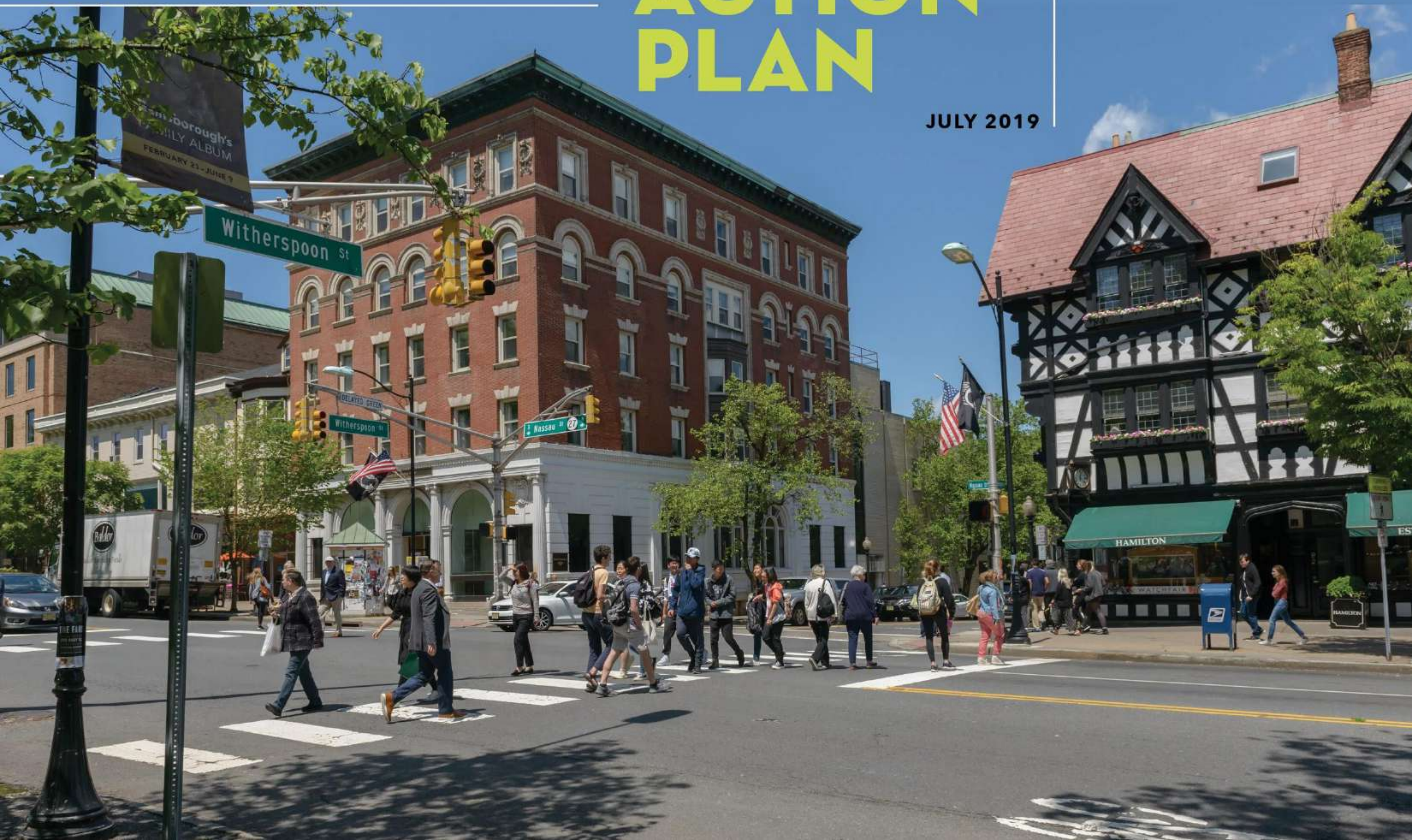
PRINCETON CLIMATE ACTION PLAN

JULY 2019



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Sustainable Princeton

Princeton New Jersey

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CLIMATE ACTION PLAN STEERING COMMITTEE

Nicole Collins Bronzan, Sr. | *Communications Officer,* RWJF
David Cohen | Councilman, Princeton Council
Eddie Cohen | K-12 Science Supervisor, Princeton Public Schools
Sophie Glovier | Chair, Environmental Commission
Jeff Grosser | Asst. Administrator/Health Officer, Municipality of Princeton
Kathy Klockenbrink | Co-owner, Jammin' Crêpes
Eric Larson | Sr. Research Engineer, ACEE/Princeton University
Bernie Miller | Former Princeton Councilman
Leighton Newlin | Co-Chair, Witherspoon Jackson Neighborhood Assoc.
Bruno Sarda | VP, Sustainability, NRG Energy, Inc
Matt Wasserman | President, Sustainable Princeton Board of Trustees
Shana Weber | Director, Princeton University Office of Sustainability

PROJECT LEADS

Christine Symington | Program Director, Sustainable Princeton
Molly Jones | Executive Director, Sustainable Princeton
Jenny Ludmer | Community Outreach Manager & Volunteer Coordinator

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Many of the actions in this plan incorporate research and recommendations provided by Princeton community members in recent years. The Princeton Climate Action Plan Steering Committee and Working Groups thank these community members for the following:

Environmental Commission's Waste Memo to Council - 5/11/15 [1]
Report of the Passive Open Space Advisory Committee - 11/23/15 [2]

ENERGY WORKING GROUP

Jackie Berger | President and Co-Founder, APPRISE
Heidi Fichtenbaum | Vice Chair, Environmental Commission
David Johnson | Ret. Research Physicist, Princeton Plasma Physics Lab
Wendy Kaczerski | Exec. Dir., The Concordia Foundation, Sustainable Princeton Founder
Tom Leyden | Sr. Director, EDF Renewables - Distributed Solutions
Ed Linky | Adjunct Professor, Sustainability Studies, Rutgers University
Adje Mensah | CEO, A.F. Mensah
Dylan Siegler | Sustainability Spec. & Consultant, NRG, Energy, Inc.

LAND USE & TRANSPORTATION WORKING GROUP

Alexandra Bar-Cohen | Board Member, Sustainable Princeton
Jim Constantine | Principal, Looney, Ricks, Kiss
Valerie Haynes | Trustee, Princeton Community Housing
Kim Jackson | Dir. Transportation and Parking, Princeton University
Tejal Patel | Asst. Municipal Engineer, PE, LEED AP, Municipality of Princeton Engineering Department
Tom Pinneo | Owner, Pinneo Construction
Lisa Serieyssol | Chair, Princeton Bicycle Advisory Committee
Zenon Tech-Czarny | Member, Princeton Planning Board
Gail Ullman | Vice Chair, Princeton Planning Board
Ralph Widner | Member, Transportation Trust Fund

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NATURAL RESOURCES WORKING GROUP

Sharon Ainsworth | Chair, Shade Tree Commission
Lily Krauss | Vice Chair, Shade Tree Commission & Landscape Architect
Wendy Mager | President, Friends of Princeton Open Space
Phyllis Marchand | Board Chair, D&R Greenway Land Trust, Former Mayor of Princeton Township
Linda Mead | Executive Director, D&R Greenway Land Trust
Richard Nosker | Commissioner, Parks & Recreation Department
Fran Price | Dir., Forest Certification Programs, The Nature Conservancy
Tammy Sands | Commissioner, Environmental Commission
Taylor Sapudar | Arborist, Municipality of Princeton
Holly Welles | Program Mgr., Carbon Mitigation Initiative, Princeton University

MATERIALS MANAGEMENT WORKING GROUP

Michael Chung | Sr. Manager Product Stewardship, Johnson & Johnson
Maurie Cohen | Professor of Sustainability Studies, NJIT
Liz Cutler | Sustainability Coordinator, Princeton Day School
Kim Dorman | Community Engagement Coord., Princeton Public Library
Robert Hough | Dir. of Infrastructure and Ops., Municipality of Princeton
Marco Ramirez | Commissioner, Environmental Commission
James Smirk | AP Envir. Ed. Instructor, Princeton Public Schools

RESILIENCY WORKING GROUP

George DiFerdinando, Jr., MD MPH | Princeton Board of Health, NJ Climate Change Alliance
Mark Freda | President, Princeton First Aid & Rescue Squad
Bob Gregory | Director of Operations, Princeton Department of Emergency and Safety Systems
Edith Juarez | Resident Service Coordinator, Princeton Community Housing
Mia Sacks | Member, Princeton Planning Board
Frank Setnicky | Director of Operations, Princeton First Aid & Rescue Squad

CAPERS TEAM (Climate Action Plan Emission Reduction Strategies)

William Atkinson | Fellow, Climate Central & CAPERS Team Lead | SiSi Peng (PU '19) | Clare Martin (PU '21) | Chris Lugo (PU '22) | Anika Sonig (PHS '19) | Justin Ripley (PU GS) | Rebecca Elyanow (PU GS) | Iris Stone (PU GS) | Jacob Schwartz (PU GS) | Dean Patel (NU '22) | Jessica Chen (PU '22) | Phil Chao, David Johnson

MARKETING & COMMUNICATIONS

Ellen Malavsky | Mkt. Communications Consultant, Sustainable Princeton
Sue Bannon, Graphic Design

VOLUNTEER WRITERS AND EDITORS

Betsy Garber | Sustainable Princeton Volunteer
Ned Higgins | Sustainable Princeton Volunteer
Gillian Reeder | Sustainable Princeton Volunteer

PHOTO CREDITS

Chris Coucill, Wiebke Martens, Weronika Plohn, Lauren Suchenski

INTRODUCTION

Climate change is here. Scientists around the world acknowledge that climate change will have serious environmental, public health and economic consequences from which it will be increasingly difficult to recover. While climate change is a global problem, it is felt locally. We can make changes in our own community — neighborhoods, schools, businesses large and small — that can ameliorate the impacts of a changing climate. In doing so, we will make our community a more equitable, sustainable, healthier and resilient place to live and work.

This Climate Action Plan (CAP) provides a roadmap to reduce Princeton's contribution to climate change and to prepare for its effects. It establishes an ambitious goal of reducing 80% of greenhouse gas emissions by 2050 (based on 2010 emissions). Achieving this goal will take the collective effort of the entire community working together to ensure Princeton remains a prosperous and vibrant town for future generations.

Palmer Square Park

The Princeton Climate Action Plan (CAP) is a community plan to **reduce greenhouse gas emissions** and **become more climate resilient.**

DEVELOPING THE PLAN

This plan was developed over a 16-month period using subject matter expertise from the community, extensive analysis, modeling, stakeholder input and community engagement to ensure buy-in and feasibility. Representatives from Princeton organizations and institutions critical to implementing the plan were involved to foster a sense of shared leadership and responsibility.

Steering Committee & Working Groups

A Steering Committee and five Working Groups representing Municipal boards, committees and commissions, staff and Council; local subject matter experts, community groups, schools and Princeton University developed the plan. Their role was to:

- Serve as a sounding board during plan development to ensure ideas are feasible and relevant to Princeton
- Offer subject-matter expertise and input to ensure the plan is forward-thinking and innovative and is connected with other municipal and regional initiatives
- Serve as ambassadors to respective stakeholder communities to ensure that Princeton residents, government and businesses are engaged throughout the process
- Represent the diversity of culture, race, gender, age and economic means within Princeton

Emissions Analysis

The Climate Action Plan Emissions Reduction Strategies (CAPERS) team was responsible for forecasting future emissions and modeling scenarios to estimate their potential to reduce Princeton's emissions. The CAPERS team was comprised of recent Princeton University undergraduates, graduate students, high school students and community members. It was supervised by a senior research engineer from the Andlinger Center for Energy and the Environment.

See Appendix D for a detailed description of the Climate Action Plan Development Process

Community Engagement

Over 80 meetings were held to discuss the plan. A draft of the plan was also made available online for feedback. In total, 2,900 Princeton community members attended an event, responded to surveys or interacted with the draft online.

Steering Committee and Working Group members met to evaluate climate mitigation and resiliency actions.

CAPERS team met weekly to analyze emissions reduction strategies.

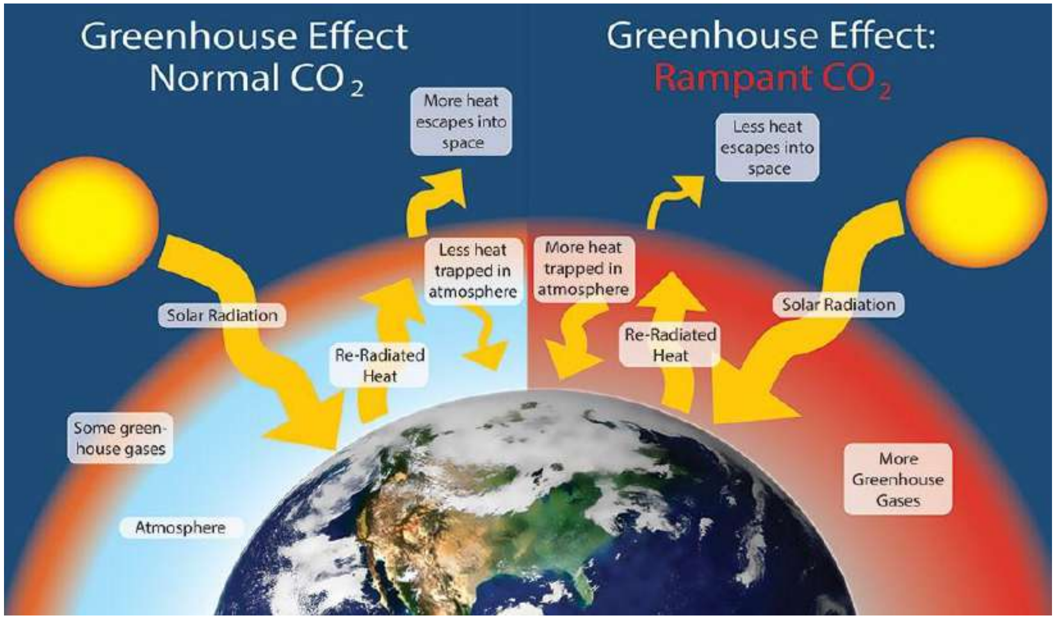
Community members offered ideas at Let's Talk Climate event

CLIMATE CHANGE SCIENCE

The Earth's atmosphere is naturally composed of a number of gases that blanket the surface and act like the glass panes of a greenhouse. These "greenhouse gases" (GHGs) absorb outgoing heat and re-radiate energy back down to the surface, warming the earth and making it stable and hospitable for life at an average temperature of 60°F. Without the natural warming effect of these gases the average surface temperature of the Earth would be around 14°F.

However, recently elevated concentrations of these gases in the atmosphere have had a destabilizing effect on the global climate, fueling the phenomenon commonly referred to as climate change. Carbon dioxide (CO_2) is the most important anthropogenic (caused or produced by humans) GHG in our atmosphere.

In May 2019, atmospheric CO_2 concentrations rose to 415 parts per million — the highest value in human history. The primary source of the increased CO_2 is the burning of fossil fuels, which is also at an all-time high. Other GHGs such as methane (CH_4) and nitrous oxide (N_2O) have gotten more concentrated with human activity as well.



Source: National Park Service, https://www.nps.gov/goga/learn/nature/climate-change-causes.htm

These additional heat-trapping gases have turned recent years record-hot. The last five years have been the hottest five on record, and 2019 is on pace to continue that trend. In fact, June 2019 was the hottest June on record for the globe. These trends are the foundation for the range of climate impacts that we are already experiencing (see page 9). Impacts will continue to worsen unless we substantially reduce our GHG emissions.

CLIMATE CHANGE IS HERE

Temperatures and precipitation have been increasing in the Princeton region. Local temperature data show that Mercer County has experienced a 3.6°F degree increase in average annual temperatures during the past century. During the same time period, average annual precipitation has increased two inches.

Furthermore, several local precipitation peaks have been recorded over the past several decades, with 2018 experiencing the highest annual precipitation ever recorded.

