy and governance — as components that are built into the development and implementation of solutions. There is interest in development of equity-based evaluation criteria, monitoring and accountability systems, finance, and benchmarking of the human costs of status-quo practices. In implementation, members are interested to engage applied researchers, policy and governance experts, and pilot sites for community development engaged in the behavioral, institutional, and cultural context of solution-building for MCSC focus areas.

SELECTED HIGHLIGHTS

Twelve MCSC companies participated in stakeholder interviews to inform the social dimensions of sustainability. This effort facilitates knowledge sharing and peer-to-peer learning across sectors and industries, helping member companies fine-tune

commitments and communication (both internally and externally) around social sustainability goals and outcomes.

MCSC researchers gathered member perspectives on global corporate citizenship and business operations experts, and leaders

in ESG and sustainability innovation, sustainable materials experts, and metrics developers.

Implementing the equitable resilience framework (ERF), developed as a proposal for MIT's Climate Grand Challenges — which strives to take a comprehensive approach to get to net zero — builds on the technocratic approach to climate change, incorporating social impacts and human dimensions of sustainability.

MCSC members recognize that first-generation sustainability strategies, while critical, yield finite returns and true transformation requires new business models designed from the ground up. Collaborative work across all member companies aims to catalyze large-scale cross-sectoral strategies, which requires that we understand the social context of innovation and of value chain activity, as the success of MCSC technical projects may also hinge on compliance and corporate citizenship.



**What frameworks and tools can we develop to incorporate social sustainability within core business operations?
How can the MCSC most effectively leverage collaborations across domains of expertise to build the next generation of comprehensive sustainability tools?**

MCSC LEADS

- LAURA FRYE-LEVINE
MCSC Impact Fellow
- JUNGWOO CHUN
MCSC Impact Fellow



Crossovers



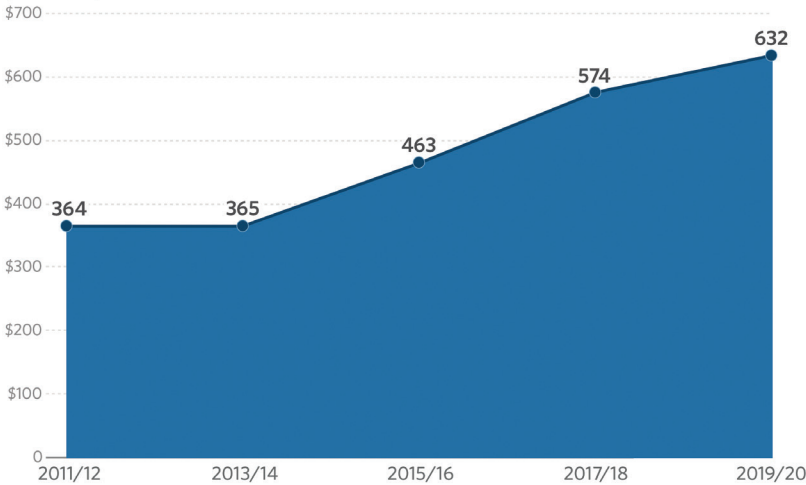


CLIMATE FINANCE

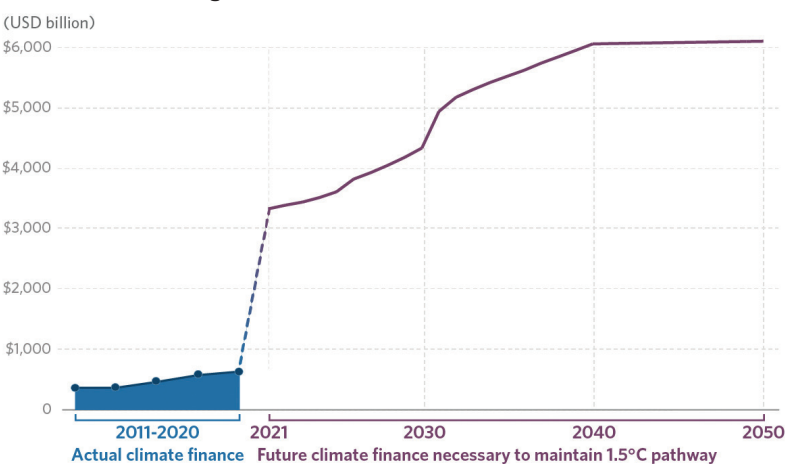
Climate finance is a cross-cutting theme focused on accelerating the adoption of climate and sustainability solutions by clarifying communication between corporations and the global financial system through measurement, monitoring, reporting, and decision-making. Specific research under this theme includes data management, climate financial innovation, net zero alignment, incentives in the verification and validation of ESG ratings, and the financial case for corporations to use carbon markets and other tools in the climate finance space.

