Office of Sustainability

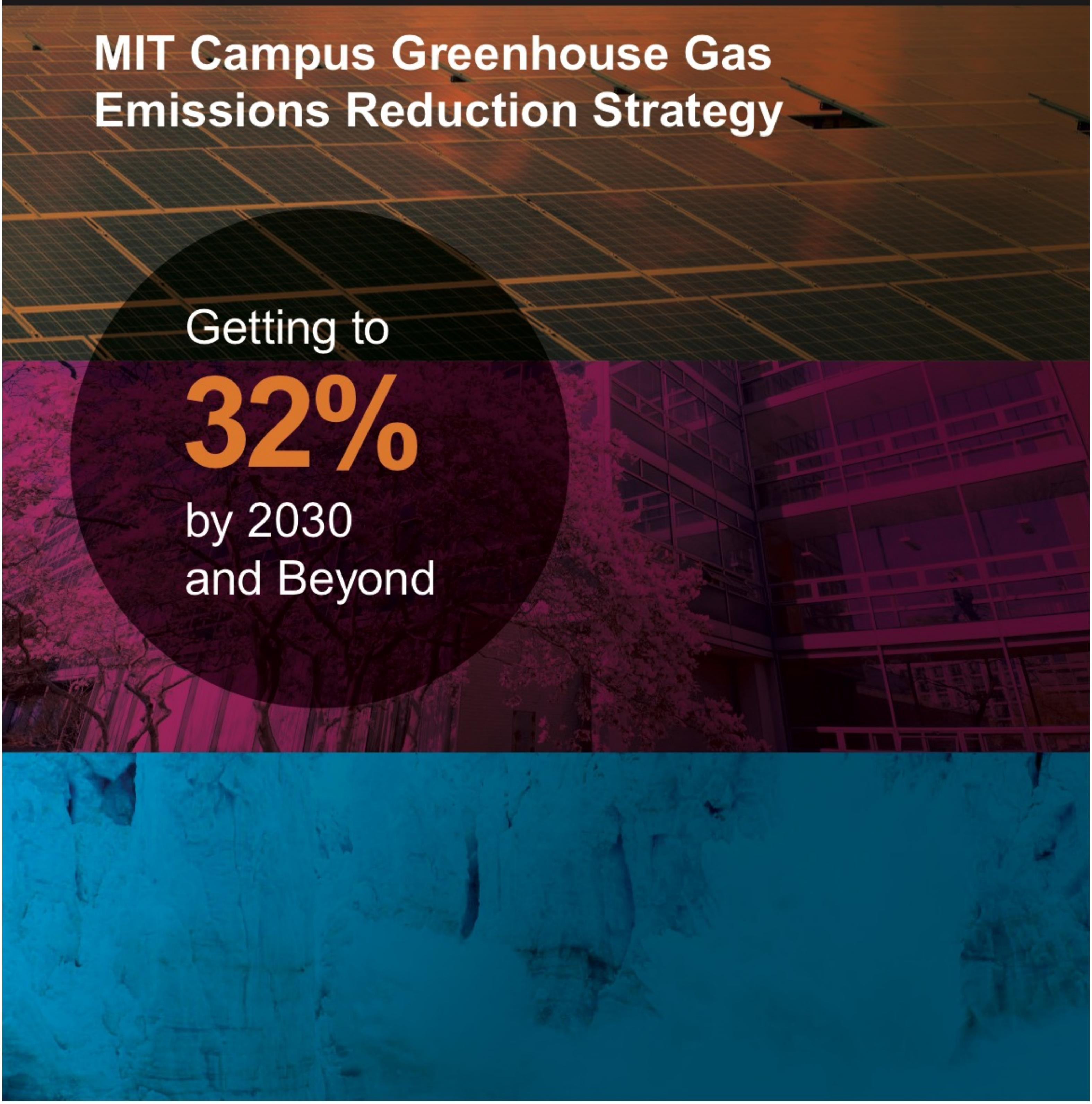
Department of Facilities

From Plan to Action:

START STUDY SOLVE

MIT Campus Greenhouse Gas Emissions Reduction Strategy

Getting to 32% by 2030 and Beyond



Massachusetts Institute of Technology

October 2017

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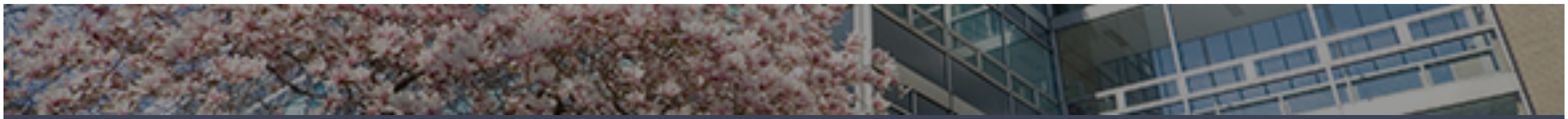


Executive Summary

The Challenge

The MIT *Plan for Action on Climate Change* articulated an unequivocal position that climate change is one of the most important challenges facing our global society and that MIT will take on many of the scientific, technological, and social challenges needed to contribute to the understanding and mitigation of the impacts of global warming. MIT recognizes that finding solutions to climate change requires inter-disciplinary approaches across the Institute that mobilizes not only MIT's research and educational resources, but also operational practices to have maximum impact.

To meet the global greenhouse gas emission (GHG) reduction levels dictated by science to minimize the worst impacts of climate change, individual institutions must reduce emissions associated with their own operations. However, there is not a clear path for large, energy intensive institutions like MIT to meet the necessary GHG reduction levels nor sufficient understanding of the optimal balance of new technology deployment, energy efficiency investments, and on-site and off-site renewable energy procurement. Experimentation and innovation is needed at the institutional level to ensure the necessary organizational changes are developed and scaled globally.

The Opportunity

MIT has embraced the challenge outlined in the *Plan for Action on Climate Change* to use the campus as test bed for experimentation and innovation in reducing its GHG emissions by a minimum of 32% by 2030 from a 2014 baseline, and aspire to being carbon neutral as soon as possible. Pairing its academic research and teaching with its own campus management expertise, MIT is aligning its core expertise to find the diverse solutions required to address climate change. With a baseline GHG emissions level of 213,428 metric tons of carbon dioxide equivalent (MTCO2e) from our building energy use, campus vehicles, and fugitive emissions, MIT has to reduce its emissions by 2030 to a minimum of 145,131 MTCO2 even after accounting for anticipated growth of the campus' physical footprint. MIT has seized the opportunity to demonstrate leadership in campus greenhouse gas reduction strategies and seeks to have global influence through sharing our experience widely.

Our Approach

To develop the pathways and strategies to reach and surpass our 32% GHG reduction goal by 2030, MIT has convened the Greenhouse Gas Working Group[i] under the auspices of the Office of the Executive Vice President and Treasurer. MIT's overall strategy for reducing GHG emissions on campus is focused on achieving four core objectives:

- **Reducing overall energy use and energy use intensity**
- **Reducing the use of fossil fuels to power our campus and vehicles,**
- **Increasing the use of renewably produced power, and**
- **Minimizing the release of fugitive process gases.**

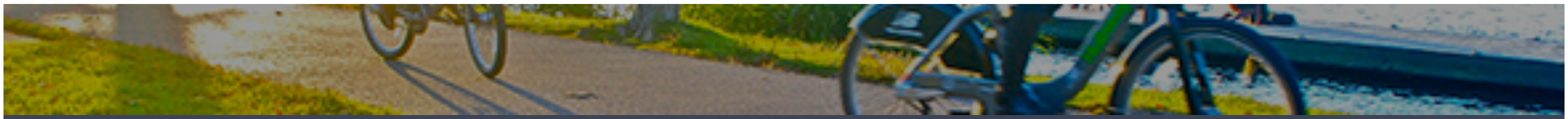
To accelerate and amplify impacts across local, national, and global scales, our GHG reduction strategy seeks to advance innovative approaches and collaborative processes within each core objective.