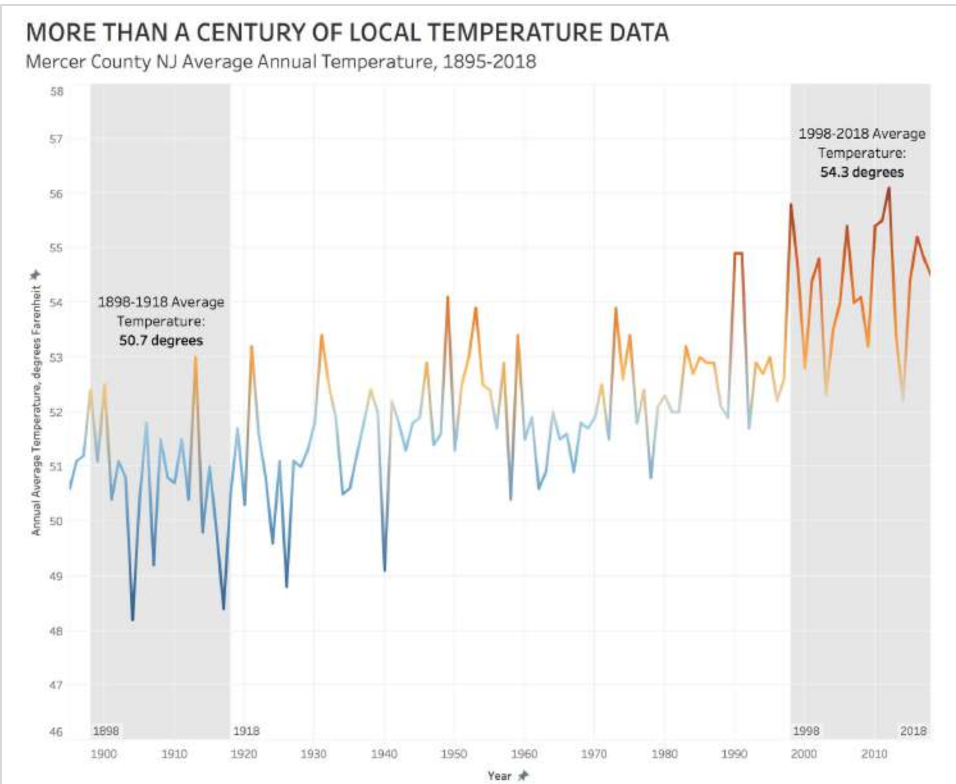


Figure 1. Mercer County, NJ temperature data 1895-2018. *Source: Office of the NJ State Climatologist (ONJSC)* *https://climate.rutgers.edu/stateclim/*

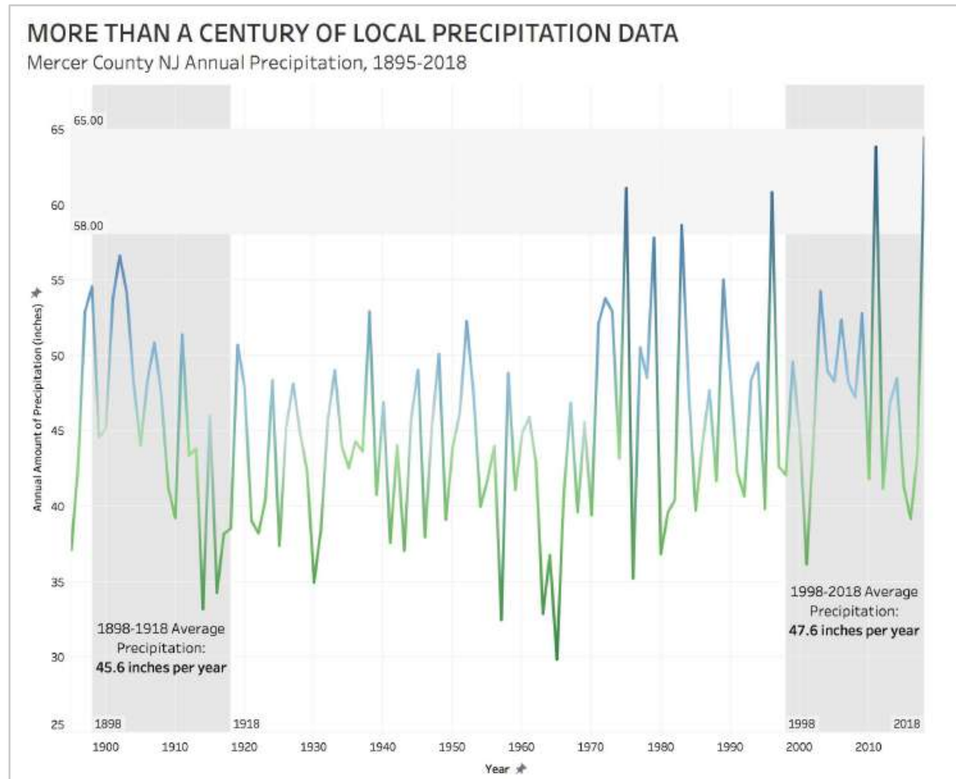


Figure 2. Mercer County, NJ precipitation data 1895-2018. *Source: Office of the NJ State Climatologist (ONJSC)* *https://climate.rutgers.edu/stateclim/*

CLIMATE CHANGE IMPACTS TO PRINCETON

Climate change affects everyone in Princeton and disproportionately affects Princeton's most vulnerable community members.

MORE FREQUENT HIGH HEAT DAYS

Extreme heat will exacerbate cardiovascular and respiratory conditions and diabetes. Princeton's elderly, young children, those lacking access to air conditioning, and outdoor laborers will be impacted the most.[8]

INCREASE IN HEAT RELATED ILLNESSES

Princeton's elderly, young residents and outdoor workers will suffer more from heat stroke. Pets will also be affected by the intense heat. Princeton residents without air conditioning as well as outdoor workers are at risk of heat-related illnesses and death.[10]

INCREASE IN AVERAGE TEMPERATURE

Princeton's natural habitat will be disrupted by temperature changes. Plant and animal species that are native to New Jersey or migrate through New Jersey will be impacted by climate change, in combination with other stressors.[9]

DECLINE IN OUTDOOR AIR QUALITY

Changing climate conditions influence the level and concentration of pollutants such as ground-level ozone (O_3), and particulate matter. Ground level ozone is a strong lung irritant that has been associated with increased hospitalizations for pneumonia, chronic obstructive pulmonary disease (COPD), asthma and allergies.[11]

CLIMATE CHANGE IMPACTS TO PRINCETON

Continued from previous page

HEAVIER RAINS

Flooding from heavier rains disrupts businesses, taxes our roads, infrastructure and waterways, damages property and increases risk of injury and death. Infrastructure damage from flooding and storms threatens access to medication and can disrupt electricity to power medical equipment for those with existing medical conditions.[12]

INCREASE IN VECTOR-BORNE DISEASES

Vector-borne and zoonotic diseases are expected to expand their ranges, including tick-borne illnesses and mosquito-borne diseases. An increase in precipitation and extreme weather events increases the risk of contracting food- and water-borne diseases.[14]

POTENTIALLY LONGER DRY SPELLS

Droughts brought on by climate change increase the frequency of wildfires which increase particulate matter emissions as well as ecological and infrastructural damage. Droughts impact crops and livestock; threatening the security of our food supply.[13]

IMPACTS TO MENTAL HEALTH AND WELLBEING

Extreme weather, changing weather patterns, damaged food and water resources, and polluted air impact human mental health. Impacts include increases in trauma and shock, post-traumatic stress disorder (PTSD), compounding stress, anxiety, substance abuse and depression.[15]

PRINCETON'S GHG EMISSIONS

Production-based carbon emission inventories are widely used by local, state and national governments. The U.S. Community Protocol for Accounting and Reporting Greenhouse Gas Emissions developed by ICLEI - Local Governments for Sustainability is the most frequently used protocol for measuring and tracking production-based emissions.

This inventory method allocates carbon emissions among the Commercial, Residential and Transportation sectors according to how much energy is used and the carbon intensity of energy in each sector. Emissions for solid waste are measured based on the tonnage of Solid Waste hauled to the landfill. Wastewater & Water are emissions from the energy used to treat water and wastewater.

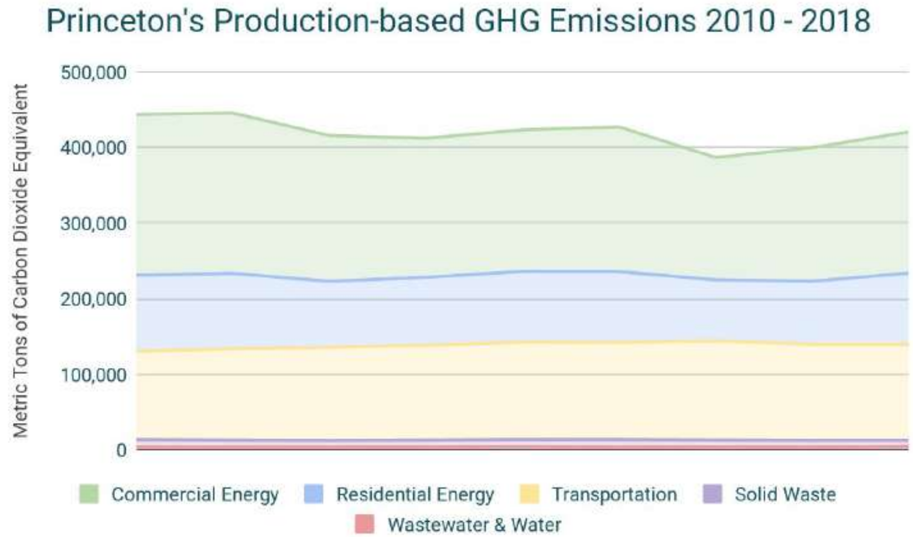
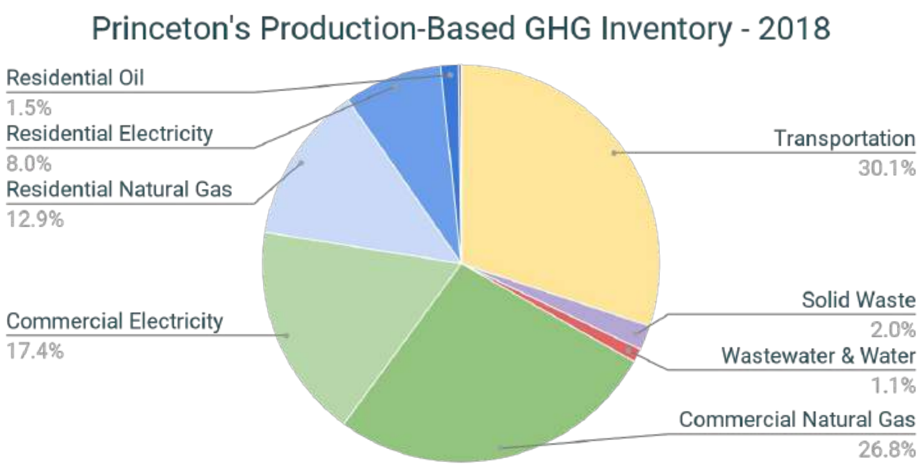


Figure 3. Princeton's production-based greenhouse gas inventory 2018. *See Appendix* Figure 3. Princeton's production-based greenhouse gas inventory 2018. *See Appendix B*



To make significant GHG emissions reductions and improve our quality of life locally, Princeton must especially reduce emissions from: Heating, cooling and the electrification of our buildings; Cars, trucks, buses and other vehicles.

Figure 4. Princeton's annual greenhouse gas emissions 2010-2018. *See Appendix B*

PRINCETON'S GHG EMISSIONS (continued)

Emissions Sector	Includes	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2e$)								
		Baseline 2010	2011	2012	2013	2014	2015	2016	2017	2018
Commercial	Use of electricity by the community, use of fuel in heating/cooling equipment (e.g., boilers, furnaces)	210,720	211,930	192,653	183,726	187,225	191,279	161,696	176,625	186,552
Residential	Single-family homes and most multi-family dwellings	100,306	99,801	87,146	86,873	93,445	93,694	80,720	83,296	94,158
Transportation	On-road passenger, transit and freight vehicles	117,151	120,795	123,286	125,474	128,893	128,573	131,217	127,050	126,810
Solid Waste	Generation and disposal of solid waste by the community	9,621	9,060	8,605	8,877	9,298	9,608	8,882	8,748	8,412
Wastewater & Water	Operation of water delivery facilities, use of energy associated with potable water, generation of wastewater, process emissions from the operation of wastewater treatment facilities	4,073	4,022	4,119	4,270	4,499	4,098	4,338	4,121	4,590
	Total	443,871	445,608	415,808	412,220	423,360	427,253	386,853	399,839	420,522

Table 1. Princeton's annual GHG emissions 2010-2018. *See Appendix B.*

PRINCETON'S GHG EMISSIONS (continued)

A production-based inventory is an important way of measuring Princeton's greenhouse gas emissions. However, it does not capture the emissions from the full life-cycle of the goods and services we utilize as a community. A consumption-based inventory complements a production-based inventory. It focuses on the consumption of goods and services by residents (such as food, clothing, electronic equipment, etc.). This approach captures the full life-cycle emissions of goods and services including those resulting from the extraction of the raw materials, to the manufacture, distribution, sale and disposal. Since a consumption-based inventory takes into account the full life-cycle emissions of goods and services, its emissions results are usually larger than a community's production-based inventory.

Reducing production-based emissions has local benefits.

Reducing consumption-based emissions reduces emissions globally.

Both are important to mitigate climate change.

Princeton's consumption-based inventory determined that emissions from residents' consumption profile are almost twice that of the community's production-based emissions. Reducing consumption emissions, however, is difficult to achieve as it relies on changes to individual habits and societal norms and varies greatly between individuals.

Approximation of Princeton's consumption-based emissions as compared to its production-based emissions.

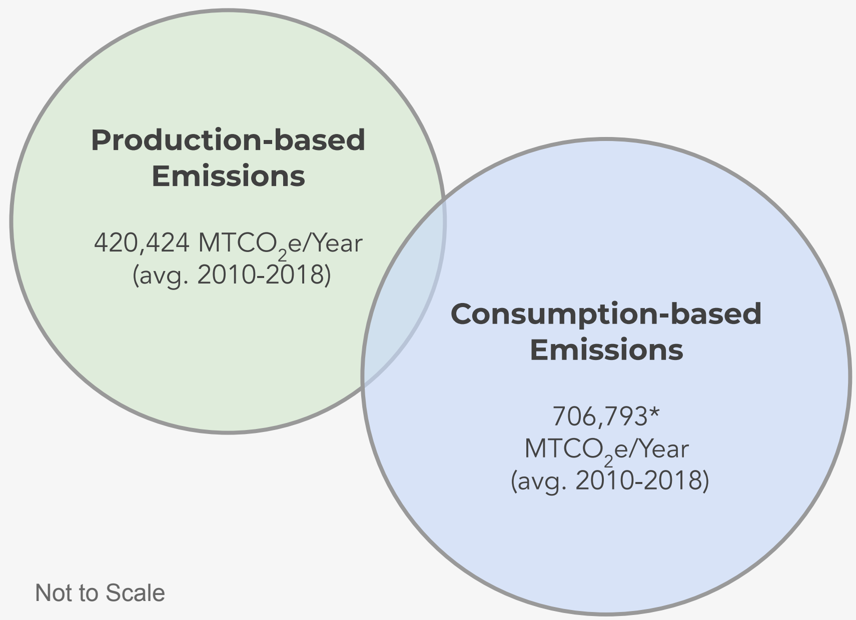


Figure 5. Comparison of Princeton's annual average production-based GHG emissions vs. consumption-based. *Source: CoolClimate; See Appendix B.*

*Note: Princeton's Carbon Emissions reduction goal will be measured against its Production-Based Emissions Inventory.

SETTING A GOAL & REACHING IT

To avoid the worst effects of climate change, science says that we must keep the global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 °C.

This Climate Action Plan is Princeton's effort to help meet this challenge and establishes a goal to reduce 80% of emissions by 2050 from the baseline year of 2010.

	Baseline 2010	2030 Target	2040 Target	2050 Target
		50% reduction	65% reduction	80% reduction
Annual community-wide GHG emissions ($MTCO_2e$)	444,693	222,347	155,643	88,939
Population (values are estimates)	28,621	36,048	36,946	37,866
Annual per-capita community-wide GHG emissions ($MTCO_2e$/person)	15.5	6.2	4.21	2.35

Table 2. Princeton's climate action plan greenhouse gas emissions goal projection.
See Appendix B.

SETTING A GOAL & REACHING IT (continued)

Princeton's goal is to reduce community-wide carbon emissions:

50% by 2030

65% by 2040

80% by 2050

from 2010 levels, while pursuing efforts to reduce 100% of emissions by 2050.

Progress of the Climate Action Plan will be reported every 3 years and the plan will be updated every 9 years.

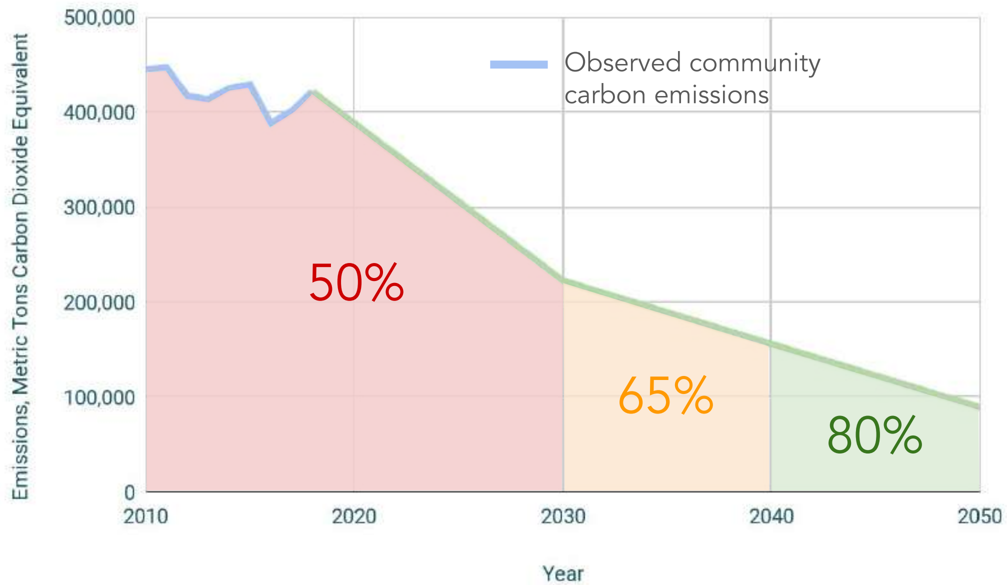


Figure 7. Princeton's climate action plan greenhouse gas emissions goal projection. *See Appendix C.*

PATHWAYS TO PRINCETON'S GHG REDUCTION GOAL

The Climate Action Plan Emissions Reduction Strategies (CAPERS) team modeled a number of scenarios to estimate their potential to achieve the goal of 80% reduction in emissions by 2050 based on 2010 levels.