➔ **What are the most effective financial tools and markets to support corporate action on climate change?**

Global climate finance flows between 2011-2020, biennial averages (USD billion)
(USD billion)



Global tracked climate finance flows and the average estimated annual climate investment need through 2050
(USD billion)



COURTESY OF CLIMATE POLICY INITIATIVE

SELECTED HIGHLIGHTS

By 2030 climate finance must increase by 590% to USD 4.35 trillion annually to meet climate adaptation and mitigation objectives (Climate Policy Initiative 2021).

Member companies working on the carbon capture & storage (CCS) and nature-based solutions (NBS) MCSC focus areas have highlighted financing gaps for these forms of climate action. The Intergovernmental Panel on Climate Change estimates that NBS could deliver one-third of emissions reductions required by 2030. Yet currently, NBS only receives 3% of global climate finance annually for mitigation. Direct air capture CCS technologies often require nearly USD 1 billion for the deployment of even mature technologies. Carbon markets are one avenue of finance that could provide needed financing toward CCS and NBS.

BBVA and PepsiCo contributed to study groups and a symposium panel on carbon markets and climate finance along with MIT researchers from MIT Sloan School of Management and the Department of Urban Planning and Development.

MCSC LEAD

- ANEIL TRIPATHY
MCSC Impact Fellow



Educate

Exploring New Sides of Climate and Sustainability Research

When the MCSC launched its Climate & Sustainability Scholars Program in fall 2022, the goal was to offer undergraduate students a unique way to develop and implement research projects with the strong support of each other and MIT faculty. Having recently wrapped up its second semester, the program is underscoring the value of fostering this kind of network — a community with MIT students at its core, exploring their diverse interests and passions in the climate and sustainability realms.

Inspired by MIT's successful SuperUROP program, the yearlong MCSC Climate & Sustainability Scholars Program includes a classroom component combined with experiential learning opportunities and mentorship, all centered on climate and sustainability topics. The first and current cohort of Climate & Sustainability Scholars consists of 19 students, representing MIT's School of Engineering, Schwarzman College of Computing, School of Science, School of Architecture and Planning, and Sloan School of Management. These students are learning new perspectives, approaches, and angles in climate and sustainability — from each other, MIT faculty, and industry professionals.

Students in the program work directly with faculty and principal investigators across MIT to develop their research projects focused on a large scope of sustainability topics. Examples of projects from the 2022-23 cohort include exploring how to optimize the power of wind farms, measuring carbon in wetlands, the “backfire effects” in climate change communication, and Indigenous data sovereignty in environmental contexts.



[→ Read more in MIT News](#)

Melissa Stok, materials science and engineering major, during a classroom discussion. Photo by Andrew Okyere.

“The diverse range of people talking about their own fields has allowed me to make connections between all my classes.”

Grace Harrington (Civil and Environmental Engineering), a student in the Climate & Sustainability Scholars Program



MCSC members come together on MIT's campus in October 2022



Member Benefits

Collaborate with MIT's renowned research community as well as other companies dedicated to climate and sustainability solutions, participate in events and workshops that help move the needle, and work with MIT students committed to making positive change.

Benefits & Expectations

- Participation in developing and implementing climate and sustainability impact pathways and cross-cutting themes in collaboration with member companies, Consortium researchers, the broader MIT community, and key stakeholders.
- Designation of one representative to the MIT Climate and Sustainability Consortium Industry Advisory Board. Option to designate one additional representative with expertise in social equity and sustainability issues to the Board.
- Designation of multiple representatives to Technical Teams who work with representatives from other Consortium companies, across MCSC focus areas, to advise and support the work of MIT researchers.
- Exposure to MIT leaders in climate and sustainability research.
- Participation in Consortium-organized online and in-person seminars and workshops relevant to existing and potential impact pathways and cross-cutting themes that will include MIT researchers and industry members.
- Engagement with MIT Undergraduate Research Opportunities Program (UROP) and Climate and Sustainability Scholar students conducting climate and sustainability-related research.
- Opportunity to engage with and mentor climate and sustainability-focused student clubs and groups, in addition to student entrepreneurship efforts on climate mitigation and adaptation.
- Opportunity to expand relationship into larger and focused efforts, including separate research agreements.

Get involved with us!