A core mitigation strategy is to reduce emissions associated with the generation, delivery, and use of energy on campus including natural gas, fuel oil, gasoline, and the produced utilities steam, chilled water, and electricity. Maximizing energy efficiency across our campus operations in both our existing and new buildings is our first priority. Reducing the demand for traditional fossil fuel sources of utilities on campus is coupled with the development and adoption of increased sources of renewable energy produced on campus and in the region.

Emissions associated with the operation of MIT's fleet vehicles and use of certain global-warming gases used in research and operations, known as fugitive gases, comprise the remaining 2% of MIT's GHG emissions and mitigation strategies include reducing the use of fossil fuels in our fleets and reducing the volume of fugitive gases emitted on campus through better control, capture, reuse, and chemical substitution strategies.

This initial plan is focused on identifying the essential pathways to meet MIT's greenhouse gas reduction goal of a minimum 32% by 2030. In a parallel and complementary planning effort, MIT will catalyze a broader process to examine scenarios for achieving campus carbon neutrality.

Historical information on the evolution of MIT's campus energy systems, energy use, and greenhouse gas emissions as well as details on previous energy efficiency investments are outlined in a companion document entitled *Understanding Campus Energy: A Historical Narrative of Powering MIT from 1916 to the Present* available from the Office of Sustainability.



MIT's Campus GHG Reduction Goal

Launched in October 2015, MIT's ***Plan for Action on Climate Change*** calls for reducing campus greenhouse gas (GHG) emissions by at least 32% by 2030 from a 2014 baseline. Since the Plan's publication, Vice President for Research Maria Zuber has underscored that the 32% reduction target is a floor, not a ceiling, and that the campus aspires to carbon neutrality as soon as possible. To achieve or exceed this goal, MIT will need to lower annual GHG emissions to a yearly level of 145,100 metric tons of carbon dioxide equivalent (MTCO2e) or less by 2030. MIT's reduction must also accommodate a projected estimate of 10 percent growth in campus energy use during this timeframe[ii]. The *Plan* builds on a long history of investments and activities in advancing campus energy efficiency. Additional information on MIT's previous work advancing energy efficiency can be found in the companion *Energy Narrative* report available from the Office of Sustainability.

About the Plan for Action on Climate Change

The *Plan for Action on Climate Change* outlines the steps that MIT will take to intensify its impact in advancing solutions to the urgent problem of global climate change. The overall objective of the Plan is "to minimize emission of carbon dioxide, methane and other global warming agents into the atmosphere, and to devise pathways for adaptation to climate change, through the active involvement of the MIT community, proactively engaged with industry, government, academia, foundations, philanthropists and the public."

Organized around five pillars of focus, the Plan seeks to align the full array of expertise within the Institute to advance solutions not only through academic research, teaching, and learning, but also in practice. MIT has positioned and challenged its administration to jointly contribute solutions by developing and testing new approaches for reducing carbon emissions associated with its campus operations. In summary the Plan calls to:

- **Pillar A: Improve MIT's understanding of climate change and advance novel, targeted mitigation and adaptation solutions**
- **Pillar B: Accelerate progress towards low- and zero-carbon energy technologies**
- **Pillar C: Educate a new generation of climate, energy, and environmental innovators**
- **Pillar D: Share what MIT knows and learn from others around the world**
- **Pillar E: Use MIT's community as a test bed for change**

MIT's Campus GHG Reduction Goal

MIT's administrative units have embraced the challenge to develop solutions to climate change through the alignment of its research, education, and campus assets and expertise.

This greenhouse gas emissions reduction strategy report articulates MIT's progress to date on developing a roadmap for reducing our campus greenhouse gas emissions. This report outlines MIT's core strategies for reaching our 32% reduction goal and is intended to keep both the MIT community and public informed of MIT's thinking and action for GHG emissions reductions. A broader and complementary planning effort will be convened to examine implications and possible scenarios for achieving campus carbon neutrality.

This report is designed to be a living document and will be updated annually to reflect our learning and experience as well as emerging new technologies and best practices. Historical information on the evolution of MIT's campus energy systems, energy use, and greenhouse gas emissions as well as details on previous energy efficiency investments are outlined in the companion document *Understanding Campus Energy: A Historical Narrative of Powering MIT from 1916 to the Present* available from the Office of Sustainability.

From Plan to Action

Climate Leadership

Oversight of the *Plan for Action on Climate Change's* general overall implementation is carried out by the Vice President for Research Dr. Maria Zuber, which involves coordination across many offices, programs, initiatives, and labs at MIT.

The MIT Office of Sustainability, headed by Director Julie Newman, plays the lead role in advancing MIT's campus sustainability initiatives in close collaboration with the Department of Facilities - led by Don Holmes, Joe Higgins, Dick Amster and John DiFava - which is charged with jointly developing and implementing measures to reduce campus greenhouse gas emissions. These offices – reporting to the Executive Vice President and Treasurer Israel Ruiz – carry out this work in close collaboration with other operational and administrative units across campus.

To support our campus emissions reduction work, MIT assembled a multidisciplinary team of subject matter experts – both staff and faculty – to inform, develop and advise on our strategy for reducing emissions on campus, developing meaningful research and learning opportunities, and engaging our community to leverage the collective intelligence and experience around us.

From crowd-sourcing mitigation strategies from around the globe through the MIT Climate Co-Lab, to challenging our faculty and students in classes and applied projects, to seeking out solutions from staff who know our campus best, we are committed to exploring both cutting-edge solutions and time-tested strategies that have proven effective. We are considering solutions that are both local as well as regional and global in scope and implementation.

Planning and Implementation

In February 2016, the Greenhouse Gas [GHG] Working Group was established at the request of the Office of the Executive Vice President and Treasurer to summarize, develop and coordinate MIT's campus GHG reduction strategies and implementation activities. The Working Group is tasked with analyzing existing programs and projects, identifying new opportunities and developing coordinated strategies to reach, and surpass, the emissions reduction target. The working group is comprised of staff from the departments that have primary responsibilities for managing and influencing the MIT systems that contribute to MIT's GHG emissions, including the Department of Facilities, Office of Campus Planning, Environment, Health and Safety Office, and Office of Sustainability. The Working Group's mitigation strategies and implementation plans are reflected in this report.

The GHG Working Group is guided by a set of primary objectives and expected deliverables to develop the pathways towards a low or carbon neutral future campus using an iterative planning process that provides a flexible framework to support both the development of a portfolio of future activities as well as the ability to quickly capitalize on existing and emergent opportunities.

MIT's Greenhouse Gas Reduction Strategy

Overview

Building energy use contributes the vast majority (98%) of overall campus GHG emissions with 208,278 metric tons of carbon dioxide equivalent (MTCO2e) in baseline year 2014. Because of this, reducing emissions associated with the generation, delivery, and use of energy on campus including natural gas, fuel oil, gasoline, and the produced utilities steam, chilled water, and electricity is one of MIT's core mitigation strategies. Maximizing energy efficiency across our campus operations in both our existing and new buildings is our first priority. Reducing the demand for traditional fossil fuel sources of utilities on campus is coupled with the development and adoption of increased sources of renewable energy produced on campus and in other regions. Emissions associated with the operation of MIT's fleet vehicles and use of certain global-warming gases used in research and operations, known as fugitive gases, comprise the remaining 2% of MIT's Scope 1 and 2 GHG emissions. MIT's mitigation strategy includes a focus on reducing the use of fossil fuels in our fleets and reducing the volume of fugitive gases emitted on campus. More information on MIT's GHG Inventory can be found **here**.