Since emissions from the built environment and transportation are the largest sources of Princeton's emissions, the team focused on combinations of strategies in those sectors.

Emissions Grow with Population

Princeton's population continues its current growth of 1.47% per year until 2025; growth to 2050 follows DVRPC projections of 0.25% per year.

Observed community carbon emissions

Continued Efficiency Trend

Building and transportation efficiency trends continue at historical rates

Pathway to 80% reduction in carbon emissions by 2050

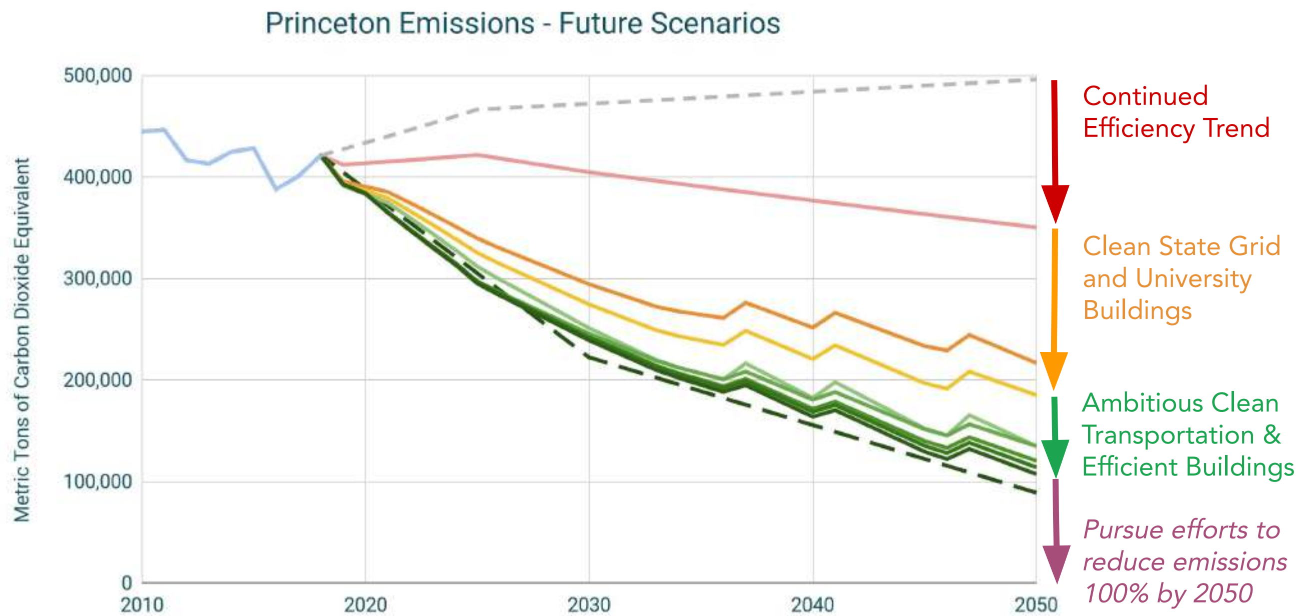


Figure 8. GHG emissions reduction strategy projections. *See Appendix C.*

Clean State Grid and University Buildings

- NJ achieves goal of zero emissions electricity by 2050
- Princeton University meets zero emissions goal by 2046 (excludes transportation)

Ambitious Clean Transportation & Efficient Buildings

- 50% vehicle miles traveled with electric vehicles by 2050
- Residential electricity supply from 100% renewables by 2025
- Reduction in commercial & residential gas usage by accelerated energy efficiency retrofits
- Zero-emission in-town trips (bike, walk, EV) by 2050

RELATIONSHIP TO OTHER PLANS

The CAP In Relation To Other Plans

The CAP does not replace nor revise the sustainability goals included in other community plans, namely the Princeton Community Master Plan and the 2009 Sustainable Princeton Community Plan. The CAP aims to complement these plans by considering their interrelated goals and strategies through the lens of climate change mitigation and resiliency. The CAP and community plans are connected in that they should all include certain actions to be accomplished.

The Princeton Community Master Plan

Embedding the Climate Action Plan mitigation and resiliency visions, objectives and actions into the Princeton Community Master Plan will be necessary to enable their completion. The addition of a Green Building and Environmental Sustainability Element and updates that embed the Climate Action Plan visions, objectives and actions into the Land Use, Future Housing Policies, Circulation, Utility Service, Communities Facilities, Open Space & Recreation, Historic Preservation, and Conservation Elements will be necessary. It is recognized that an overhaul of the Master Plan that follows contemporary best practices is also necessary to fully realize the Climate Action Plan visions, objectives and actions.

The 2009 Sustainable Princeton Community Plan

A climate action plan can be viewed as a subset of an overall sustainability plan. Sustainability plans typically incorporate the other two legs of the sustainability stool – economic sustainability and social sustainability – in addition to the environmental considerations. The Sustainable Princeton Community Plan was released in 2009 and reviewed in 2017. It is expected that it will be revised and harmonized with this Climate Action Plan in the future.

Nassau Street

Mary Moss Park

Marquand Park

HOW TO READ THE PLAN

1		2	3	4	5	6	7	8
OBJECTIVE 3: Promote mixed-use development and pedestrian- and transit-oriented, location-efficient neighborhoods		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever(s)	Related Plans	Potential Funding Sources
3.1	Adopt a Green Building and Sustainability Element into the Master Plan and integrate the principles of transit-oriented and location-efficient development		N/A	Short-term/ Initiated	PB/PD	Policy	Master Plan	Transit Village Initiative

1 **OBJECTIVES & ACTIONS**
The broad and big-picture activities or changes that must occur to make significant progress in reducing community-wide GHG emissions or be more resilient to climate change.

2 **CO-BENEFITS**
The primary, additional positive benefits related to the reduction of GHG.

- Promotes Equity: Ensures those most impacted by climate change are prioritized and that costs and benefits of climate mitigation and resiliency are equitably distributed
- Fosters Economic Sustainability: Improves levels of critical services, infrastructure, resource efficiency, labor and productivity and promotes low-emission economic development, e.g., green jobs, clean technology
- Improves Local Environmental Quality: Improves local air and water quality, reduces pollution, preserves habitat diversity and ecosystems
- Enhances Public Safety and Health: Reduces impacts on human physical and mental health and improves disaster planning and management
- Builds Resilience: Reduces damage costs and disruption of critical services, e.g., energy, water, communication, transportation

3 **CARBON REDUCTION POTENTIAL**
(based on annual average MTCO$_2$e for 2019-2050)
Low: 0 - 1,000
Medium: 1,001 - 5,000
High: 5,001 +
N/A: Analysis requires more information, cannot be determined, or is not applicable

4 **TIMEFRAME/STATUS**
Short-term (2019-2024): Important to start early, relatively easy and quick to implement, precursors for additional actions

Long-term (2025-2035): More difficult or time-intensive to implement, contingent upon new funding sources, preliminary research, or coordination with partner entities, a logical follow-on to a short-term action

5 **LEADER/PARTNER(S)**
(see Appendix for abbreviations)

Leader: Lead organization responsible for seeing the action through to completion

Partner: Supporting organization necessary to enable the Leader to complete the action

6 **LEVER(S)**
Education, Infrastructure, Management, Policy

7 **RELATED PLANS**
State, regional and community plans that support or overlap with the action

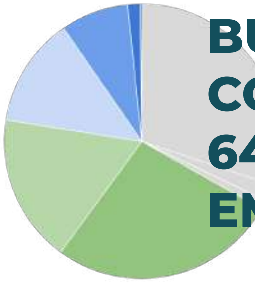
8 **POTENTIAL FUNDING SOURCES**
Potential funding sources, financial mechanisms or grants that can be leveraged to offset the costs to implement the action

ENERGY

Our Vision: All Princeton community members efficiently use clean, reliable and affordable energy.

Buildings are Princeton's single largest source of GHG emissions. These emissions come from residential and commercial buildings consuming electricity and burning natural gas. Reducing carbon emissions from building energy use requires improving energy efficiency and reducing the carbon intensity of Princeton's energy supply, primarily by increasing renewable sources of electricity. Climate change will shift building heating and cooling demands. By 2050, Princeton will experience hotter temperatures, increasing energy use and costs for cooling.

Low-income residents in Princeton spend up to 21% of household income on energy bills. Implementing energy efficiency programs and initiatives will help to reduce emissions while also reducing the costs to low- income households.



BUILDINGS CONTRIBUTE 64% OF COMMUNITY EMISSIONS (2018)

Last year approximately 3% of electricity provided by our utility was generated from renewable sources. Efforts that promote the development of more renewable energy sources will help displace non-renewables from our electricity supply.

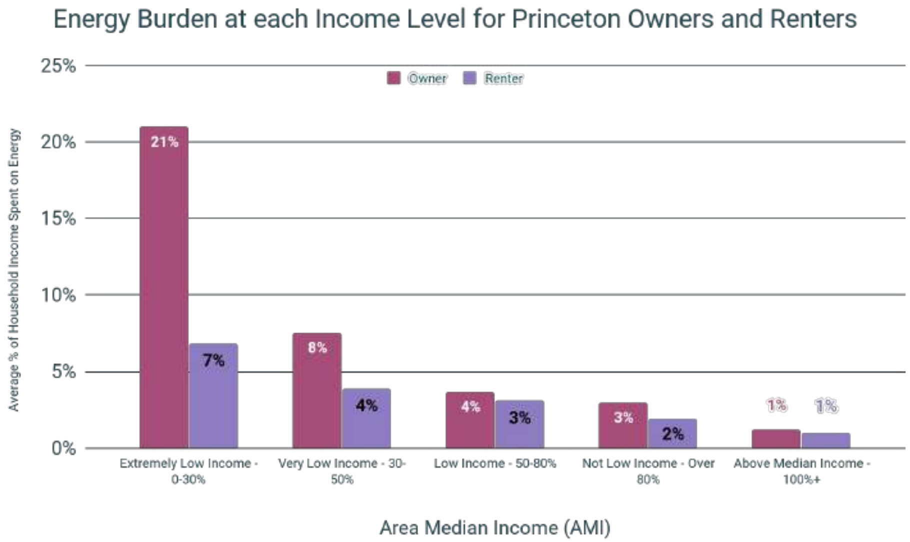


Figure 9. Energy burden for Princeton residents.
Source [Low-Income Energy Affordability Data (LEAD) Tool]

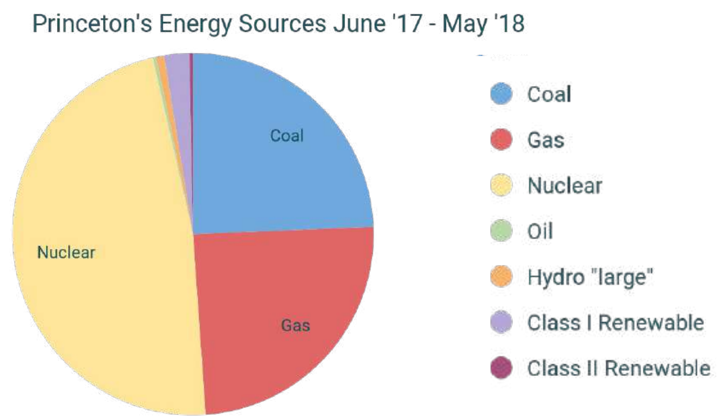


Figure 10. PSE&G Supplied Electricity Electricity Year (EY) 18.
Source:https://corporate.pseg.com/-/media/pseg/corporate/corporate-citzenship/environmentalpolicyandinitiatives/environmental_label2018.ashx

Since 2006, 558 properties in Princeton have utilized NJ Clean Energy & PSE&G programs to offset the cost of energy efficiency upgrades.

Building Type	2006-2017 Energy efficiency upgrades
Residential	384
Commercial	174

Table 3. Historical NJ Clean Energy Program participation for Princeton residential and commercial property owners. *Source: NJ Board of Public Utilities*

To date, 174 commercial buildings have been upgraded with more efficient HVAC systems, insulation and lighting, thereby saving money on operating costs and improving the comfort of occupants.

Princeton's River Road 3 megawatt (MW) Solar Array was constructed in 2017 atop an 8-acre closed and capped municipal landfill. The array supplies up to 25% of the energy needs for the Stony Brook Regional Sewerage Authority (SBRSA)

3MW Solar array at former landfill at the Municipality of Princeton's River Road facility.

Since 2004, over 120 homes, businesses, nonprofits have installed rooftop or ground-mounted solar photovoltaic arrays.*

*Ideally, healthy trees (as determined by a Princeton-registered arboricultural company) should be preserved where they would likely diminish the efficiency of solar panels, and solar panels should be installed where trees won't be grown.

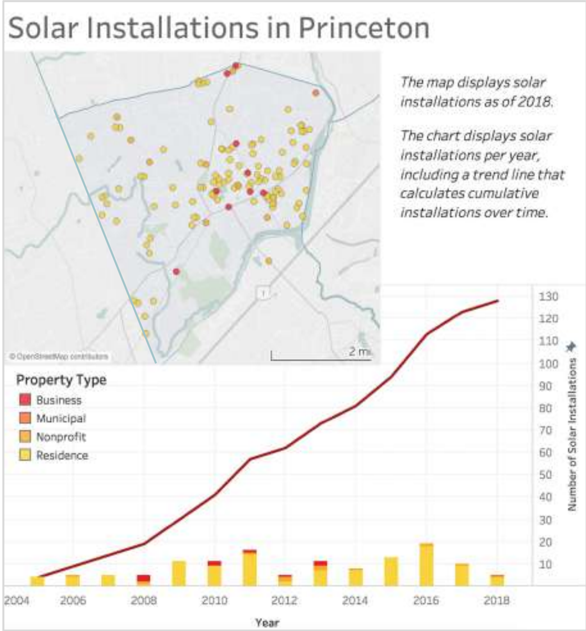


Figure 11. Solar PV installations in Princeton since 2004. *Source: NJ Board of Public Utilities*

OBJECTIVE 1: Reduce emissions in the built environment		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
1.1	Accelerate residential and commercial participation in state and utility energy efficiency programs		High	Short-term/ Initiated	SP/EC	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G
1.2	Require large commercial buildings and multi-family buildings to benchmark and report their energy performance		N/A	Short-term	PC/EC	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G
1.3	Require an energy audit and disclosure at time of sale or lease for older residential, commercial and multi-family buildings		Medium	Short-term	PC/EC	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G
1.4	Investigate the ability to provide energy efficiency incentives to middle-income homeowners, addressing a gap in the NJ Clean Energy Program		N/A	Long-term	SP/EC	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G
1.5	Adopt policies and programs to ensure new buildings in the community achieve near-zero/net energy/fossil fuel-free performance		N/A	Short-term	PC/EC,SP, PB	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G
1.6	Explore options to accelerate affordable electrification of building energy systems		Medium	Long-term	SP/EC	Education, Policy	NJ Energy Master Plan	NJ Clean Energy & PSE&G

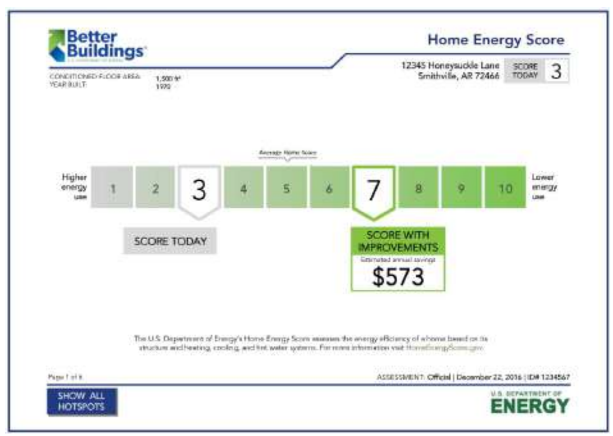
ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

LEED FOR HOMES

ENERGY STAR HOMES

PHIUS Passive House Institute US

A variety of energy efficiency programs and certifications exist for homes to achieve a low- or no-carbon footprint.