MIT's greenhouse gas mitigation efforts are integral to MIT's capital planning processes. MIT's 2030 capital plan outlines a significant existing building renewal program, along with an aggressive new construction program designed to position MIT for the challenges and opportunities of a changing world. Building investment decisions are closely assessing projects' net impact on MIT's energy and GHG footprint and mitigation measures are being considered and designed into projects.

Broadly, MIT's overall strategy for reducing GHG emissions on campus is focused on achieving four primary objectives: reducing energy use across all campus operations, reducing the use of fossil fuels to power our campus and vehicles, increasing the use of renewably produced and low carbon power, and minimizing the release of fugitive gases. Advancing innovation and collaboration across all our strategies is a core objective within our mission for transforming campus sustainability. Finding innovative approaches and embracing collaborative processes are essential to accelerate and amplify our impact across local, national, and global scales.

MIT's Greenhouse Gas Emissions

To inform the development of our GHG reduction strategy, MIT identifies sources of greenhouse gases associated with the operation of our Cambridge campus. Emissions are then calculated using the leading GHG inventory protocols and tools. MIT's current **greenhouse gas emissions (GHG) inventory** includes emissions from three source categories: building energy use, fugitive gases, (which are non-combusted greenhouse gases that are used on campus to support research and operations such as CO2, refrigerants, and electrical insulators), and campus-owned vehicles.

Emission scopes

OPERATIONS

Each GHG source category includes certain areas of measurement, as outlined by the GHG Protocol's "scopes" for emissions accounting. MIT's emissions under Scope 1 include direct emissions from sources owned and/or controlled by the Institute for Cambridge campus purposes, including buildings, fuel consumed on campus, campus vehicle fuel use, and fugitive gases. Scope 2 includes indirect emissions from purchased electricity, steam, and chilled water. Scope 3 includes energy used in building space leased for Cambridge campus purposes, and transmission & distribution losses from the grid.

SPACE

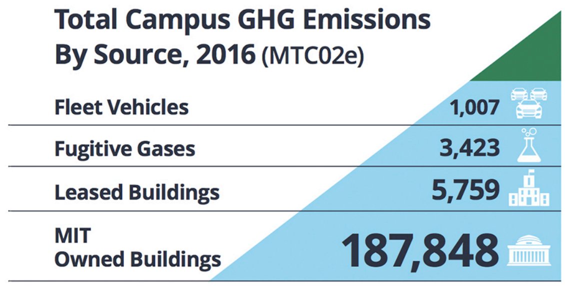
MIT's GHG Inventory includes buildings owned and leased for research, teaching, and administrative purposes on the Cambridge campus. The inventories do not currently include MIT's real estate investment assets (managed by the MIT Investment Management Company), Lincoln Laboratory, the Bates Linear Accelerator Center, Haystack Observatory, or other off-campus facilities. Additional details on spatial boundaries, buildings included in the inventory, and the categories and scopes of emissions can be found in the **GHG Inventory** on the MIT **Office of Sustainability website.**

PROGRESS REDUCING EMISSIONS

Since 2014, total greenhouse gas emissions have declined, as the campus strives for carbon neutrality. Between FY2014 and FY2016, the campus achieved a 7 percent reduction in overall emissions: from 213,428 MTCO2e in FY2014 to 198,038 MTCO2e in FY2016. For FY2016, reductions in MIT's own building emissions accounted for the vast majority of the total GHG reduced, followed by reductions in fugitive gases and fleet vehicle emissions, while emissions associated with leased space grew in the same period. A summary of total campus emissions by source in 2016 is outlined in Figure 1.

MIT's Greenhouse Gas Reduction Strategy

FIGURE 1. DETAILS OF MIT CAMPUS EMISSIONS BY SOURCE IN 2016



The 2016 GHG emissions inventory represents the third year of comprehensive inventory assessment for the Institute and was audited by the MIT Office of Treasury. The total change in emissions is a reduction of 15,390 MTCO2e from 2014 to 2016. The reduction in GHG emissions was primarily achieved through:

- **Implementation of energy efficiency measures in existing buildings, including investments in new construction and renovation, lighting, building retro- and monitoring based-commissioning, mechanical system upgrades, and utility system insulation.**
- **Use of less carbon-intensive fuels in the central utility plant.**
- **Reduced demand from buildings partially or fully offline for renovation.**
- **Modest reductions attributed to weather variation.**
- **Improvements in carbon-intensity of grid-purchased electricity.**

A DETAILED SUMMARY OF CAMPUS ENERGY USE AND GHG EMISSIONS FY2014-2016 IS OUTLINED IN TABLE 1. BELOW.

MIT's Greenhouse Gas Reduction Strategy

Table 1. CAMPUS ENERGY USE AND GHG EMISSIONS, FY2014-2016

MIT Building Energy Use					
		Unit	**2014**	**2015**	**2016**
Buildings Supplied by the Central Utilities Plant	**Electricity (Purchased)**	**kWh**	87,445,993	80,490,556	117,065,854
	Oil #6	**Gallons**	1,044,703	1,226,880	-
	Oil #2	**Gallons**	779,501	665,373	19,700
	Natural Gas	**CCF**	24,948,560	22,950,922	23,863,434
Buildings Not Supplied by the Central Utility Plant	**Electricity**	**kWh**	28,130,477	28,315,832	29,092,887
	Oil #2	**Gallons**	2,407	2,431	2,239
	Natural Gas	**CCF**	858,000	855,264	796,024
MIT Greenhouse Gas Emissions					
	BY CATEGORY	**Unit**	2014	2015	2016
All Inventory Emissions	**MIT Owned Buildings**	**MTCO2e**	204,177	191,768	187,848
	Fleet Vehicles	**MTCO2e**	1,150	1,151	1,007
	Fugitive Process Gases	**MTCO2e**	4,000	4,000	3,423
	Leased Buildings	**MTCO2e**	4,101	4,101	5,759
	BY TYPE				
	MIT Owned Buildings: Fuels	**MTCO2e**	161,579	151,665	134,913
	Fleet Vehicles	**MTCO2e**	1,150	1,151	1,007
	Fugitive Process Gases	**MTCO2e**	4,000	4,000	3,423
	Buildings: Purchased Electricity	**MTCO2e**	38,765	36,494	48,086
	T&D Losses from Purchased Electricity	**MTCO2e**	3,834	3,609	4,848
	Leased Buildings	**MTCO2e**	4,101	4,101	5,759
	BY SCOPE				
	Scope 1: Direct Emissions	**MTCO2e**	166,729	156,816	139,344
	Scope 2: Indirect Emissions	**MTCO2e**	38,765	36,494	48,086
	Scope 3: Indirect Emissions	**MTCO2e**	7,935	7,710	10,608
	Total Emissions	**MTCO2e**	213,428	201,020	198,038
Space					
	BY CATEGORY				
Gross Square Footage	**MIT Owned Buildings**	**GSF**	12,149,907	12,093,381	12,164,223
	MIT Leased Buildings	**GSF**	451,064	451,064	515,732

Notes: Data sources: MIT SAP purchase detail via MIT Data Warehouse; Department of Facilities and Office of Sustainability; Reporting periods: Fiscal year (July-June), and billing period; Building energy and emissions data is based on fiscal year; Fleet and Leased Building data is calendar year.