Developed by the U.S. Department of Energy, the Home Energy Score reflects the energy efficiency of a home based on the home's structure and heating, cooling, and hot water systems. This information, available to homeowners and prospective buyers, provides actionable measures to reduce emissions.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

OBJECTIVE 2: Increase the supply of low-carbon, affordable, reliable energy		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
2.1	Pursue community solar and ensure maximum participation of low- to moderate-income households		Medium	Short-term/ Initiated	PC/SP,PCH, PHA	Education, Policy, Management	NJ Energy Master Plan	
2.2	Pursue Renewable Government Energy Aggregation (R-GEA) at a price lower than the default electricity rate for residents		High	Short-term/ Initiated	PC/SP	Education, Policy	NJ Energy Master Plan	
2.3	Increase adoption of low-carbon, on-site power generation, e.g., rooftop solar, ground source heat pumps		N/A	Short-term	SP	Education	NJ Energy Master Plan	
2.4	Implement microgrids at Princeton's critical facilities, e.g., police and fire stations		N/A	Short-term	PC/PPS, SP	Infrastructure Management	NJ Energy Master Plan	NJ DEP

A Community solar project is a local solar facility shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced. It reduces energy bills for low- and moderate-income residents and supports the development of more renewable energy in NJ.

Renewable Government Energy Aggregation allows municipalities to aggregate the energy requirements of residential customer accounts so that the participating customers can purchase electric supply at prices lower than the average utility price, with higher renewable energy content.

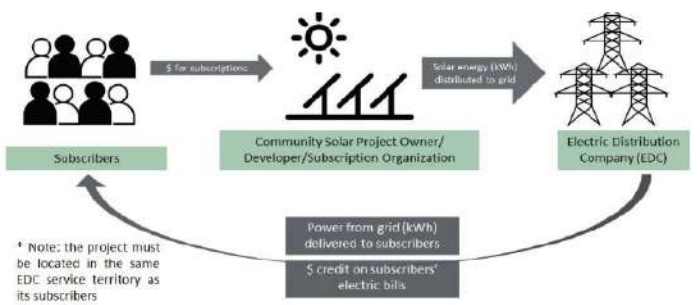


Image Source: http://njcleanenergy.com/renewable-energy/programs/community-solar

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ENERGY | Measuring future progress

Key Performance Indicator		Target
Number of energy efficiency retrofits	➤	400 homes by 2030, 100 commercial buildings by 2030
Percentage of residential electricity use from renewables	➤	100% by 2025
Community Solar implementation	➤	100% of low- and moderate-income households by 2025, 2,000 other subscribers by 2025
Number of Microgrids	➤	To be determined

BEYOND PRINCETON

National, regional and state policies, programs, plans and initiatives that may enable Princeton to meet its CAP goals.

NEW JERSEY'S ENERGY MASTER PLAN (EMP) is due to be updated in December 2019. The EMP is a strategic plan to accomplish the state's goal of 100% clean energy by 2050. It will play a role in Princeton's ability to meet its GHG reduction and climate resiliency goals.

NJ CLEAN ENERGY & UTILITY PROGRAMS provide rebates and incentives to residential and commercial customers for energy efficiency upgrades and renewable energy projects. They are a source of funding for energy efficiency and renewable energy actions in this plan.

PROPERTY ASSESSED CLEAN ENERGY (PACE) financing is being considered by the NJ State Legislature. PACE is a funding mechanism for energy efficiency, renewables, and resiliency improvements.

The REGIONAL GREENHOUSE GAS INITIATIVE (RGGI) is a market-based program to reduce GHG emissions by placing a cap on emissions from large power plants in the region. Proceeds from RGGI can be used for energy efficiency, renewable energy, bill payment assistance and GHG abatement.

A CARBON FEE AND DIVIDEND is a market-based mechanism for reducing carbon emissions. The Energy Innovation and Carbon Dividend Act of 2019 (H.R. 763) is a bill in the U.S. House of Representatives that proposes a fee on carbon at the point of extraction to encourage market-driven innovation of clean energy technologies to reduce greenhouse gas emissions.

Updates to the **INTERNATIONAL ENERGY CONSTRUCTION CODE® (IECC®)** that require higher energy efficiency minimums for new construction and major renovations is necessary to realize lower emissions from the built environment.

LAND USE & TRANSPORTATION

Our Vision: All Princeton community members have access to safe, affordable, low-carbon housing and transportation.

PRINCETON'S GHG EMISSIONS (continued)

The CoolClimate calculator developed by University of California, Berkeley, allows an individual to estimate their household's carbon footprint. An average Princeton household's carbon emissions result from the goods and services it consumes, 27% from their travel, 26% from housing and 12% are a result of their food choices. A household's footprint can vary based on the number of cars they own, the size of their home, the distance of their commute, etc.

To reduce GHG emissions that are produced outside our community as a result of our consumption choices, we must:

- **consume less,**
- **choose options with a smaller carbon footprint,**
- **and extend the useful life of the things we possess.**

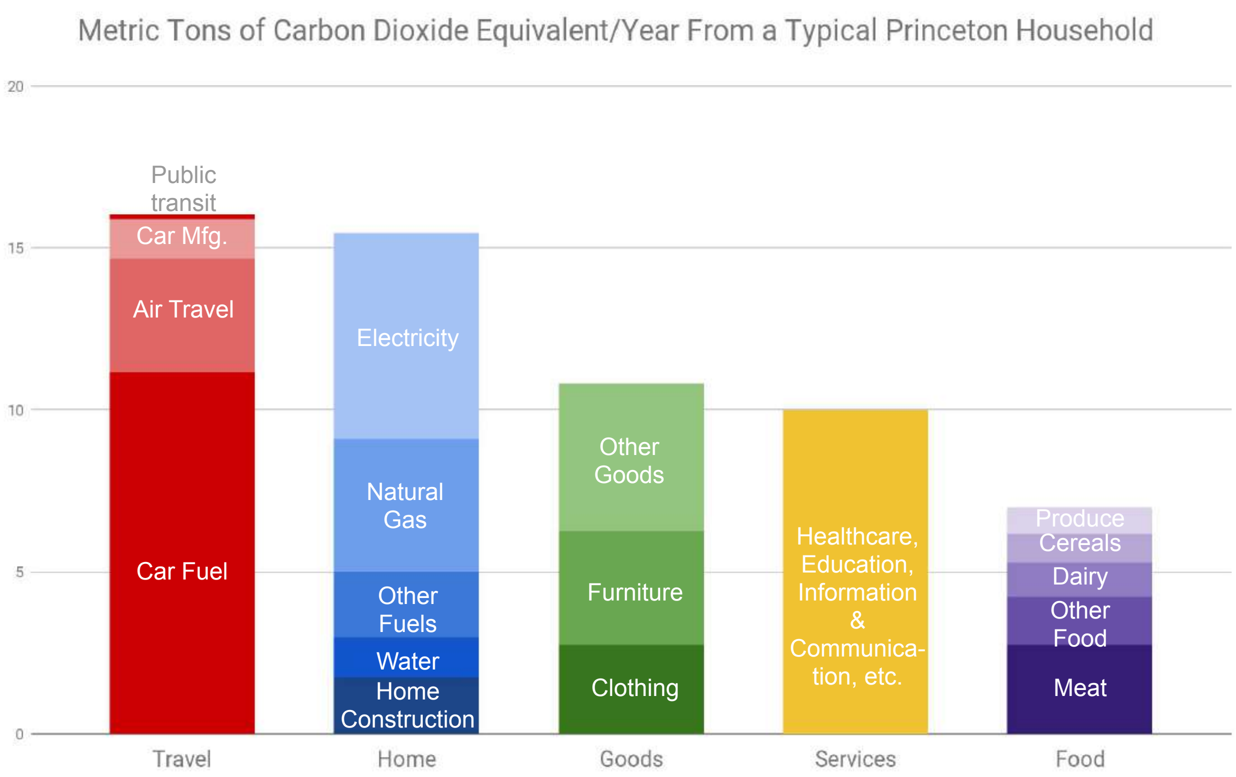
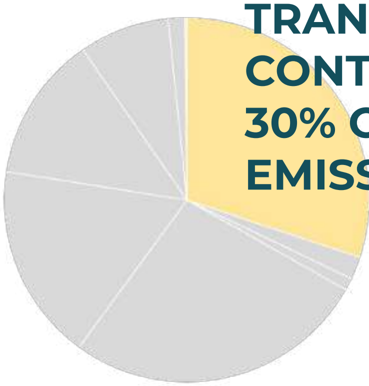


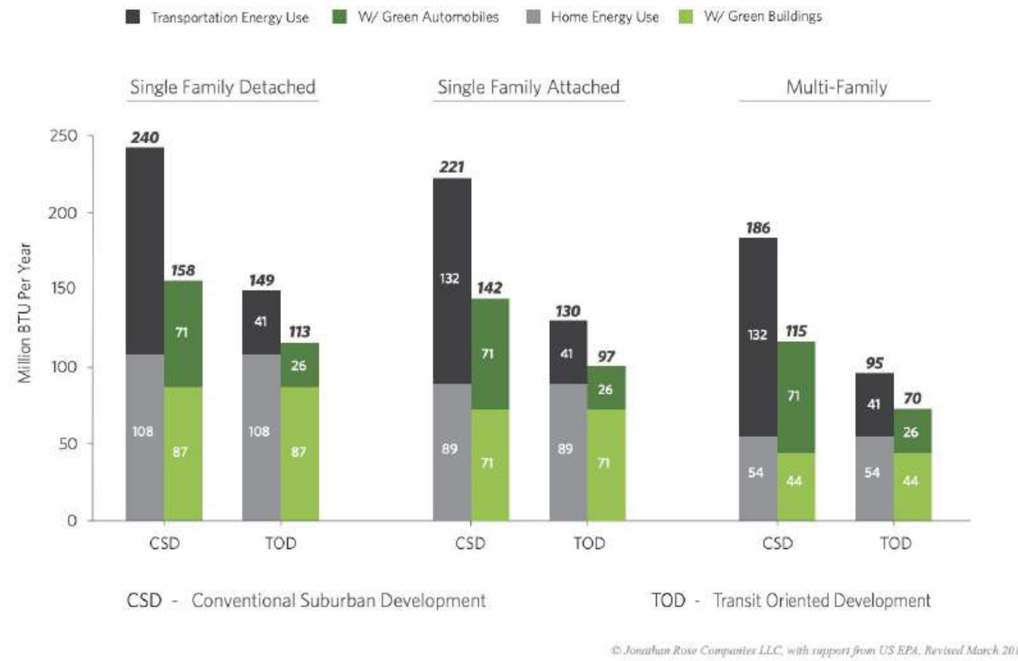
Figure 6. A typical Princeton household's consumption-based GHG emissions. *CoolClimate; See Appendix B.*



TRANSPORTATION CONTRIBUTES 30% OF COMMUNITY EMISSIONS (2018)

Princeton is expected to grow over the next decade. If Princeton meets this growth with inefficient land use and transportation policies, per capita GHG emissions will increase. New growth, if managed well, can support Princeton's efforts to reduce emissions. Land use policies that support location-efficient, pedestrian- and transit-oriented and mixed-use development represent major opportunities to reduce Princeton's GHG emissions. Additionally, reducing the number and length of vehicle trips, increasing the number of people moved per vehicle, and increasing the number of clean vehicles on the streets will significantly reduce Princeton's transportation-related emissions.

The combination of compact development built with green building features, close to transit and supporting zero-emission vehicles has the most potential to reduce energy use.



Location Efficiency: Household and Transportation Energy Use by Location

Figure 12. Location Efficient & Transit Oriented Development.
Source: https://www.epa.gov/smartgrowth/location-efficiency-and-housing-type

Downtown Princeton with a mix of retail, office space, and residential property, access to transit routes and pedestrian-friendly infrastructure.

In 2017, Princeton incorporated the Bicycle Mobility Plan into the Circulation Element of the Community Master Plan. The plan includes a list of priority actions that can reduce emissions by creating the infrastructure for lower-emission and less expensive transportation options.

Figure 13. A snapshot of the proposed bicycle network identified in the 2017 Bicycle Mobility Plan.
See Appendix F

Princeton Bike Share is a collaboration between the Municipality of Princeton and Princeton University. There are currently 19 stations and over 100 bikes in the system managed by Zagster.

Zagster is a bikeshare platform

The freeB, Princeton's community bus service, was launched in 2008 and provides free public transportation to the community. Average daily passenger trips increased 54% between 2015 and 2018. In 2018, GPS tracking was added to shuttles to provide real-time arrival information.

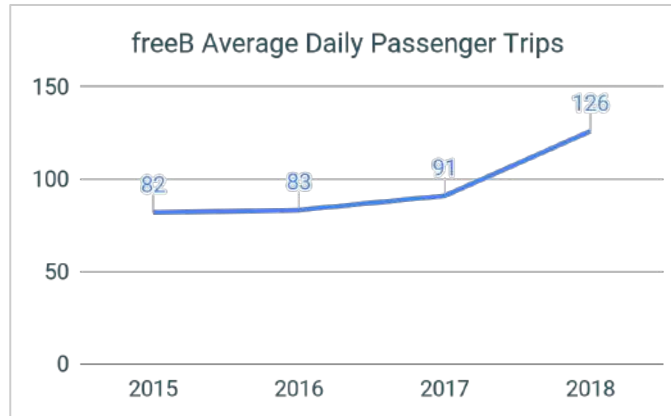


Figure 13. Annual average daily freeB ridership data *See Appendix B.*

The freeB connects riders with the NJ Transit 605 bus line and Princeton University's Tiger Transit bus line which, is free and available to the public.

OBJECTIVE 3: Promote mixed-use development and pedestrian- and transit-oriented, location-efficient neighborhoods		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
3.1	Adopt a Green Building and Sustainability Element into the Master Plan and integrate the principles of transit-oriented and location-efficient development		N/A	Short-term/ Initiated	PB/PD	Policy	Master Plan	Transit Village Initiative
3.2	Develop a form-based code that will ensure location-efficient and transit-oriented building design and siting and improves the development review and permitting process, increasing its predictability for developers		N/A	Short-term	PC/PB	Policy		DVRPC
3.3	Use incentives such as density bonuses and parking credits to promote affordable and accessible housing development that is transit-oriented and location-efficient		N/A	Short-term	PC/PB,EC	Policy		Transit Village Initiative
3.4	Prepare plans and update zoning regulations in selected areas to build mixed-use, transit-oriented and location-efficient development: Lower Alexander Rd., S2 Zone, Clifftown Center, Princeton Shopping Center, Nassau North, Lower Witherspoon and other areas near transit routes		N/A	Short-term	PB/PC,PD	Policy		DVRPC

Mixed-use development and pedestrian- and transit-oriented and location-efficient neighborhoods contribute fewer GHG emissions by using resources more efficiently.

A representation of a mixed-use development and pedestrian- and transit-oriented, location-efficient neighborhood.

Mixed-use development in downtown Princeton.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

	OBJECTIVE 4: Reduce community-wide vehicle miles traveled by switching to public transit, bicycling and walking	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
4.1	Develop and implement community-wide, comprehensive Traffic Demand Management (TDM) programs that offer cost-effective and convenient alternative transportation services that reduce travel demand and traffic congestion		Medium	Short-term	PTAC/ GMTMA	Management	Master Plan	
4.2	Improve the user experience, convenience and frequency of TigerTransit, free-B and the jitney systems of the Institute for Advanced Study, Princeton Theological Seminary, Westminster Choir College of Rider University, and encourage use by students of public and independent schools		N/A	Short-term	PTAC/ GMTMA	Infrastructure, Management	Master Plan	
4.3	Ensure ridership by instituting an intensive and continuous transit information and education campaign (i.e., Transit Princeton) that includes elements such as public wayfinding signs, Wi-Fi enabled, and real-time information about transportation options		N/A	Short-term/ Initiated	PTAC/ GMTMA, SP	Management	Master Plan	
4.4	Require employers with more than 50 employees and new developments that will have more than 50 employees to implement transportation demand management programs		Medium (included in 4.1)	Short-term	PC/ GMTMA, PB	Education, Infrastructure	Master Plan	

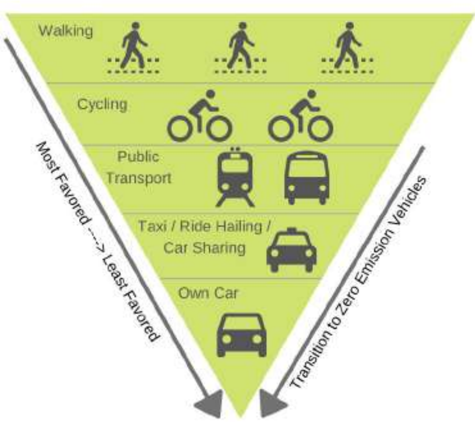


Figure 14. The mobility hierarchy prioritizes low-emission modes of transport over higher-emission modes.

Actions in the Land Use & Transportation sector follow a mobility hierarchy which favors infrastructure and community design that promotes low-emission modes of transport over higher-emission modes. Walking, cycling and using the most fuel-efficient public transportation are the modes of transport that produce the fewest GHG emissions.