MIT’s Implementation Plan

MIT’s GHG phase 1 reduction strategy focuses on mitigating emissions associated with its primary sources of GHG: academic building spaces, fleet vehicles, and fugitive emissions. Emissions associated with the operation of MIT-owned academic buildings make-up the single largest source of GHG, equaling 204,000 metric tons of CO2 equivalents (MTCO2e) in our baseline year [2014]. A 32% net reduction of those emissions (excluding any campus growth) requires a reduction by 2030 of approximately 65,280 MTCE from our existing building operations. However, to accommodate expected campus growth through 2030, additional reductions will have to be realized to off-set the projected additional emissions.

GHG Reduction Plan in Summary

Analyses of impacts from different strategies were considered and prioritized based on MIT’s current campus conditions and systems. Under this current working scenario, MIT’s implementation plan encompasses the following set of mitigation strategies and estimated contribution to reach – and surpass - MIT’s 32% GHG reduction target.
(See Table 2. GHG Reduction Plan in Summary.)

TABLE 2. GHG REDUCTION PLAN IN SUMMARY

		Contribution to Overall Reduction Objective			
Mitigation Strategy	**Current Working Scenario Contribution to 2030 GHG Reduction Goal**	**I. Reducing energy use**	**II. Reducing the use of fossil fuels**	**III. Increasing the use of renewable energy**	**IV. Minimizing fugitive emissions**
Investments in Building Energy Efficiency and Operations					
Existing Building Energy Efficiency Measures	5%	Yes	Yes	No	No
Commissioning/Re-commissioning Processes	1.5%	Yes	Yes	No	No
Operational Strategy Improvements	6%	Yes	Yes	No	No
Utilities Distribution Improvements	1.5%	Yes	Yes	No	No
New Campus Growth	-10%	No	No	No	No
Central Utility Plant Upgrade Project	10%	Yes	Yes	No	No
On-Site Renewable Energy	1%+	No	Yes	Yes	No
Off-Site Renewable Energy	17% +	No	Yes	Yes	No
Other Strategies: Fugitive Emissions, Fleet, Leased Space	<1%	Yes	Yes	No	Yes
TOTAL	**32% or more**				

Energy Efficiency Investments in Buildings

A primary focus of the plan presents a comprehensive set of strategies for reducing building-related energy and GHG emissions. We have designed these strategies to address all areas of energy use, and prioritize work based on energy use intensity and opportunities for reduction. These building energy strategies focus on both existing buildings and new construction and renovation.

These energy efficiency strategies are informed by the successes of MIT's Efficiency Forward program - the state's largest and first-of-its-kind energy efficiency partnership with the utility provider Eversource, which has demonstrated impressive results during the program's first 6 years. Efficiency Forward has identified, implemented, and proven a robust set of energy efficiency strategies on campus, resulting in over $6 million of energy savings annually. To date, the program has implemented 252 projects in the following high-priority and high-return project areas:

- **Capital projects (new construction and major renovation)**
- **Lighting upgrades**
- **Building retro-commissioning**
- **Mechanical system improvements**
- **Utility distribution system insulation**
- **Building continuous commissioning (MBCx)**
- **Equipment replacement incentives**

A summary of results from the past six years of MIT's Efficiency Forward program is presented in Table 3.

TABLE 3. EFFICIENCY FORWARD PROGRAM SAVINGS AND COSTS, 2010-2016

Efficiency forward program cumulative totals (2010-2016)

	Projects Completed	kWh Savings	Therm Savings	Total Project Cost	Annual Cost Avoided
Totals	252	55,629,822	1,658,667	$19,364,092	$6,473,161

Total expected lifetime savings*: $205,572,163

***Defined and estimated by MIT's utility provider Eversource as the cumulative total expected savings over the course of each measure's anticipated equipment useful lifetime.**

Additional investments in building renovations, repairs, and maintenance as part of MIT's extensive capital renewal program are anticipated to contribute additional improvements in energy performance. The contributions from these additional investments are currently being estimated.

Energy efficiency in existing buildings

OBJECTIVE

Implement comprehensive energy efficiency projects in buildings with highest total greenhouse gas savings potential ("priority buildings").

- **Deploy a set of building commissioning processes designed to improve building performance or verify operation of building systems meet the project design.**
- **Optimize targeted, energy-intensive building systems to reduce energy through campus-wide programs.**
- **Coordinate Capital Renewal priorities with Energy Efficiency priorities to reduce energy and GHG, reduce maintenance costs, enhance occupant comfort, and improve financial return.**

DISCUSSION

In general, building efficiency projects will be comprehensive in nature, with the objective to evaluate all major building systems that impact building energy use, including:

- **Heating, ventilation, and air conditioning (HVAC)**
- **Lighting**
- **Process, and**
- **Building envelope**

Comprehensive energy efficiency initiatives will also be complemented with strategic, single-technology efficiency measures including lighting, lighting controls, mechanical insulation, and steam trap retrofits where appropriate.

MIT has long used the commissioning process on new construction projects to ensure buildings operate as intended. These strategies will be expanded in the following areas to:

- **Verify performance of new construction projects; and introduce new post-occupancy commissioning process to track performance over the first year of operation;**
- **Improve performance of existing buildings through retro-commissioning processes on buildings where significant operational issues have been identified;**
- **Verify performance on an on-going process by developing a continuous commissioning program, with a goal to use monitoring, analysis and investigation to continually maintain system performance throughout the life of the facility; and**
- **Develop a re-commissioning process to be executed on a repeatable basis (every 3-5 years) in older buildings that do not have a robust enough building automation system to be connected to the continuous commissioning program.**

Many buildings across campus are similar in terms of occupancy, construction, HVAC systems, and operating characteristics. Although building infrastructure operates to maintain comfort and support building activities, systems do not currently operate as efficiently as possible. For example, heating and cooling for many HVAC systems operate simultaneously throughout most of the year, wasting energy. The Operational Improvements strategies described below are designed to systematically improve building-related systems such as building management systems, lighting controls, and building envelope systems.

Buildings throughout the campus are continuously enhanced, reconfigured, and retrofitted via renewal and renovation projects, which have the potential to significantly increase energy use if implemented without regard to efficiency. Conversely, with thoughtful management and planning, these projects often present opportunities to reduce energy use.

MIT's GHG working group has focused on developing a detailed 3-year program for project development and implementation to quickly capitalize on existing opportunities. Based on our current working scenario, this first 3-year plan is expected to reduce GHG emissions by approximately 12% over the next three years. See Table 4. FY17-19 Program Priorities.

TABLE 4. FY17-19 PROGRAM PRIORITIES

FY17-19 Programmatic Priorities for GHG Reductions – Current Working Scenario		
Program Component	Definition/Scope	Projected GHG Reduction from Baseline
Building Efficiency and Operations	Building-focused improvements such as retro-commissioning, BMS (building management system) optimization, lighting upgrades, utility pipe insulation, and energy optimization.	10%
Utilities Distribution	Improve efficiency of the utility generation and distribution systems including chilled water, steam, and hot water systems outside of the central utilities plant.	1.5%
On-Site Renewable Energy	Install solar, wind, and other technologies that generate energy from renewable energy sources.	<0.5%
TOTAL		**12%**

Potential priority buildings to target GHG mitigation efforts have been selected based on their overall impacts on campus emissions as well as their potential for mitigation. Preliminary buildings considered for early investment based on their mitigation potential are listed in Table 5. FY17-19 Priority Efficiency Strategies.