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	OBJECTIVE 4: Reduce community-wide vehicle miles traveled by switching to public transit, bicycling and walking (con't)	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
4.5	Implement Princeton's Bicycle Mobility Plan and its prioritized commuter and school routes		Low	Short-term/ Initiated	ED/PBAC, GMTMA, PPD	Education, Infrastructure	Master Plan	
4.6	Promote alternatives to car ownership such as car sharing and bike sharing (e.g., Zip Car, Greenspot, Zagster) and implement curbside management locations for the staging and loading of passengers to support the shift to ridesharing (e.g., Uber, Lyft)		Low	Short-term	PTAC/SP, GMTMA	Education, Infrastructure	Master Plan	
4.7	Work with regional partners to plan for transit and traffic management in the U.S. 1 corridor and neighboring municipalities		N/A	Short-term	CTPA/PC	Infrastructure, Policy	Master Plan	
4.8	Ensure the potential transition to autonomous vehicles increases public safety, serves the mobility disadvantaged and leads to a reduction in vehicle miles traveled and emissions		N/A	Short-term	PTAC	Infrastructure, Policy	Master Plan	

Princeton's Bicycle Mobility Plan includes actions with high potential for GHG emissions reduction such as priority bike routes, a Bicycle Parking Ordinance, permanent and/or temporary open streets events that close roadways to vehicular traffic allowing enjoyment of the space for other purposes and activities, bicycle safety education for K-12 students, and Complete Streets training for the Police Department and the Department of Infrastructure and Operations.

The temporary bicycle rack on Witherspoon St. and the covered bike parking in the nearby Spring Street Garage are examples of infrastructure that reduces traffic congestion by providing convenient locations for a mode of transport that requires less physical space.

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	OBJECTIVE 5: Expand access to zero-emission vehicles	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
5.1	Partner with car sharing companies to increase access to zero-emission vehicles		N/A	Short-term	PC/PTAC,SP	Education, Management		
5.2	Require all new development to provide electric vehicle charging infrastructure in appropriate locations		N/A	Short-term	PC/EC	Infrastructure, Policy		NJ DEP, PSE&G
5.3	Promote the installation of visible and accessible zero-emission fueling stations for use by the public		N/A	Short-term/ Initiated	SP	Infrastructure, Management		NJ DEP, PSE&G
5.4	Transition fleets and public transit vehicles to zero-emission		Low	Short-term	DIO,PPS,PU /GMTMA	Education, Infrastructure, Management		NJ DEP, PSE&G, DOE, FTA

As of 2018, there were approximately 610 electric vehicles (EV) registered in Princeton, and NJ ranked sixth in the nation for EV sales. There are currently six Level 2 charging stations in Princeton, as well as one Tesla port..

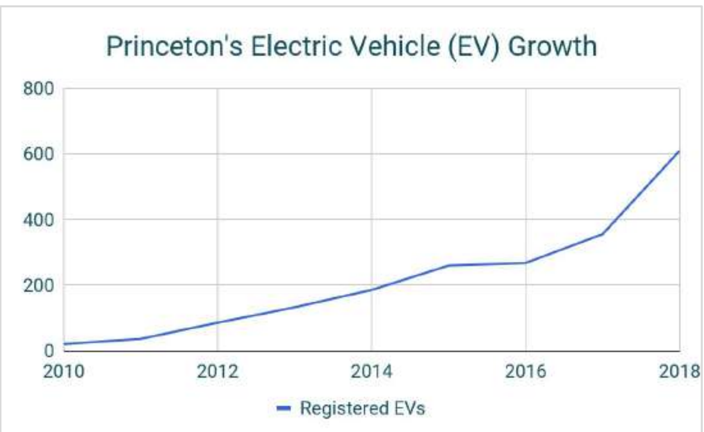

Figure 15. Princeton's Annual Electric Vehicle Registrations. *Source: NJ DEP Appendix B.*

Level 2 public EV charging stations are currently located in Spring Street Garage, Chambers Street Garage and at the Princeton Shopping Center. Preferred locations for future charging stations are workplaces and near public transit.

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Key Performance Indicator	Target
Number of publicly available EV chargers in Princeton	20 by 2025
Percentage of registered privately-owned zero-emission vehicles	Target to be determined
Percentage of zero-emission vehicles in fleets	75% of sedans and SUVs by 2035 50% of medium- and heavy-duty vehicles by 2035
Affordability Index: average housing and transportation cost as percentage of income	Target to be determined
Percent of households living within 1/4 mile of public transit and daily services	Target to be determined
Mileage of new and upgraded bike lanes	Target to be determined
Percent of commutes made by public transit, biking, walking or carpooling	Target to be determined
Reduce vehicle miles traveled by single occupancy vehicles	Target to be determined

BEYOND PRINCETON

National, regional and state policies, programs, plans and initiatives that may enable Princeton to meet its CAP goals.

The **CENTRAL JERSEY TRANSPORTATION FORUM (CJTF)** addresses concerns of municipalities in Mercer, Middlesex, and Somerset counties and focuses on the US 1, US 130, and US 206 corridors. High-level representatives from 25 municipalities including Princeton, three counties, numerous state agencies meet to coordinate, discuss transportation and land use issues, and implement solutions. The Forum implements projects, encourages multi-municipal approaches to solve problems, and provides technical assistance to local governments. The key issues it addresses are east-west access; improving coordination of transportation and land use in this high growth, congested area; and transit.

Proposed **NJ SENATE BILL S2252/A4819** will establish a statewide public plug-in EV charging system, improve EV infrastructure, establish incentives for purchases of light-duty electric vehicles and set requirements for a gradual electrification of NJ Transit and state-owned non-emergency light duty vehicles.

NATURAL RESOURCES

Our Vision: All Princeton community members benefit from a healthy and resilient ecosystem.

Princeton is fortunate to have a number of natural spaces that provide multiple benefits for the community, including the provision of clean air and water, recreational opportunities, and wildlife habitat. Many of Princeton's natural systems and surrounding natural areas will be impacted by climate change, threatening important benefits such as water filtration and flood abatement. Although not formally accounted for in Princeton's GHG inventory, natural ecosystems such as forests capture and store carbon, acting as carbon "sinks." Proper ecosystem management can optimize this process of carbon sequestration, as well as minimize the potential risks posed by climate change.

With 55% of Princeton's canopy footprint, Princeton tree carbon storage is equivalent to about 2 years of our CO_2 emissions. The growing trees in Princeton are annually sequestering a carbon equivalent of approximately 4% of our emissions. 27% of Princeton's area is groundcover, with some potential for reforestation.

Areas of forest and fields capture and store carbon. Princeton's tree canopy also helps to reduce urban heat island effects in developed areas.

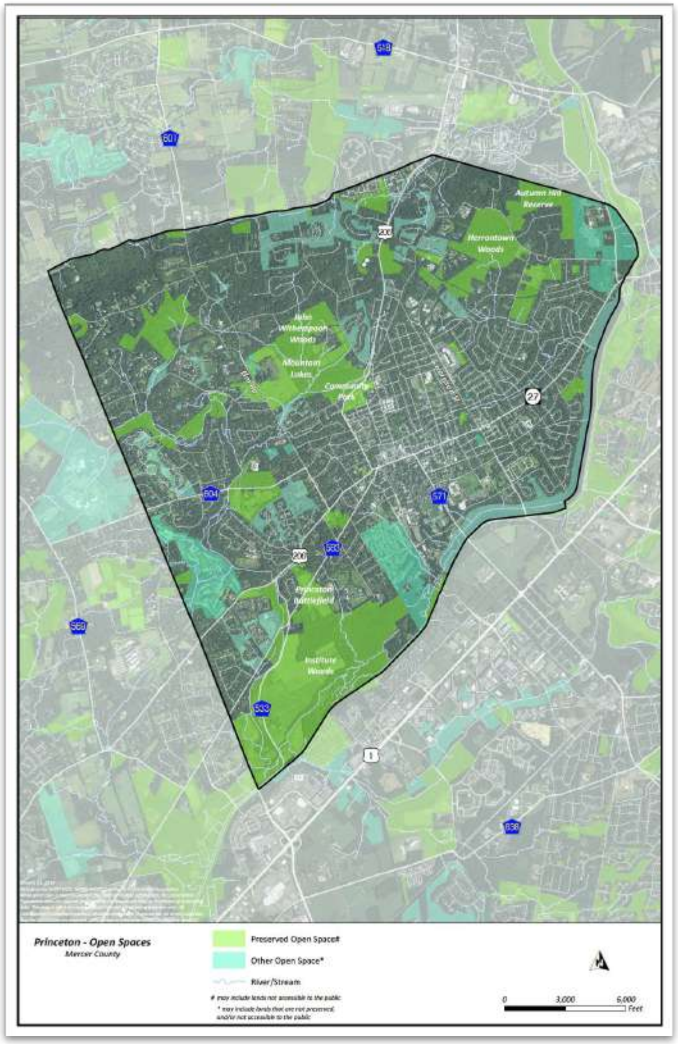
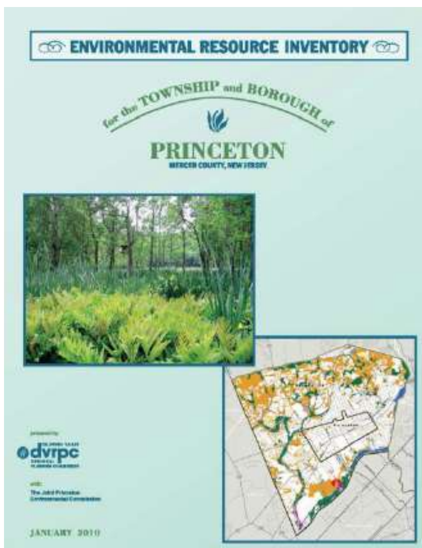


Figure 16. Map of Princeton's preserved Open Space 2018.

Completed in 2010, the Princeton Environmental Resource Inventory (ERI) identifies the types of land, water bodies, trees, plants and wildlife within Princeton's boundaries. The ERI details Princeton's history and climate, landscape topography, surface water assessment, soil classification, and lists of vegetation and wildlife.The ERI is an important tool for Princeton's Environmental Commission, Planning Board, and Zoning Board. ERIs are dynamic documents and should be revised and refined as additional information and updated data become available. The ERI is an important land use tool as the natural resources it identifies should be taken into account during land use decision-making processes.

Certified Wildlife Habitats have doubled in Princeton since 2008. These habitats provide food, water, cover and places to raise young for birds, butterflies and other native species. Monarch Waystations have also been helpful to support a species sensitive to climate change.



Cover page of Princeton's Environmental Resource Inventory. https://drive.google.com/file/d/1VkQi WMqcycTFLhyg4WhX5im7Q5EuYzli/view

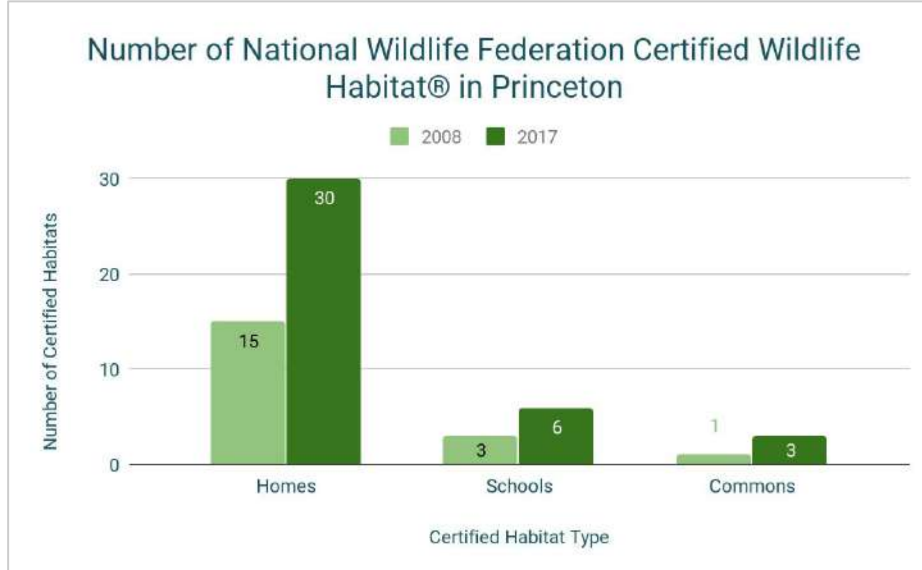


Figure 17. National Wildlife Federation Certified Wildlife Habitat in Princeton. *Source: National Wildlife Federation.*

A monarch butterfly habitat is an example of how Princeton can use its natural spaces to support native species that are sensitive to climate change.

OBJECTIVE 6: Protect and enhance local natural resources that provide carbon capture; reduce flooding and heat island impacts		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
6.1	Update the Master Plan Open Space and Conservation Elements to add more parcels of significance to preserve as open space and mitigate the effects of climate change	Promotes Equity, Enhances Public Safety and Health, Builds Resilience	Medium	Short-term	PC/PD,EC	Policy	Open Space Plan	
6.2	Establish a campaign to educate residents, landscapers, municipal staff, garden clubs and other practitioners about low-maintenance landscaping, protecting native species and preventing the spread of invasive species	Improves Local Environmental Quality, Builds Resilience	N/A	Short-term	SP	Education, Management		
6.3	Appoint an Open Space Manager to oversee municipally managed land and ensure it is managed in a manner that protects and enhances natural resources	Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	BPRC/PC	Management, Policy		
6.4	Protect and expand connective corridors between habitats and open spaces and expand no-mow/low-maintenance areas	Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	EC/BPRC, SP	Education, Management, Policy		
6.5	Reduce emissions from public and private lawn maintenance equipment	Promotes Equity, Improves Local Environmental Quality, Enhances Public Safety and Health	Medium	Long-term	SP/DIO	Education, Policy		
6.6	Limit ecosystem stressors such as deer population and invasive species	Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term/ Initiated	HD/BPRC, STC	Education, Management		
6.7	Create adaptive restoration planting and a list of seeds and plants that are likely to succeed in the region and endure climate change	Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	EC/STC, SP	Education, Management		

No-mow and low-mow lawns and fields provide connectivity across habitats to facilitate dispersal, migration, and maintenance of native species, and the regional movements of populations in response to changing climate factors.

Battery-powered lawn mowers and lawn maintenance equipment are becoming more affordable and practical for use and can replace more polluting and noisy gas-powered models.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

OBJECTIVE 7: Protect the tree canopy		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
7.1	Implement a data-driven plan to protect and expand tree canopy, monitoring its effect on carbon sequestration, water quantity and quality; maintain an inventory of public street trees to monitor their health and survival, taking climate change into account; and identify new planting areas to increase the number of public trees		Medium, included in 6.1	Short-term/ Initiated	DIO/STC, EC	Education, Management	Community Forestry Plan and Tree Cover Goal	
7.2	Revise the tree planting list, given expected climate changes and the importance of maintaining species diversity		N/A	Short-term/ Initiated	DIO/STC, EC	Management	Community Forestry Plan and Tree Cover Goal	
7.3	Ensure a minimum 1:1 tree re-planting ratio for public trees		N/A	Short-term	DIO/STC, EC	Management	Community Forestry Plan and Tree Cover Goal	

In 2018, the Municipal arborist developed a list of preferred native trees and shrubs that are recommended for planting in Princeton. Ensuring that trees that must be removed are replaced on at least a 1:1 basis and that replanting with native species will maintain and protect Princeton's tree canopy.

Figure 19. Princeton's current street tree inventory

Marquand Park

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

Key Performance Indicator	Target
Percentage of street trees inventoried	100% by 2023
Ash tree replacement on public property	100% by 2025
Acres of land preserved	As much as possible consistent with affordable housing obligations
Acres of land converted to no-mow or low maintenance	50% of non-forest, non-playing fields by 2025
Achieve target deer population per acre	20-30 deer per sq. mile by 2025

BEYOND PRINCETON

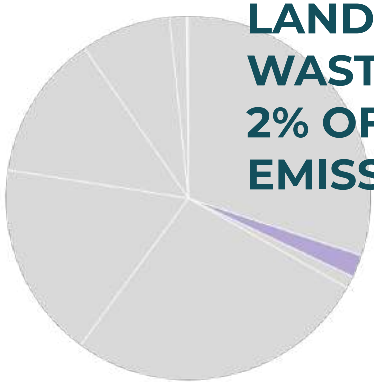
National, regional and state policies, programs, plans and initiatives that may enable Princeton to meet its CAP goals.

MULTIPLE MEASURES TO PROTECT POLLINATORS IN NEW JERSEY. This set of bills propose to encourage healthy pollinations across the state and develop existing spaces into pollinator habitats through the promotion of native plants. S-3916/A-5529 creates a "Pollinator Pathway" designation for municipalities; S-3912/A-5530 requires the State Board of Agriculture to provide a list of environmentally harmful plant species to the Legislature each year; S-3917/A-5531 establishes a "pollinator-friendly" label for plants; S-3913/A-5532 directs the DEP to establish pollinator habitat program for closed landfills; and S-3910/A-5533 directs the DEP to establish a leasing program for state-owned land to be used and managed as pollinator habitat.

NEW JERSEY NATIVE PLANTS PROGRAM S-3000/A-4492. The bill proposes to establish a program to promote the sale of plants that are native to the Garden State at local garden centers and nurseries and will create a labeling system to identify native plants as "Jersey natives." The bill also aims to increase consumer awareness and educate residents about the importance, variety and availability of native plants.

MATERIALS MANAGEMENT

Our Vision: All Princeton community members are aware of the carbon emissions of the resources they utilize.



LANDFILLING OF SOLID WASTE CONTRIBUTES 2% OF COMMUNITY EMISSIONS (2018)

What we buy matters. Recycling and composting are helpful steps in reducing carbon emissions associated with our consumption habits (e.g., clothing, electronics and furniture). These actions reduce disposal emissions, but the majority of carbon emissions are generated before we purchase the products. To achieve carbon reduction goals, individuals, businesses, governments and other organizations not only need to recycle and compost but must also make more sustainable purchasing decisions.

Recycling waste such as cardboard is dependent upon a clean stream of materials, access to facilities that can recycle the materials and the value of the materials, which is market driven.

Mercer County's 2013 Waste Characterization report shows that there is opportunity to reduce emissions from the landfilling of food waste, paper and plastics by source reduction, reuse and the recycling of materials.

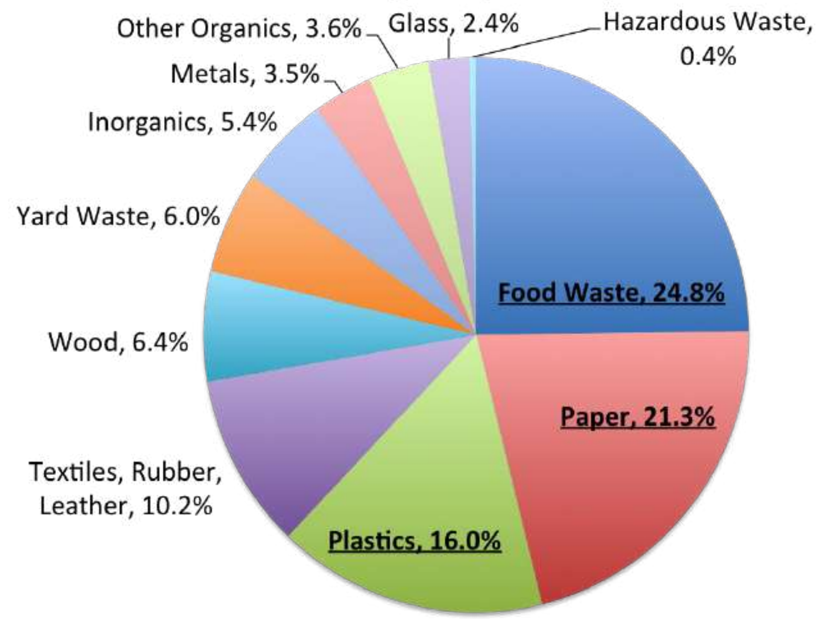


Figure 18. Mercer County's 2013 Waste Characterization report. *See Appendix B.*

While not fully accounted for in Princeton's production-based emissions inventory, the consumption habits of a typical Princeton household do contribute to global emissions.

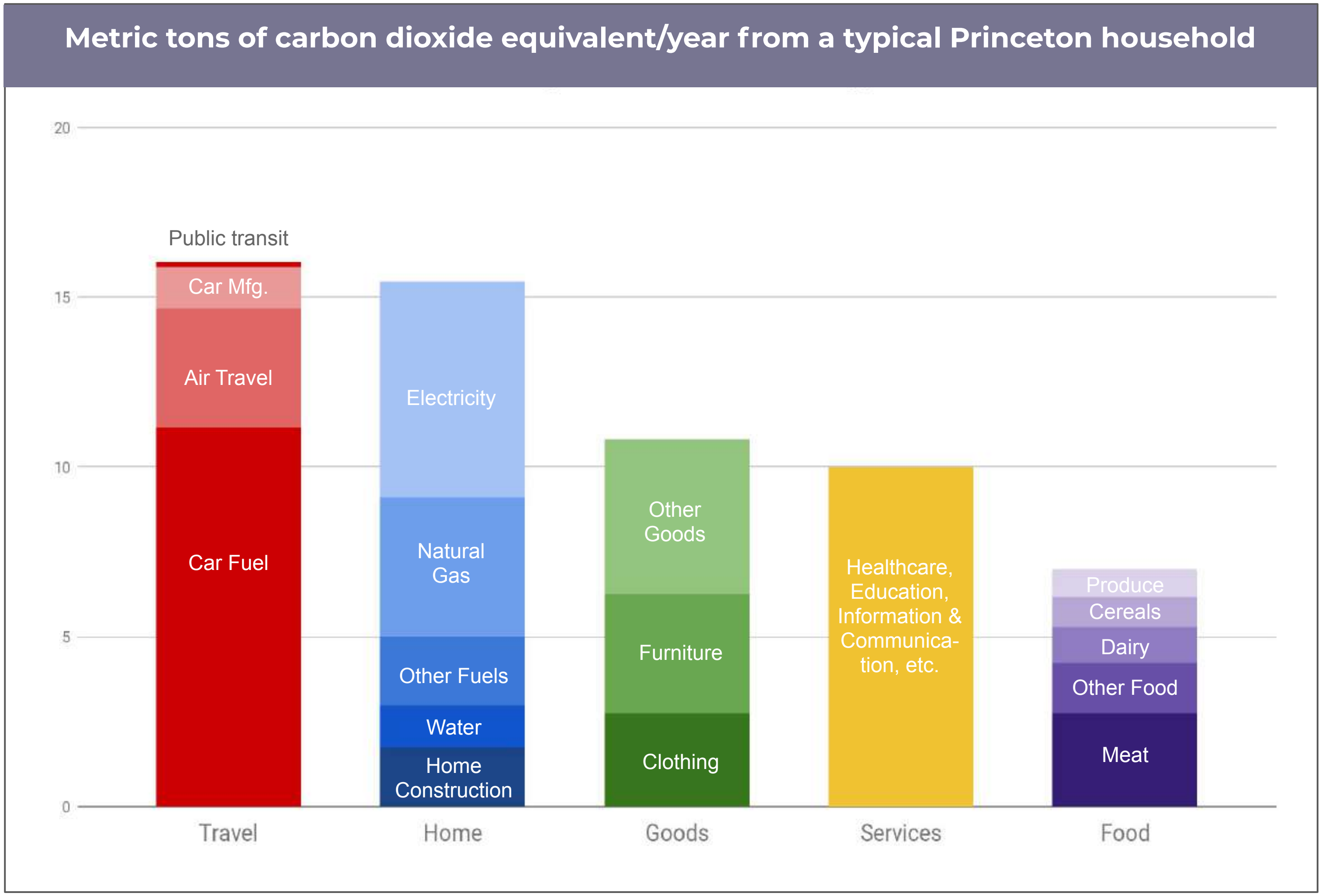
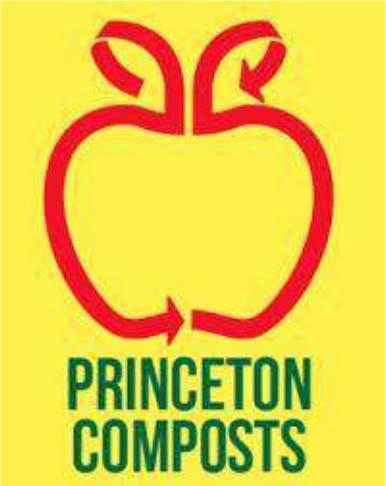


Figure 19. Princeton's production-based greenhouse gas inventory 2018. *See Appendix B.*

Launched in 2012, the Municipality of Princeton's voluntary residential curbside organic collection diverted approximately 1,868 tons of food and other organic waste from the landfill. This is equivalent to removing 144 vehicles off of the road every year. The program is currently on hiatus while a local composting facility is identified.



Curbside collection cart provided to residents that participate in the program.

Princeton's annual S.H.R.E.D.temberfest, organized by the Municipality's Department of Infrastructure and Operations, diverts tons of materials that would otherwise end up in the landfill. Residents are able to donate clothes, household goods, bicycles, and recycle computers and electronics. In 2018, residents were able to drop off polystyrene for recycling.

Princeton's annual S.H.R.E.D.temberfest recycling collection and paper shredding event.

MATERIALS MANAGEMENT | Progress to date, continued

The New Jersey Sustainable Business Registry (NJSBR) was created to recognize and promote sustainable businesses, nonprofit organizations and higher education institutions. To join the Registry, organizations are required to demonstrate that they have adopted measurable cost-saving practices that reduce their environmental impact. Princeton has been a leader in the NJSBR with thirteen businesses and organizations certified.

Arlee's Raw Blends
Copper River Salon & Spa
greendesign
Homestead
Jammin' Crêpes
JZA+D
Lasley Brahaney
McCaffrey's Grocery
Princeton Printer
Princeton Public Library
Sustainable Princeton
The Peacock Inn
The Whole Earth Center

The ReThink Disposable campaign helps small food business operators reduce waste and cut costs by minimizing disposable packaging items.

The Green Restaurant Association (GRA) provides a transparent method of measuring a restaurant's environmental accomplishments, while also providing a pathway toward increased environmental sustainability. To date, three food service venues have achieved a level of certification.

Forbes College at Princeton University: A 3 Star Certified Green Restaurant

Princeton Day School: A 4 Star Certified Green Restaurant

Rockefeller Mathey at Princeton University: A 1 Star Certified Green Restaurant

Parklet on Witherspoon Street

OBJECTIVE 8: Reduce life-cycle emissions occurring outside the community from products and services used by the Princeton community		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
8.1	Implement initiatives that demonstrate the value of wellbeing, livability and community connectivity over material goods		N/A	Short-term	SP/BPRC, PPL	Education, Management		
8.2	Develop educational materials that illustrate the emissions impacts of the use of goods and services, e.g., shopping, travel, housing and food, and encourage residents, businesses and institutions to take action to reduce their carbon footprint		N/A	Short-term	SP	Education, Management		
8.3	Support businesses and institutions in minimizing the carbon intensity of their supply chains and operations through increasing the number of businesses that participate in accreditation and recognition programs such as Green Restaurant Awards, ReThink Disposable, etc.		N/A	Short-term	SP	Education, Management		
8.4	Develop and implement a cost effective plan to reduce the use of non-recyclable and non-reusable items and ensures items are not replaced with ones that have a larger life-cycle emission footprint		N/A	Short-term	SP	Education, Management		
8.5	Support efforts to require responsible manufacturing, product and packaging design, and reuse recovered materials to expedite the transition to a circular economy		N/A	Long-term	EC	Education, Management		

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

	OBJECTIVE 9: Reduce the life-cycle emissions from the use of products and services within the community	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
9.1	Reduce consumption-related emissions by promoting sustainable consumption tactics, e.g., plan before purchasing; give the gift of experiences; reuse, borrow, share, rent, barter and fix items; and refuse single-use disposable items		N/A	Short-term	SP	Education, Management		
9.2	Identify and promote reuse and repair programs, businesses and opportunities that can reduce the disposal of goods and extend the useful life of the materials		N/A	Short-term	EDC/SP	Education, Management		
9.3	Foster networks that connect residents, businesses and institutions to exchange reused and reusable goods		N/A	Short-term	SP	Education, Management		
9.4	Prevent food waste by encouraging strategies for residents, businesses and institutions to reduce the volume of food waste generated, such as proper food storage, meal planning and donation of excess food to organizations that serve the food insecure		N/A	Short-term	SP/SHUPP	Education, Management		

Actions in Materials Management follow the waste reduction hierarchy. The reduction and more efficient use of materials has a greater impact on reducing GHG emissions.

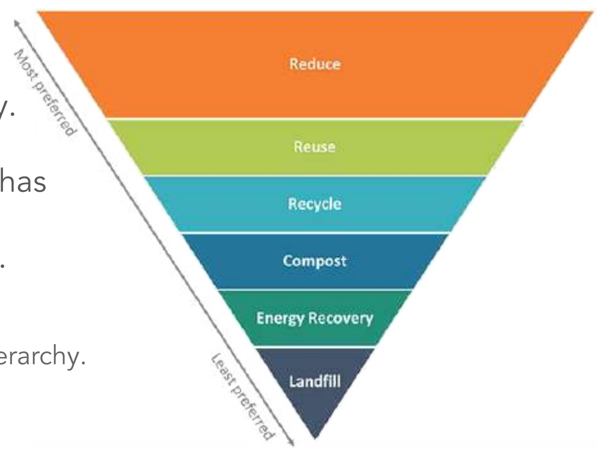


Figure 20. Waste reduction hierarchy.

Similar to the waste reduction hierarchy, the Food Recovery Hierarchy establishes actions to reduce emissions from the food system in order from most preferred to least preferred.

Figure 21. The food recovery hierarchy. *Source:*https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy

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OBJECTIVE 9: Reduce the life-cycle emissions from the use of products and services within the community (con't)		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
9.5	Expand neighborhood and backyard composting of organic materials	Fosters Economic Sustainability, Improves Local Environmental Quality	N/A	Short-term/ Initiated	DIO/CFAC	Education, Management		
9.6	Develop a Creative Placemaking Plan that enhances the positive, distinct qualities of Princeton, makes the most of existing resources and ensures equitable participation	Promotes Equity, Fosters Economic Sustainability	N/A	Long-term	PAC	Infrastructure		
9.7	Convene a committee to discuss the impact the current system of municipal public finance has on emissions	Promotes Equity, Fosters Economic Sustainability	N/A	Short-term	TBD	Education, Management		
9.8	Facilitate the transition to a new form of work and consumption that reduces carbon intensity and promotes equity, e.g., compressed and flexible work schedules	Promotes Equity	N/A	Short-term	TBD	Education, Management		

Backyard composting of food waste, leaves and brush reduces the amount of emissions from hauling these materials to the landfill. It also provides a beneficial soil amendment .

Dohm Alley on Nassau Street is an example of Creative Placemaking.

The Princeton Parklet is another example of Creative Placemaking.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

OBJECTIVE 10: Reduce the life-cycle emissions from the disposal of waste generated by the Princeton community		Co-Benefits	GHG Reduction Potential	Timeframe	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
10.1	Evaluate all waste streams (solid waste, recycling, food, leaf and brush, electronics, etc.) from all sectors (residential, commercial and institutional) and implement a plan to save money and reduce emissions	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality	N/A	Short-term	PC/DIO	Management, Policy		
10.2	Implement an equitable unit-based/variable rate waste management program, e.g., save-as-you-throw, that includes a well-designed transition plan	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality	N/A	Short-term	PC/DIO	Management		
10.3	Conduct a cost-benefit analysis for the municipality to provide additional collection of non-mandated and hard-to-recycle items at the River Road facility, e.g., textiles, #3-7 plastics, polystyrene	Fosters Economic Sustainability	N/A	Short-term	PC/DIO	Infrastructure, Management		
10.4	Establish metrics to measure and improve the performance of waste reduction and management practices, and report progress annually	Fosters Economic Sustainability	N/A	Short-term	PC/DIO	Management		

Approximately 9,000 communities across the country have shifted to a different waste model that provides a direct incentive to those who reduce their waste. Termed save-as-you-throw or SMART: Save Money and Reduce Trash, this approach employs a fee based on the volume or weight of landfill trash collected. At the same time, recycling and/or organics collection are commonly provided free of charge or at a lesser fee. Thus, households are only charged for the landfill waste service they utilize, similar to our current fee system for water or electricity.

Communities in New England who have made the switch to SMART have experienced increased recycling rates combined with significant drops in waste, both of which have led to tax savings for all and a step toward achieving the goals established through the waste management hierarchy.

In a save-as-you-throw waste management approach, residents receive a cart for organics, recycling and landfill. Combined with effective education about what items belong in each cart, this approach can reduce the amount of waste produced, improve recycling rates, and divert items from the landfill.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

MATERIALS MANAGEMENT | Objective & Actions, continued

OBJECTIVE 10: Reduce the life-cycle emissions from the disposal of waste generated by the Princeton community (con't)		Co-Benefits	GHG Reduction Potential	Timeframe	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
10.5	Implement a comprehensive waste reduction and education compliance strategy that increases the quantity and quality of recyclable materials collected from residents, businesses and institutions	$ ✱	N/A	Short-term	DIO	Education	Mercer Cty District Solid Waste Plan	
10.6	Develop and implement a financially viable enforcement strategy for the municipal recycling ordinance	$ ✱	N/A	Short-term	DIO/HD	Policy, Management	Mercer Cty District Solid Waste Plan	
10.7	Require businesses and institutions to annually submit a waste reduction plan to the municipality and link the plan to a certificate of occupancy from Construction and Health Dept. if applicable	$ ✱	N/A	Short-term	PC/HD	Policy, Management	Mercer Cty District Solid Waste Plan	
10.8	Require public events to be Zero-Waste to Landfill and submit a waste reduction plan as part of the permitting process	$ ✱	N/A	Short-term	PC/HD	Policy, Management	Mercer Cty District Solid Waste Plan	
10.9	Advocate at the county and state level for improved waste reduction policies and infrastructure	$	N/A	Long-term	PC/EC	Policy, Infrastructure	Mercer Cty District Solid Waste Plan	

Effective waste management strategies focus first on reducing waste and reusing materials, followed by recycling and composting appropriate items, before energy recovery from waste and finally landfill. In New Jersey, per capita waste has risen steadily over the past two decades, peaking in 2014, when the average NJ household generated over 4,500 pounds of solid waste per year. Analyses of the waste composition in Mercer County have found that approximately one-half of all this waste could be diverted to recycling programs or organics collections.