Specific priority projects in the first 3-year plan for existing buildings are listed in Table 5.

TABLE 5. FY17-19 PRIORITY EFFICIENCY STRATEGIES

FY17-19 PRIORITY EFFICIENCY STRATEGIES FOR GHG REDUCTIONS	SCOPE
Efficient lighting & lighting controls	Campus-wide
Mechanical insulation	Campus-wide
Steam trap retrofits	Campus-wide
Building Management System optimization	Campus-wide
Building 68 energy optimization	Building 68
Air change optimization	Campus-wide, focus on laboratories
Cage rack air change optimization	Campus-wide
Building 46 energy optimization	Building 46
Retro-commissioning	Building 13, 32, E62, 56, 16

Energy efficiency in new construction and major renovation

OBJECTIVE

Through campus planning and campus construction, plan, design and build new buildings and major renovations to exceed high performance GHG and sustainability benchmarks to minimize energy impact of growth & renovations.

DISCUSSION

The **Sustainable Design and Construction Working Group**, consisting of staff appointed by members of the Office of the Executive Vice President and Treasurer and supported by faculty expertise, established a set of principles to guide the development and implementation of recommendations to advance sustainable design within new buildings and major renovation:

- **Commit to an integrated design process that embeds sustainability into the planning, design, construction, and renovation of all new and existing MIT buildings, including their systems, materials, sites, and infrastructure.**
- **Prioritize energy efficiency strategies and reduction in carbon emissions in new and existing MIT buildings based on a life-cycle approach.**

MIT's Implementation Plan

- **Create feedback loops for all stakeholders that result in continuous improvement and ongoing performance optimization and enhancement of the buildings.**
- **Develop internal resources to ensure the implementation of sustainable design and construction for all projects, ranging from small-scale renovations to large-scale new construction.**

Highlights of specific programmatic recommendations
(several of which are already in progress) include:

- **Design and build to the LEED Gold version 4 rating system for all capital construction and major renovation projects and integrate LEED certification strategies into renovations and capital renewal projects.**
- **Develop MIT-specific sustainability standards within the LEED Gold certification process for capital construction, renovation, and capital renewal projects.**
- **Develop sustainability standards for system-wide initiatives, partial renovations, and limited- scope projects that do not comply with LEED.**
- **Develop a product sustainability assessment and building materials list to integrate with building design standards.**
- **Develop and implement a streamlined life-cycle cost analysis framework and calculator applicable to capital construction and capital renewal projects.**
- **Develop benchmarks for building and space types (labs, offices, classrooms, and residences), and review and update them annually.**
- **Develop Sustainable Building Operations and Maintenance Guidelines.**

MIT has a number of significant new construction and major renovation projects either currently in construction or in the planning and design stages, including a center for nanoscience and nanotechnology, undergraduate and graduate residences, and a music & theater arts facility. All of these projects, no matter how efficient their design, will add to MIT's energy demand and will therefore need to be off-set by implementing energy efficiency projects elsewhere on campus. Minimizing the energy and GHG impact of these projects is vital to meeting the campus GHG goal.

For example, the MIT.nano building, which will be providing state-of-the-art nano scale research facilities, is leveraging some of the most advanced energy efficiency strategies ever considered in clean-room research facilities. Sustainable design features centered around creatively designed air filtering systems will maintain cleanroom standards at lower energy intensity levels than similar facilities. A few features include:

- **Heat recovery on building exhaust**
- **Variable frequency drives on motors that save energy by adjusting airflow based on cleanliness of the clean rooms**
- **Chiller heat recovery system that makes use of waste heat from air conditioning systems**
- **Low-flow exhaust devices that minimize the amount of exhaust needed to maintain the cleanroom air purity and filtration**
- **High performance windows and glazing systems**

Utility Distribution System Improvements

OBJECTIVE

Improve efficiency and operation of steam, chilled water, hot water, and electric distribution systems.

DISCUSSION

The Central Utility Plant (CUP) distributes electricity, steam, chilled water, and hot water throughout the campus. Further, the East Campus Chilled Water Plant distributes chilled water to east campus buildings. The strategies described below are designed to improve operational efficiency and reduce energy use without compromising reliability. Many of the strategies below will also enhance overall operation and performance of the CUP and distribution systems. For example, new chilled water valves will reduce chilled water flow demand on the CUP chilled water plant, and retrofitting building chilled water piping systems will mitigate or eliminate pressure problems at the buildings that adversely affect performance of the CUP chilled water system. Table 6. FY17-19 Utility Distribution System Priorities outlines our current priority strategies.

TABLE 6. FY17-19 UTILITY DISTRIBUTION SYSTEM PRIORITIES

FY17-19 PRIORITY EFFICIENCY STRATEGIES FOR GHG REDUCTIONS	SCOPE
Chilled water distribution system optimization	**Campus-wide**
Chilled water plant optimization	**Central utility plant**
Comprehensive building energy metering	**Campus-wide**

Funding Strategies

New approaches to GHG mitigation project development and funding are being designed at MIT to ensure an integrated strategy that identifies opportunities to maximize efficiency and high performance for both small and large capital projects, renovations, and repair and maintenance. All capital projects will be reviewed by a team to determine possible impacts on GHG emissions and ensure mitigation measures are considered. In addition, new unified project funding processes are being put in place to streamline the development, review, and funding of energy efficiency projects to expedite the time from development to implementation. Projects are moving towards being jointly developed and reviewed among several organizational units to minimize overlap and maximize project impact. MIT is embracing a portfolio approach to project development, review, funding, implementation and reporting.

Central Utilities Plant Renewal

Plant expansion project

OBJECTIVE

Upgrade MIT's on-campus cogeneration system so that will serve as a bridge to future energy technologies and equipment, while reducing GHG emissions and enhancing power reliability.

DISCUSSION

Flexible in its design and adaptable to change, the new co-generation system will enable MIT to incorporate innovations as they emerge, improving plant efficiency and optimizing operations.

The current power plant is a 21-megawatt natural gas turbine. After twenty years of operation, the cogeneration facility is nearing the end of its useful life. The CUP Expansion Project will replace the current natural gas turbine, add a second turbine, and upgrade for energy efficiency. This second turbine will bring the total plant's capacity to 42 megawatts. These renovations will bring three major improvements: improved campus power resilience, reduced GHG emissions, and reduced regulated pollutant emissions. The renovation is expected to be completed by late 2020.

The Central Utility Plant renewal project will be deploying state-of-the-art power generation equipment and providing significant improvements to MIT's utility systems that will increase efficiency and reduce GHG emissions. With new and upgraded equipment at the CUP, MIT will be able to reduce its emissions substantially:

The upgraded CUP will use natural gas for all normal operations, lowering the plant's regulated pollutant emissions more than 25% from 2014 emissions levels. This fuel is the same natural gas that is used to heat homes.

Modeling shows that in 2020, the upgraded plant's higher energy efficiency will off-set the expected 10% growth in energy demand from new buildings and other research requirements during that period. The plant upgrades are essential to MIT's commitment to reducing campus GHG emissions at least 32% by 2030.

The two new gas turbines will be more efficient and emit less pollutants than the plant's existing turbine. The new turbines will have a lower exhaust temperature, and they will use state-of-the-art controls to reduce pollutants. These controls include two different catalysts that will reduce the plant's NOx (nitrogen oxides) emissions by 90% compared to the current system.