Water stations that are made available in workplaces, schools and public buildings are a way to reduce single-use disposable beverage containers.

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Key Performance Indicator	Target
Development of a long-term materials management plan	Complete by 2025
Number of businesses that participate in accreditation and recognition programs such as Green Restaurant Awards, ReThink Disposable, etc.	20 by 2025
Compliance with waste reduction plans	100% by 2030
Establish a per capita waste reduction goal	Target to be determined

BEYOND PRINCETON

National, regional and state policies, programs, plans and initiatives that may enable Princeton to meet its CAP goals.

The **NEW JERSEY FOOD WASTE TASK FORCE S-3232/A-4705** seeks to prevent food waste, increase food donations, provide consumers with education on food storage, lower unreasonably high cosmetic standards for fruit and vegetables, cease or significantly reduce the rejection of even marginally imperfect-looking food, build statewide systems to distribute surplus edible food to charities, eliminate unnecessary state statutes or regulations that contribute to food waste; and modify "best by" food labels, consistent with uniform national standards, to inform consumers of the latest possible date food can be safely consumed.

REQUIRE LARGE FOOD WASTE GENERATORS TO SEPARATE AND RECYCLE FOOD WASTE S-4039/A-3726. The proposed legislation establishes a date by which large food waste generators located within 25 road miles of an authorized food waste recycling facility must separate its food waste from other solid waste and send the source-separated food waste to an authorized food waste recycling facility that has available capacity and will accept it.

The **NEW JERSEY SINGLE USE PLASTIC AND POLYSTYRENE LEGISLATION S-2776/A-4330** prohibits carryout bags made of plastic film, polystyrene foam food service products, and single-use plastic straws; it also assesses a fee on paper carryout bags.

RESILIENCY

Our Vision: All Princeton community members are prepared for the impacts of climate change.

Preparation actions that reduce a community's exposure to and risk from climate change can also directly benefit health, particularly if these actions are focused on those at highest risk. In addition, reducing the community's risk from natural hazards that will be exacerbated by climate change (e.g., flooding and extreme heat) — and strengthening emergency management capacity to respond to hazards when they do occur — can reduce the number and severity of resulting illnesses and injuries.

An increase in the severity and frequency of storms is resulting in more damage to Princeton's trees, downed power lines, risks to life and property and costs to clean up after an event.

Impervious cover is any surface in the landscape that cannot effectively absorb or infiltrate rainfall. This includes driveways, roads, parking lots, rooftops and sidewalks. When natural landscapes are intact, rainfall is absorbed into the soil and vegetation. Increased impervious cover combined with increased precipitation results in increased stormwater runoff and impaired waterways.

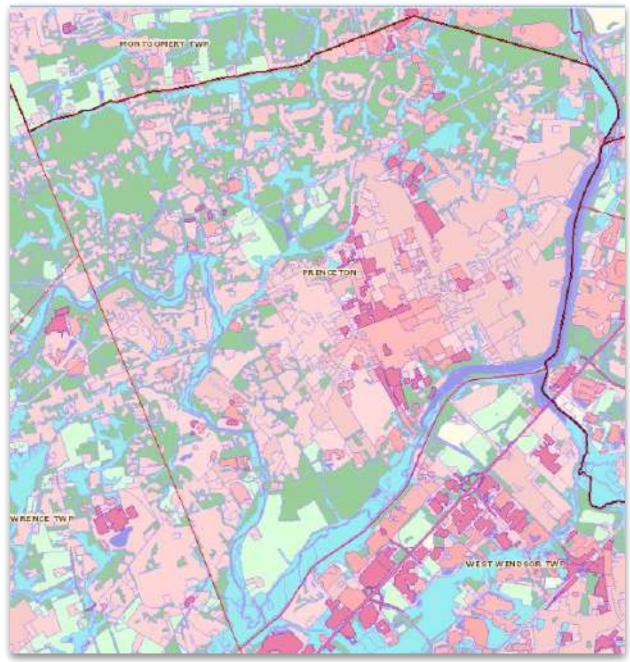

Figure 22. Princeton map of impervious cover

Table 4. Princeton's historical impervious cover acreage and percent of land area.

Year	Acres	Impervious cover (% of land area)
1995	1521.18	13.13
2002	1598.58	13.80
2010	1634.16	14.12
2012	1644.08	14.19

In May 2017, Princeton adopted an enhanced stormwater ordinance for minor redevelopment projects that will help address flooding problems and reduce the amount of pollution discharged into its waters, including Lake Carnegie. As climate change increases precipitation, stormwater runoff increases. The ordinance requires to the "maximum extent practicable" using techniques that include minimizing impervious surfaces and breaking them up/disconnecting them so that stormwater flows over pervious surfaces, protecting natural drainage features and vegetation, and minimizing soil compaction.

Left to right, Nancy Tindall, board president of the Association of New Jersey Environmental Commissions; Sophie Glovier, chair of the Princeton Environmental Commission; Michael Pisauro, policy director of the Watershed Institute; Jennifer Coffey, ANJEC executive director; and Jack West, land use engineer.

On June 18th, 2019 members of Princeton's emergency services, major institutions (Princeton University, Princeton Theological Seminary, Tenacre Foundation, Princeton Public School District), representatives from Princeton's Health Department and Human Services, and the Princeton Senior Resource Center participated in a climate change preparedness tabletop exercise. Led by a facilitator, the tabletop challenged the participants to identify areas of improvement in their plans to respond to an extreme weather event.

Climate change preparedness tabletop exercise with community groups and Municipal officials - June 2019

The Neighborhood Buddy Program & Sustainable Princeton's STAR Neighborhood Program offer two ways that the Princeton can be better prepared for the effects of climate change by fostering a sense of community and connecting neighbors so that they can look out for one another in times of need.

OBJECTIVE 11: Protect lives, property and critical facilities from the impacts of stormwater flooding		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
11.1	Develop a multi-layer map of Princeton's stormwater system including storm drains, outfalls, flooding zones, etc.	Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	ED/DIO	Management	Stormwater Mgmt. Plan	
11.2	Adopt best practices for stormwater management to mitigate flooding from the 2-year storm (defined as 3.3" of stormwater in 24 hours) and below	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	PC/EC,ED		Stormwater Mgmt. Plan	
11.3	Develop a Stormwater Mitigation Plan	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	ED/PC, DIO,SOC	Management, Policy	Stormwater Mgmt. Plan	
11.4	Establish a stormwater utility to fund the installation and maintenance of stormwater infrastructure, preferably green infrastructure and projects identified in the Stormwater Mitigation Plan	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	PC/EC,ED	Management, Policy	Stormwater Mgmt. Plan	
11.5	Update Complete Streets Policy to include Green Streets guidelines	Promotes Equity, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	PC/EC,ED	Policy	Stormwater Mgmt. Plan	
11.6	Update the stormwater ordinance for redevelopment projects	Promotes Equity, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term/ Initiated	PC/EC,ED	Policy	Stormwater Mgmt. Plan	

A representation of multiple forms of green infrastructure

Lake Carnegie

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OBJECTIVE 11: Protect lives, property and critical facilities from the impacts of stormwater flooding (con't)		Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
11.7	Develop a maintenance plan to ensure that stormwater drains are kept free of debris that clogs grates, resulting in flooding in unanticipated places		N/A	Short-term	DIO/ED	Policy, Management	Stormwater Mgmt. Plan	
11.8	Develop a system for better understanding and predicting when and where storms will trigger flooding		N/A	Short-term	ED/EC	Management	Stormwater Mgmt. Plan	
11.9	Leverage new technology including sensors to monitor and maintain the stormwater system		N/A	Short-term	ED/EC	Infrastructure	Stormwater Mgmt. Plan	
11.10	Install green infrastructure demonstration projects on municipal property		N/A	Short-term	ED/DIO	Infrastructure	Stormwater Mgmt. Plan	
11.11	Provide green infrastructure training to key municipal personnel including Public Works, Engineering, Planning and Parks and Recreation to ensure proper installation and maintenance of green infrastructure on public property		N/A	Short-term	DIO,PBRC	Management, Education	Stormwater Mgmt. Plan	
11.12	Provide green infrastructure education to design professionals, landscape architects, civil engineers and other practitioners		N/A	Short-term	SP/EC	Management, Education	Stormwater Mgmt. Plan	

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OBJECTIVE 12: Build Municipal and community capacity to prepare for and respond to climate change		Co-Benefits	GHG Reduction Potential	Timeframe/Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
12.1	Institutionalize climate preparation planning and best practices in municipal operations and decision-making, and monitor effectiveness	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term	ES	Management, Education	Emergency Operations Plan	
12.2	Amend the Emergency Operating Plan (EOP) to include an annex that addresses climate change vulnerabilities, identifies high priorities to educate, train and conduct necessary exercises to better prepare for and respond during extreme weather events	Promotes Equity, Fosters Economic Sustainability, Improves Local Environmental Quality, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term/ Initiated	ES	Management	Emergency Operations Plan	
12.3	Assess and improve Princeton's public notification systems such as Register Ready, Access Princeton and Everbridge to better prepare for and meet community needs during extreme weather events	Promotes Equity, Fosters Economic Sustainability, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term/ Initiated	ES/PPD, PFARS	Management	Emergency Operations Plan	
12.4	Engage first responders, municipal inspectors and other public facing personnel in identifying vulnerable community members, e.g., the oxygen-dependent, wheelchair users, low-income and undocumented and streamline the process to include in the Register Ready database	Promotes Equity, Fosters Economic Sustainability, Enhances Public Safety and Health, Builds Resilience	N/A	Short-term/ Initiated	ES/PPD, PFARS	Education	Emergency Operations Plan	


Flooding at Quaker Rd.


Climate Change Tabletop exercise.

Promotes Equity | Fosters Economic Sustainability | Improves Local Environmental Quality | Enhances Public Safety and Health | Builds Resilience

	OBJECTIVE 12: Build Municipal and community capacity to prepare for and respond to climate change (con't)	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
12.5	Increase ability to provide real-time updates on flooding, road closures and downed power lines; and review and update communication processes related to these events during Emergency Operations Center (EOC) operations and during normal day-to-day situations		N/A	Short-term	ES/PPD, PFARS	Infrastructure	Emergency Operations Plan	
12.6	Install job boxes equipped with supplies and/or permitting gates at locations prone to flooding to improve response time and increase safety		N/A	Short-term	PPD/DIO	Infrastructure	Emergency Operations Plan	
12.7	Require leaves to be bagged at the curb to reduce flooding caused by clogged storm drains and to keep roads and sidewalks clear for bicyclists and pedestrians and/or implement other measures to reduce the placement of leaves and brush in the right of way		N/A	Short-term	PC/DIO	Policy	Bicycle Mobility Plan	

Permitting gate at Quaker Road, which is closed frequently due to flooding

Every $1 spent on hazard mitigation nationally can save $6 in future disaster recovery costs.[16]

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	OBJECTIVE 13: Prepare for the impact of climate change on human health	Co-Benefits	GHG Reduction Potential	Timeframe/ Status	Leader/ Partner(s)	Lever	Related Plans	Potential Funding Sources
13.1	Implement Health in All Policies that incorporates health impacts due to climate change		N/A	Short-term/ Initiated	HD/BOH	Policy, Management		
13.2	Increase collaboration of outreach efforts among municipal departments and partner organizations on prevention, early identification and treatment of health impacts due to climate change (Health Dept., Corner House, Princeton Senior Resource Center, Human Services, Sustainable Princeton, etc.)		N/A	Short-term	HD/BOH, HS,SP	Management		
13.3	Assess vulnerability, magnitude and capacity to respond to the health-related impacts of climate change, and incorporate recommendations to address them in the Emergency Operations Plan		N/A	Short-term/ Initiated	HD/ES, BOH	Management		
13.4	Develop and distribute culturally appropriate and accessible materials about the health impacts of climate change with particular attention to underserved community members		N/A	Short-term	HD/BOH, HS, SP	Management, Education		
13.5	Advocate for the health and safety of outdoor workers during extreme weather events			Short-term	HD/BOH, HS, SP	Management, Education		

Flooding and road closures impact Princeton's businesses. Workers who rely on daily wages face economic stress when they cannot work when business are closed as a result of flooding and power outages.

Princeton's power lines are vulnerable to damage during extreme storms. Power outages due to downed wires will impact community members that rely on electricity for medical needs.

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Key Performance Indicator		Target
Climate Change and Flood Hazard Annexes added to Emergency Operations Plan	➤	Complete by 2021
Mitigate flooding from the 2-year storm (defined as 3.3" of stormwater in 24 hours) and below	➤	Complete by 2030
Number of vulnerable community members identified	➤	from 23 to 100 by 2021
Number of individuals signed up for emergency notifications	➤	Target to be determined
Reduction of impervious cover	➤	Below 10%

BEYOND PRINCETON

National, regional and state policies, programs, plans and initiatives that may enable Princeton to meet its CAP goals.

The **CLEAN STORMWATER AND FLOOD REDUCTION ACT S-1073/A-2694** authorizes municipalities, counties and certain authorities to establish stormwater utilities. The governing body of any county or municipality may, by resolution or ordinance, as appropriate, establish a stormwater utility for the purposes of acquiring, constructing, improving, maintaining and operating stormwater management systems in the county or municipality, consistent with State and federal laws, rules, and regulations.

Topics for Consideration in Plan Update

The following topics will be evaluated for inclusion in the Plan when it is reviewed in three years. Further analysis is required to determine their feasibility for Princeton to implement and the GHG emissions reduction potential.

Energy
Green Leases and other funding mechanisms to resolve the split incentive

Land Use & Transportation
The potential for a Vision Zero effort to reduce emissions

Natural Resources
Carbon Capture and Storage (CCS)
- Consider uses of trees removed in Princeton that would store carbon
- Potential of soil carbon capture

Materials Management
Alternative methods for managing the sludge produced at the Stony Brook Regional Sewerage Authority wastewater treatment facility that have a lower carbon footprint.

Resiliency
Further efforts to reduce intrusion of stormwater into sewer lines to reduce the energy demand for treating water

Other: Fugitive emissions from refrigerants

APPENDIX A - ACRONYMS & DEFINITIONS

Municipality of Princeton Department, Board, Committee or Commission		**Municipality of Princeton Department, Board, Committee or Commission - con't**	
Animal Control	AC	Princeton Council	PC
Board of Health	BOH	Police Department	PPD
Board of Parks and Recreation Commission	BPRC	Public Transit Advisory Committee	PTAC
Citizens' Finance Committee	CFAC	Shade Tree Commission	STC
Economic Development Committee	EDC	**Local Organizations and Institutions**	
Emergency Management	EM	Central Jersey Transit Forum	CJTF
Engineering Department	ED	Greater Mercer Transportation Mgmt. Assoc.	GMTMA
Environmental Commission	EC	Princeton Arts Council	PAC
Health Department	HD	Princeton Community Housing	PCH
Housing Authority Board	AHB	Princeton Public Library	PPL
Human Services Commission	HSC	Princeton First Aid and Rescue Squad	PFARS
Human Services, Department of	HS	Princeton Public Schools	PPS
Infrastructure and Operations, Department of	DIO	Princeton University	PU
Planning Board	PB	Send Hunger Packing Princeton	SHUPP
Princeton Bicycle Advisory Committee	PBAC	Sustainable Princeton	SP

APPENDIX A - ACRONYMS & DEFINITIONS

Adaptation: Adjustment to the inevitable effects of climate change that will occur despite efforts to reduce greenhouse gas emissions.

Autonomous Vehicle: A vehicle capable of sensing its environment and moving with little or no human input, also known as self-driving, robot and driverless vehicle.

Bicycle Mobility Plan: Plan adopted by the Princeton Planning Board in November 2017 aimed at making cycling an essential, comfortable, convenient and safe form of transportation for residents and visitors.

Bike-sharing: Model of bike rental allowing a person to rent a bike from various collection sites around town for a short period of time, often by the hour. This concept is part of a larger trend of shared mobility.

Biodiversity: The variety of genes, species, habitats, landscapes, ecosystems, and all biota and their relationship to air, land, and water.

Bioswales: Landscape topography designed to remove silt and pollution from surface runoff water.

Built Environment: Facilities and infrastructure built by humans.

Business as Usual (BAU): An unchanging state of affairs or continuation of daily operations in their current state.