The new heat recovery steam generation system will be built to accommodate a condensing economizer (hot water) coil to capture additional waste heat from the exhaust stream – if MIT expands its hot water distribution system. MIT would then add the hot water coil and distribute the resulting heated water around campus through an expanded medium temperature hot water loop, providing heat and hot water to MIT buildings. If added, this will raise the efficiency of the plant's overall operation and enable MIT to further reduce its greenhouse gas emissions.

The upgraded plant will enable MIT to eliminate the use of fuel oil in campus power generation by 2020. Our new gas service agreement with Eversource will enable the cogeneration plant to run entirely on natural gas with the exception of emergencies and testing. This will assist MIT with its efforts to reduce emissions.

In addition, MIT will eliminate all use of #6 oil on campus by 2019, modifying the plant's three older boilers to make them compatible with cleaner #2 fuel oil. In the case of an emergency (when the natural gas supply is interrupted) or in a testing situation, the boilers will burn #2 oil only. (The plant's two newer boilers already burn this cleaner fuel.) Cleaner fuel means fewer particulates in the air.

Renewable Energy

On-site renewables

OBJECTIVE

Deploy renewable energy systems on-campus to displace conventional energy sources; advance research and learning; and provide a physical demonstration of MIT's commitment to clean energy.

DISCUSSION

While MIT's dense, urban location currently limits development of many commercially available renewable energy systems; we continue to explore possibilities for the installation of effective renewable energy sources on campus that can bolster MIT's current solar photovoltaic systems and/or provide a platform for advancing research and teaching.

MIT recently completed a campus-wide roof evaluation, which considered savings and costs associated with roof-mounted PV systems. The study did identify locations that may be good candidates for solar PV and initial opportunities are being assessed, namely on buildings E53 and W7. As MIT renews or replaces roofs across campus the roof tops will be examined for suitability for renewable energy systems, application of sustainable roofing technologies, or stormwater management enhancements.

The five solar PV systems currently in operation on campus (with a total capacity of approximately 70 kilowatts) have been renewed and production data will be made publically available.

Off-site renewables

OBJECTIVE

Advance the national development of renewable energy systems and capacity through strategic investments that create additional renewable energy capacity, help to advance research, education and practice for scalable, climate action; secure quality and reliable sources of renewably-generated power for the MIT campus or on the grid.

DISCUSSION

MIT must invest in off-site renewable power to meet and surpass its 32% goal by 2030. It is anticipated that by 2030, up to two-thirds of MIT's reduction goal of 32% will have to come from the purchase or generation of renewable energy.

There are a number of strategies available to institutions to acquire large-scale renewable energy to off-set the GHG emissions remaining on campus. They range from purchasing solely the environmental attributes of existing renewable energy production in the form of Renewable Energy Credits (RECs), to purchasing both the electricity and the RECs from a third party, to outright investment and ownership of large-scale, off-site renewable energy generation infrastructure. After thorough analysis, MIT has identified an off-site renewable energy strategy that we think makes a meaningful contribution to the renewable energy market and climate action strategies.

Guiding MIT's investment considerations in renewable energy have been the following principles:

- **MIT's investment in renewable energy should contribute to MIT's overall objectives of the Plan for Climate Action in helping to develop new as well as scaling-up existing strategies for climate action.**
- **MIT's investment in renewable energy should be catalytic to add new capacity in the marketplace, therefore increasing the total amount of renewable energy available nationally.**
- **MIT investments in off-site renewable energy should provide additional research and learning opportunities for MIT faculty, students, and staff, and seek to develop new knowledge in the technology or investment strategy.**

As a test bed for MIT's off-site renewable energy strategy, MIT recently formed an alliance for the development of a 60 megawatt solar photovoltaic farm in North Carolina that led to a long term power purchase agreement. MIT will purchase solar energy equivalent to 40 percent of its current electricity use, which will neutralize emissions by 17 percent.

This investment in off-site renewable energy by no means reduces the ambitions, priorities or objectives of reducing on-campus emissions and fostering local solutions. MIT recognizes that the most effective solutions will be on continuum of scales and locations.

Other GHG Emission Sources

Comprising approximately 4% of MIT's total GHG inventory in baseline year 2014, emissions from fugitive gases, fleet vehicles, and leased academic building space totaled 9,250 MTCO2e. Developing action plans to address these emissions will be a focus of this year's activities.

Fugitive emissions

Fugitive emissions are greenhouse gases that are directly emitted on campus through non-combustion processes including research, refrigeration, and electric equipment insulation. Common fugitive gases include purchased CO2, SF6, and select refrigerants. MIT's baseline fugitive emissions totaled 4,000 MTCO2e in 2016. Mitigation strategies include chemical substitution, enhanced material capture and reuse, and process redesign.

Fleet vehicles

Comprising over 160 departmental vehicles and shuttles, fuel use by MIT's campus vehicle fleet contributed 1,150 MTCO2e in baseline year 2014. Mitigation strategies include expansion of alternative fuels (including expanding campus electric-vehicle charging infrastructure), optimizing vehicle sizes for required duty, and improved transit routing and scheduling.

Leased academic building space

MIT leased approximately 450,000 GSF from commercial real estate partners in baseline year 2014 to accommodate academic departments, labs, and centers off-campus in Cambridge. These leased building spaces contributed approximately 4,100 MTCO2e. Mitigation strategies will require partnerships with our leasing companies to advance energy efficiency and renewable energy investments in non-MIT owned properties.

Enabling Strategies for GHG Reductions

MIT's planning effort includes a number of projects and activities that, although they do not directly reduce GHG emissions, help to support, develop, and optimize its GHG reduction strategy.

Data Analytics

The Sustainability Data Hub and Dashboard

The Sustainability Data Hub, currently in development, is a central data repository and analytic tool where sustainability information such as greenhouse gas emissions, waste, energy usage, and food & dining will be uploaded to a cloud system. The purpose of the Data Hub is to standardize data MIT decision makers use, inform and enable actions through data, and provide a secure centralized location for sustainability data. In the Data Hub, authorized users will be able to continually improve and update data, creating a culture of collaboration and accuracy. The information stored on the Data Hub can become visualized to further support sustainability initiatives on campus such as consumption reduction contests or energy efficiency projects. The first phase of the Data Hub will focus on building the foundation to support data from sectors such as commuting, building, and energy should be live in the first quarter of 2017.

MIT Building Energy Forecasting Tool

Atelier Ten (A10), an environmental design consultancy, was hired by MIT to create a **building energy use-forecasting tool.** The tool brings together a variety of data about MIT's buildings such as age, square footage, and program use to assess how lighting, heating, air condition, ventilation upgrades would affect total GHG emissions. The tool will serve as the foundation for a dynamic energy use-forecasting tool that will be built into the Data Hub.

Life Cycle Cost Analysis

Life Cycle Cost Analysis is a tool to assess the total cost of facility ownership accounting for all costs of acquiring, owning, and disposing of a building. LCCA is used to compare project alternatives, which may fulfill the same end goal but differ with respect to initial and operating costs. Life Cycle Cost Analysis can incorporate a shadow price for carbon based on the EPA's determined social cost of carbon onto potential projects to compare project options to optimize for cost and projected GHG emissions from new construction.

Roof Assessment Tool

MIT commissioned a roof assessment tool in the fall of 2015 to determine the potential for implementing sustainable features across campus rooftops. Such sustainable features explored were: reducing the campus' negative environmental impact of the surrounding ecology such as the Charles River, increasing research potential on campus, and realize renewable power generation potential. For example, the tool will help understand which roofs could help mitigate the urban heat island phenomenon the campus is facing. These sustainable features include green/white/blue roofs, added insulation capacity, and solar photovoltaic panels.

Measurement & Verification

Without solid data to quantify savings, it would be impossible to fully assess and monitor progress for the GHG reduction program. To this end, measuring and verifying the electric and thermal savings associated with all GHG activities is absolutely critical to monitoring progress and savings towards the 32% goal.

At the campus-level, MIT's GHG Inventory program established a robust process for calculating emissions. At the project and building-levels, we will develop a robust measurement and verification protocol that will guide the review and assessment of GHG performance of specific activities. This information will be used to measure the efficacy of specific initiatives, confirm expected costs and savings, and track performance over time. The DataHub can serve as the repository of this data and analysis.

Energy Benchmarking & Analytics

The Department of Facilities currently employs several systems to monitor energy use and HVAC system performance, including KGS Clockworks for HVAC systems and Pi for utility data. We plan on expanding use and capability of these systems to better benchmark and compare energy performance, identify efficiency measures, and understand operational performance in ways that were simply impossible without these technologies. In addition, we are using a third party building energy benchmarking tool to assess MIT's current building performance against a baseline of a new building providing the same mix of program space. Results are informing the selection of priority projects.

Energy Management Plan

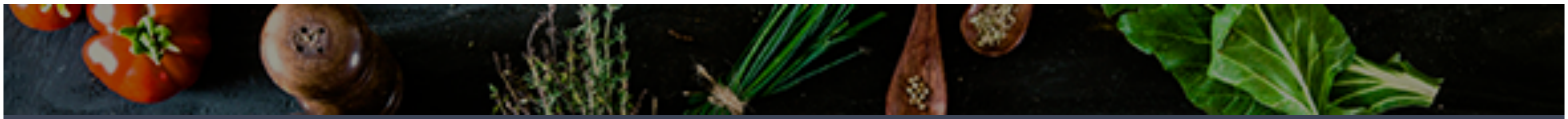
In 2013, MIT was invited by the U.S. Department of Energy to participate in a national demonstration program to develop a robust energy management plan based on the international ISO 50,001 standard to systematically improve and manage energy use.

Campus Energy Audits

Additional analysis is being conducted through high-level surveys to identify potential opportunities across the campus and help prioritize future work.

Green Labs Program

On campus, research laboratories can be energy-intensive spaces that consume well above average amounts of energy and other materials – making lab space a priority space for energy efficiency measures. The Green Labs Program is administered by the MIT EHS Office to support labs across campus to explore options and implement solutions to advance more sustainable practices with lab spaces across campus. Areas of focus include: energy and water efficiency, waste and chemical use reduction, energy efficient equipment procurement, and recycling. Occupant engagement is a cornerstone of the Green Labs program where education and outreach are encouraged to change individual behavior. Where these changes can lead to operational changes that can reduce energy use, these initiatives will contribute to campus GHG reduction goals.



Local, Regional, Global Collaborations and Engagement

MIT's greenhouse gas reduction strategy embraces the importance of collaboration among a rich variety of individuals and organizations. We recognize that these diverse collaborations are essential both to learn from others' experience as well as to share our learning with others to amplify impact. MIT has built strong partnerships and works closely with the cities of Boston and Cambridge and with our peer institutions, maximizing our ability to foster and advance sustainability and best climate action planning processes across local, regional, and global communities. Below are several of the climate-related community and peer efforts in which MIT is actively participating.

Cambridge Compact for A Sustainable Future

MIT is a founding member of the Cambridge Community Compact for a Sustainable Future, an innovative, community-based partnership on sustainability with the city of Cambridge, Harvard University and other local organizations. GHG reduction strategies and climate resiliency are priority impact areas currently being addressed.

Cambridge Climate Protection Action Committee (Cpac)

MIT is a longstanding member of the City of Cambridge's Climate Protection Action Committee (CPAC), which serves a key platform for ensuring continued alignment of campus climate activities with City-wide initiatives. The Committee membership is appointed by the City Manager and is composed of community members who take an active interest in climate change issues in Cambridge and who live or work in Cambridge. CPAC is currently serving as an advisory body for the City's implementation of the Net Zero Action Plan (2015) that aims to mitigate greenhouse gas emissions from the city's built environment. MIT's participation through CPAC is also fostering collaboration conversations with MIT's community and institutional neighbors.

Cambridge Net Zero Energy Task Force

In December 2013, the City of Cambridge created the Getting to Net Zero Task Force charged with advancing the goal of putting Cambridge on the trajectory towards becoming a "net zero community", with focus on carbon emissions from building operations. This includes reducing energy use intensity of buildings and taking advantage of opportunities to harvest energy from renewable sources.

Local, Regional, Global Collaborations and Engagement

Boston Green Ribbon Commission

MIT is actively engaged in the Boston Green Ribbon Commission, made up of members from many segments of the Boston community, dedicated to sharing ideas, monitoring progress and engaging key sectors in the implementation of Boston’s Climate Action Plan.

The Association for The Advancement of Sustainability in Higher Education

The Association for the Advancement of Sustainability in Higher Education (AASHE) works with the mission to empower higher education to lead the sustainability transformation. They do this by providing resources, professional development, and a network of support to enable institutions of higher education to model and advance sustainability in everything they do, from governance and operations to education and research. MIT is an active member organizing workshops, panels, and presentations on a variety of climate-related subjects at the annual conference.

The International Sustainable Campus Network (ISCN)

MIT is a member of the International Sustainable Campus Network (ISCN), which brings together colleges and universities from all over the world to share best practices for achieving sustainable campus operations and integrating sustainability in research and teaching. In 2014, MIT partnered with Harvard to host the annual conference in Cambridge around the theme "Pushing Boundaries: Leveraging Collective Action for Global Impact”.

Ivy Plus Sustainability Consortium

Alongside thirteen of its peer institutions, MIT is a member of the Ivy Plus Sustainability Consortium, which is committed to sharing solutions that include the implementation of innovative technologies as well as research and operational methodologies that advance a commitment to greenhouse gas reduction across all of the consortium’s campuses. MIT's Office of Sustainability hosted the Consortium's 2016 Annual Summit.

Northeast Campus Sustainability Consortium (NECSC)

The Northeast Campus Sustainability Consortium was established in October 2004 to advance education and action for sustainable development on university campuses in the northeast and maritime region. Organized around the UN Decade of Education for Sustainable Development, the NECSC members have committed to an annual meeting that advances campus sustainability by providing close networking opportunities, professional development, and access to the area’s vibrant and growing college and university sustainability practitioner community.

Integrated Planning for Climate Resiliency

Planning for Climate Resiliency

While MIT's Cambridge campus has thrived for more than 100 years, the region is already beginning to experience impacts from climatic changes. A transformation in how MIT builds, operates and renews campus infrastructure, building, landscape and community systems will enable MIT to thrive through its second hundred years in Cambridge and beyond.

OBJECTIVE

The MIT Office of Sustainability is leading campus-wide efforts with faculty, staff, students, regional peers and technical experts to develop a methodology for campus-based climate vulnerability assessment and resiliency planning that includes:

- **Evaluation of campus physical and social vulnerabilities to climate hazards;**
- **Quantification and prioritization of risks;**
- **Development of a resiliency plan for integrated decision-making that considers climate and financial implications of preparedness in operations, renovations, transit and future development.**

In order to collectively understand existing campus capabilities and needs for building a more climate resilient MIT, the Office of Sustainability has launched key initiatives including: 1) Climate Resilience Committee; 2) the MIT Flood Vulnerability Study and, 3) engagements with peer and regional partners.

The Climate Resiliency Committee has been activated to grow engagement, foster new collaborations and provide insights from diverse perspectives throughout the Institute. In particular, this committee has strengthened efforts to optimize co-benefits of near-term emergency preparedness planning with longer-term campus renovation and new construction. Also, this committee has integrated MIT's global academic expertise into campus-based problem solving, such as the MIT Flood Vulnerability Study.

The MIT Flood Vulnerability Study (in progress 2016) seeks to understand the exposure of the campus buildings and landscape to extreme precipitation events, both in the present and under future climate changes. The outcomes of the study will include identification of campus locations most at-risk from current and future extreme flooding events, enabling campus planners and facility managers to prioritize investments in building adaptations and renovations. Preliminary results show that existing campus buildings, infrastructure and landscape systems are at risk from both immediate-term and future extreme rainfall events--which are anticipated to become even more intense, probable and consequential.

The Flood Vulnerability Study represents a unique blend of academic and applied research using the campus as a test-bed. The study methodology includes downscaling global storm models to the local Cambridge context via collaboration among the Office of Sustainability, the Department of Earth, Atmospheric and Planetary Sciences, the Joint Program on the Science and Policy of Global Change and the City of Cambridge.

Disruptions in regional infrastructure services such as transit service, utilities and critical emergency services can cause cascading impacts to MIT's physical assets and community systems. MIT is engaging with the City of Cambridge and local institutions such as the Cambridge Compact for a Sustainable Future and neighboring university peers in order to explore how collective efforts might strengthen resiliency to the shared vulnerabilities.

Campus Stormwater, Land Use and Ecological Study

Approximately seventy-five percent of MITs 169-acre Cambridge campus is covered in impervious surfaces (roofs and pavement). The capacity of the campus stormwater system and landscape to absorb stormwater from more extreme precipitation events is quite limited under today's climate conditions. Potential changes in rainfall patterns and intensity, in combination with development in and around campus, is expected to further exacerbate the amount and quality of stormwater runoff.

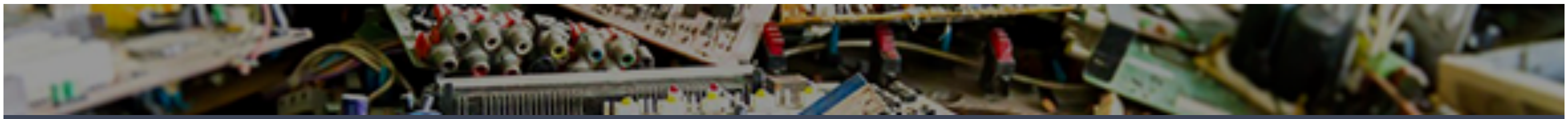
OBJECTIVE

The Office of Sustainability is teaming with the Office of Campus Planning, Department of Facilities and Office of Environmental Health and Safety to develop a comprehensive campus-wide stormwater management and landscape ecology plan that will inform climate resiliency efforts enhance the capacity of the campus landscape to mitigate flooding and heat stress.

The plan will recommend and prioritize cost-effective, incremental actions at the building site and campus scales that can enlarge the natural landscape's capacity to capture, absorb, re-use and treat stormwater while growing a healthy and maturing tree canopy for controlling local temperatures.

Phase I (in progress 2016) seeks to develop a summary of challenges and opportunities; recommend benchmarks for landscape performance and resiliency; and, identify a preliminary spatial framework of potential strategies for implementation.

Phase II will include design and operational guidance for implementing specific engineered and nature-based stormwater management solutions. Activating the campus landscape as a test-bed, this phase will also aim to create living laboratory opportunities for engaging students and faculty in the baseline data collection, performance evaluation, testing and monitoring of landscape and green infrastructure interventions.



Glossary

Campus Sustainability Task Force	The Task Force works under the auspices of the Campus Sustainability Steering Committee to shape the vision and plan of action for campus sustainability at MIT.
Carbon Neutrality	Carbon neutrality refers to achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset, or buying enough carbon credits to make up the difference.
Central Utility Plant (CUP)	The CUP is a cogeneration plant with a 20-megawatt natural gas turbine used to produce both electric and thermal energy. The waste heat from the turbine's exhaust is captured in a heat recovery steam generator, and the resulting steam is used for heating and cooling.
Energy Narrative	A summary report of MIT's historical campus energy management available from the Office of Sustainability.
Environmental Solutions Initiative	A major MIT research, education, and outreach initiative to coordinate and develop interdisciplinary solutions to urgent challenges in environment and sustainability.
Fossil Free MIT	Fossil Free MIT is a student led climate change action group participating in the development of the Plan for Action on Climate Change.
Fugitive gases (or fugitive emissions)	Fugitive emissions are emissions of greenhouse gases from pressurized equipment due to leaks and other unintended or irregular releases of gases, mostly from industrial and research activities.

Glossary

GHG Working Group	A team of MIT staff from MIT's Departments of Facilities, Sustainability, Planning, and EHS charged with shaping MIT's campus GHG mitigation strategy.
Greenhouse Gas (GHG) Emissions	Gases that trap heat in the atmosphere are called greenhouse gases. These include carbon dioxide, methane, nitrous oxide, and fluorinated gases. GHG quantities are expressed in single metric as tons of carbon dioxide equivalent (MTCO2e)
Greenhouse gas emissions inventory	An emission inventory is an accounting of the amount of pollutants discharged into the atmosphere. An emission inventory usually contains the total emissions for one or more specific greenhouse gases, originating from all source categories in a certain geographical area and within a specified time span, usually a specific year.
Metric tons of carbon dioxide equivalent (MTCO2e)	Measure for describing how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide (CO2) as the reference.
MIT 2030	MIT 2030 is a framework and capital plan to assist the Institute in making thoughtful, well-informed choices about development and renewal in the years ahead for both the campus and the innovation district close by.
MIT Energy Initiative	The MIT Energy Initiative is MIT's hub for energy research, education, and outreach.
MITIMCo	MIT's Investment Management Company supports MIT through managing MIT's investment assets.

Glossary

Plan for Action on Climate Change	Released by MIT President Reif, the Plan lays out MIT's focused strategy for leveraging its research, education, and campus develop solutions to climate change. MIT's campus goal of reducing emissions is contained in this plan.
Retro- and monitoring based-commissioning	Monitoring based commissioning (MBCx) com- bines ongoing building energy system monitoring with standard retro-commissioning (RCx) practices with the aim of providing substantial, persistent, energy savings.
Vice President for Research	The Vice President for Research has overall responsibility for research administration and policy at the Institute. Currently Maria Zuber, the position oversees implementation of the Plan for Action on Climate Change.

[i] Greenhouse Working Group consists of the following individuals and offices: Don Holmes, Ken Packard (Dept. of Facilities/Maintenance and Utilities), Bernie Richards, Mark Mullins (DOF/Systems Engineering Group), Wade Berner, Megan Kefalis, Siobhan Carr (DOF/Systems Performance & Turnover), Arne Abramson, Bill Colehower (DOF/Campus Construction), Joe Higgins (DOF/Infrastructure Business Operations), Morgan Pinney (Office of Campus Planning), Pam Greenley (Environment, Health & Safety Office), Amanda Strong (MIT Investment Management Company), Steven Lanou, Emma Corablan, Derek Wietsma (Office of Sustainability).

[ii] Under our current working scenario for GHG investments, we are estimating an approximate 10% increase in overall campus energy use from 2014-2021 due to new construction. This includes additional energy load from the following projects: MIT.nano, Site 4, Building 31, and a new Vassar Street residence hall. Modifications to the capital plan will influence this overall growth projection. Source: DOF Maintenance and Utilities.

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