Carbon Dioxide (CO_2): A crucial gas in naturally present in the atmosphere as part of the Earth's carbon cycle. CO_2 is one of the primary greenhouse gases, accounting for the majority of all U.S. GHG emissions from human activities and most frequently emitted through the combustion of fossil fuels (coal, natural gas, and oil).

Carbon Dioxide Equivalent (CO_2e/GHG): A term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact.

Carbon Footprint: The total set of greenhouse gas emissions caused directly and indirectly by an individual, organization, event or product.

Carbon Neutrality: Achievement of net-zero carbon emissions by balancing the amount of carbon released with an equivalent amount through sequestration or offset.

Carbon Sequestration: A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form.

Carbon Sink: A natural environment quantified by the ability to absorb CO_2 from the atmosphere.

Car-sharing: Model of car rental allowing a person to rent a car for a short period of time, often by the hour. Car owners are typically private individuals; carsharing facilitators are usually distinct from owners. Part of a larger trend of shared mobility.

Circular Economy: An economic system aimed at minimizing waste and making the most of resources by minimizing the input of raw materials, waste, emission and energy leakage. This is achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling. This regenerative approach is in contrast to the traditional linear economy, which has a 'take, make, dispose' model of production.

Climate Change: Any significant change in the measures of climate for a period of decades or longer, including temperature, precipitation, wind patterns, among others.

Climate Mitigation: The collective reduction of greenhouse gases to slow down and eventually stop disastrous climate change.

Climate Vulnerability: A community's exposure to climate-change-related events, its sensitivity, and its adaptive capacity. Exposure describes the susceptibilities of a place that exist due to the magnitude, frequency, duration and geographic factors.

Co-Benefit: Separate benefits or arguments in favor of an action taken.

Community Solar: A community solar farm or garden is a solar power installation that accepts capital from and provides output credit and tax benefits to individuals and/or other investors.

Complete Streets: Streets designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.

APPENDIX A - ACRONYMS & DEFINITIONS

Compost: A nutrient-rich growing amendment created through the combined decomposition of yard trimmings, food wastes, manures in proper ratios and bulking agents (e.g., wood chips).

Connective Corridors: Landscape providing natural areas, biking and pedestrian pathways, open space, and migration routes for species. These corridors often lie along streams, rivers, or other natural features.

Curbside Management Locations: These curbside flex zones can play many roles, from public space to loading zones for ride-shares. These location serve to optimize, allocate and manage curbspaces to maximize mobility and access for the wide variety of curb demands.

Delaware Valley Regional Planning Commission (DVRPC): Partnership among city, county and state representatives in Pennsylvania and New Jersey working to address key issues including transportation, land use, environmental protection, economic development and equity The organization provides services to member governments and others through planning analysis, data collection and mapping services.

Density Bonus: Refers to providing an increase in allowed dwelling units per acre (DU/A), Floor Area Ratio (FAR) or height, which generally means that more housing units can be built on any given site. A common form of incentive used by inclusionary housing programs.

Emissions: The release of a substance from an industrial process as a by-product.

Electric Vehicle (EV): Vehicle that uses one or more electric motors or traction motors for propulsion.

Electric Vehicle Charging Station: Equipment at either public or private facilities that supplies electric energy to recharge electric vehicles.

Emergency Operations Center (EOC): A central command and control facility responsible for carrying out the principles of emergency preparedness and emergency management, or disaster management functions at a strategic level during an emergency.

Emergency Operating Plan (EOP): A document which outlines how the Municipality of Princeton will respond to an emergency. The EOP sets guidelines to manage a disaster in an effective, efficient and timely manner. The plan is activated on an as-needed basis and is designed to be used for all types of emergencies.

Energy Audit: A report on the consumption and cost of a building's resource use based on utility bills, electric usage, water usage and heating load.

Energy Efficiency: Technology that uses less energy to perform a target function.

Form-based Code: A land development regulation that fosters predictable results and a high-quality public realm by using physical form (rather than separation of uses) as the organizing principle for the code.This approach contrasts with a conventional zoning focus on the segregation of land uses, and the control of development intensity through specified parameters such as dwellings per acre, setbacks and parking ratios.

Fossil Fuel Consumption: The measurable use of hydrocarbon energy sources including combustion of coal, petroleum or natural gas.

free-B: The public transit transport serving the Princeton community.

Greater Mercer Transportation Management Association (GMTMA): Association of large and small employers, local governments, authorities and state agencies that share a commitment to providing transportation choices in Mercer and Ocean Counties that are good for commuters, businesses and the environment.

Green Infrastructure: The use of vegetation, soils and natural processes to manage stormwater generally in urban environments, such as bioswales and rain gardens

Green Jobs: Occupations that provide for the needs of the present generation without causing undue harm to the needs of the environment or future generations.

Green Roofs: Roofs that absorb rainwater with vegetation. Green roofs decrease stormwater, typically have a long life, and have a higher albedo (reflectivity) than traditional roofs, allowing for decreased summer temperatures.

Green Streets: A stormwater management approach that incorporates vegetation (perennials, shrubs, trees), soil and engineered systems (e.g., permeable pavements) to slow, filter and cleanse stormwater runoff from impervious surfaces (e.g., streets, sidewalks).

APPENDIX A - ACRONYMS & DEFINITIONS

Greenhouse Gas (GHG): Any gas that absorbs infrared radiation in the atmosphere. Examples of GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

Greenhouse Gas Baseline: The initial inventory of greenhouse gas emissions that serves as a benchmark to compare future data to measure progress.

Grey Infrastructure: Infrastructure projects that utilize man-made elements, such as concrete and steel materials, as contrasted with Green Infrastructure that depends on plants and ecosystem services.

Health in All Policies: A process of integrating the health awareness and concerns into all municipal policies and procedures.

Heat Island Effect: Refers to the tendency of urban areas to be warmer than rural areas owing to the higher percentage high heat-absorbing impervious surfaces.

Heating, Ventilation, Air Conditioning (HVAC): The technology that provides indoor fresh air, thermal comfort, heating and cooling inside buildings.

Impervious surface: Any surface that does not allow water to soak into the ground, such as roofs, driveways and patios.

International Council for Local Environmental Initiatives (ICLEI): Global network of more than 1,500 cities, towns and regions committed to building a sustainable future.

Invasive Species: Non-native species that disrupt ecosystems and replace native species.

Land Use: The way in which humans develop land.

Leadership in Energy and Environmental Design (LEED): U.S. Green Building Council program to certify a building based on a scorecard of performance in energy, environmental improvements, water management, use of environmentally-friendly materials and community engagement.

Location-Efficient Development: Residential commercial development located and designed to maximize accessibility (to work, amenities, rapid transit) and overall affordability.

Low and Moderate Income (LMI): Calculations based on median family income as collected on each census tract by the U.S. Census Bureau and used as eligibility guidelines for various government services (and certain bank requirements). Low income is defined as under 50% of median family income; moderate income is defined as 50% to under 80% of median family income for the relevant area.

Low-maintenance landscaping: A garden or planted landscape that requires minimal maintenance and potentially benefits the local ecosystem.

Master Plan: A dynamic long-term planning document that provides a conceptual layout to guide future growth and development. The plan includes analysis, recommendations, and proposals for a site's population, economy, housing, transportation, community facilities and land use.

Materials Recovery Facility (MRF): A facility that receives commingled recyclable materials, then uses a combination of equipment and manual labor to separate and densify materials in preparation for shipment downstream to recyclers of specific materials.

Megawatt (MW): A unit of power, especially a measure of the output of a power station. A megawatt is equal to one million watts.

Mercer County Improvement Authority (MCIA): County agency dedicated to improving the quality of life for residents by providing programs and services for the county, municipalities, school and fire districts, and not-for-profits in areas of financing, project management, redevelopment, solid waste and recycling (created in 1967).

Microgrid: A localized group of electricity sources and loads capable of operating in parallel with, or independently from, the main power grid.

Mitigation: Reduction of impacts, particularly the greenhouse gas emissions, that cause climate change.

Mixed-Use Development: Development characterized as pedestrian-friendly development through the blend of two or more residential, commercial, cultural, institutional and/or industrial uses. Mixed use is one of the 10 principles of Smart Growth, a planning strategy that seeks to foster community design and development that serves the economy, community, public health and the environment.

APPENDIX A - ACRONYMS & DEFINITIONS

Multimodal Connections: Pathways and systems that allow commuters, workers and residents to easily move from one mode of transportation to another.

Net-zero Building: Residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies — also known as net-zero — energy building.

New Jersey Clean Energy Programs (NJCEP): A statewide program that offers financial incentives, programs and services for New Jersey residents, business owners and local governments to help them save energy, money and the environment.

Permitting Gates: Emergency gates which can be utilized to close roads with high frequency of flooding.

Photovoltaic (PV) solar: A technology that generates electricity from sunlight.

Princeton Bicycle Advisory Committee (PBAC): Local group that promotes and accommodates walking and bicycling as modes of transportation. The Committee advises the municipality on the character, safety and location of future pedestrian and bicycle facilities and/or accommodations.

Renewable Energy: Energy from fuel sources that restore themselves and do not diminish, such as the sun, wind, moving water, and the Earth's core heat.

Renewable Government Energy Aggregation (RGEA): Also known as community choice aggregation (CCA), is a program that allows local governments to procure power on behalf of their residents, businesses and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider.

Resilience: A capability to anticipate, prepare for, respond to and recover from significant multi-hazard threats with minimum damage to social well-being, the economy and the environment. Commonly used to refer to a community's ability to manage the local changes of the climate.

Retrofits: Renovations to a building to increase energy efficiency.

Ridesharing: An arrangement in which a passenger travels in a private vehicle driven by its owner, for free or for a fee, especially as arranged by means of a website or app.

Shelter in Place: To seek safety within a building one already occupies, by selecting a small, interior room with no or few windows.

Smart Growth: A planning approach that considers social, economic and environmental factors in community design. Co-locates housing and transportation options near jobs, social services, stores, and schools.

Solar Energy: Harnessing the power of the sun for energy.

Solid Waste: Garbage, refuse sludge or other discarded material; includes solid, liquid, semi-liquid, semi-solid, or contained gaseous material.

Stony Brook Regional Sewerage Authority (SBRSA): The sewage management facility that provides wastewater treatment and disposal services for Pennington Borough, Princeton Municipality, South Brunswick Township and West Windsor Township.

Stormwater: Precipitation that results from weather events.

Stormwater Management: Practices that minimize water pollution and damage to the natural and built environment from water.

Supply Chain: System of organizations, people, activities, information and resources involved in moving a product or service from supplier to customer.

Sustainability Plan: An actionable, measurable strategy for a group to meet the goal of sustainable living.

Sustainability: Practices that meet the needs of the present without compromising the long-term needs of the environment, the economy and the community.

Tiger Transit: Princeton University's shuttle system that operates on a fixed route schedule, providing free transportation to students and the public throughout the campus and surrounding community.

Traffic Demand Management: The application of strategies and policies to reduce travel demand or to redistribute the demand in space or time.

APPENDIX A - ACRONYMS & DEFINITIONS

Transit-Oriented Development: Community development that includes a mixture of housing, office, retail and/or other amenities integrated into a walkable neighborhood located a short distance from public transportation.

Tree Canopy: The above-ground branches and foliage of a tree that provide cover from the sun.

Vehicle Miles Traveled (VMTs) or vehicle miles of travel: A measurement of miles traveled by vehicles in a specified region for a specified time period.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

Walkability: Ability to walk safely to and from points of interest that are within a proximate distance.

Waste stream: Aggregate flow of waste material from generation to treatment to final disposition.

Wayfinding Signs: Signs that help guide people to a destination, or provide information or identification.

Zero-emission vehicle: Vehicle that emits no exhaust gas from the onboard source of power.

APPENDIX B - GREENHOUSE GAS INVENTORY

Introduction

Local governments account for and report on community GHG emissions data using a tool known as a GHG emissions inventory. A GHG emissions inventory estimates the quantity of GHG emissions associated with community sources and activities taking place during a chosen analysis year.

Types of Inventories

Production-based Inventory - Measures emissions that occur within the municipal jurisdiction and the emissions from generating electricity used within the municipal jurisdiction. Production-based inventories are sometimes also referred to as sector-based inventories.

Consumption-based Inventory - Measures emissions from the direct and lifecycle GHG emissions of goods and services (including those from raw materials, manufacture, distribution, retail and disposal) and allocates GHG emissions to the final consumers of those goods and services, rather than to the original producers of those GHG emissions.

For its production-based inventory, Princeton followed the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Version 1.1, July 2013, developed by ICLEI – Local Governments for Sustainability USA. This inventory protocol was developed concurrently and in parallel with the Global Protocol or Community-Scale Greenhouse Gas Emissions (GPC) Pilot Version 1.0, which was released in May 2012. The GPC was prepared by the C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability in collaboration with the World Resources Institute, World Bank, UNEP and UN-HABITAT. The GPC is intended for use by local government authorities around the world for the purpose of accounting for and reporting on community GHG emissions through inventories.

For its consumption-based inventory, Princeton followed the guidance of the Community Protocol in Appendix I by using the Household Calculator tool developed by the CoolClimate Network. The CoolClimate Network is a university, government and business NGO partnership at the University of California, Berkeley.

Inventory Years and Baseline

GHG inventories for Princeton for the years 2010-2017 were completed by Greener By Design, LLC. The CAPERS team further refined the 2010-2017 inventories and completed the 2018 inventory.

A baseline year is the year from which GHG emissions reductions will be measured. A baseline year of 2010 was determined for Princeton’s emissions reduction goal as it is the earliest year for which a complete set of data was available for the minimum number of categories required for a complete inventory according to the Community Protocol.

APPENDIX B - GREENHOUSE GAS INVENTORY

Factor Sets

The table below contains the factor sets used in the 2010-2018 inventories.

Factor Set Constants		
Emission Constants		
MTC02e per Lb	0.0004536	
MTCO2e/therm for Gas	0.005316	source: Spreadsheet - "Commercial NJCEP History & Future Estimates"
MTCO2e/therm for Oil	0.007440	ClearPath
MTCO2e/SolidWaste Tons	0.3390	CO2 Factor set from GROWS Model
MTCO2e/gallon of Gasoline	0.00889	Source: EPA https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
GHG equivalents CH_4 to CO_2	21	source: ICLEI US Community Protocol for Accounting and Reporting of GHG emissions
GHG equivalents N_20 to CO_2	310	source: ICLEI US Community Protocol for Accounting and Reporting of GHG emissions
Grams per Lb	453.58	
Waste Characterization	**Percentage**	
Mixed MSW	40.0%	Source: http://www.mcianj.org/filestorage/133/154/T%26M_Final_Waste_Study_-_Sept._2015.pdf
Newspaper	5.0%	
Office Paper	5.0%	
Percentage Corrugated Cardboard	5.0%	
Magazines	5.0%	
Food Scraps	25.0%	
Grass	2.5%	
Leaves	2.5%	
Branches	5.0%	
Dimensional Lumber	5.0%	
Transportation	**Percentage**	
Vehicle Classes		Reference: ICLEI Appx D - Transportation and other mobile emissions sources
Passenger Vehicles	60%	
Light Trucks (including SUVs and Minivans)	35%	
Heavy Trucks (Including Buses)	5%	

Community Demographics

The table below contains the community demographics used in the 2010-2018 inventories.

Community Overview

Source: US Census, Princeton U

Population: ACS Demographic and Housing Estimates 2017. Queried with US Census Bureau FactFinder tool, https://www.google.com/publicdata/explore?ds=kf7tgg1uo9ude_&met_y=population&hl=en&dl=en#!ctype=l&strail=false&bcs=d&nselm=h&met_y=population&scale_y=lin&ind_y=false&rdim=country&idim=place:3460900&ifdim=country&hl=en_US&dl=en&ind=false, https://www.census.gov/quickfacts/fact/table/princetonnewjersey/BZA010215#viewtop

Households: http://princetonfuture.org/wp-content/uploads/2017/05/Profile2014.pdf AND American Community Survey - American FactFinder query tool

Princeton University Students: https://registrar.princeton.edu/university_enrollment_sta/

http://www.princetonnj.gov/financial-docs/Princeton-Budget-Newsletter-2015.pdf

Estimates= orange text	Population	Annual Growth Rate	Households	Persons per HH	Princeton University Students	Number of businesses	Private Workers
2010	28,621		9,521		7,802		
2011	28,139	-1.68%	9,596		7,859		
2012	29,507	4.86%	9,672		8,010	1,584	30,501
2013	29,867	1.22%	9,747		8,014		
2014	29,859	-0.03%	9,822		8,088		
2015	30,333	1.59%	9,898		8138		
2016	31,249	3.02%	9,973	2.48	8,181		
2017	31,407	0.51%	9,997		8,266		
2018	31,386	-0.07%	10,067		8,330		

Production Based Inventory Model

Community Inventory

Community Demographics

In order to fill out many of the calculators in ClearPath™, we needed to get basic information about the community such as population, number of households, workers, businesses and students. This data was taken from the US Census (using the FactFinder query tool) and Princeton University. To give a brief summary: Princeton had 28,621 residents in 2010 and 31,386 in 2018. The university student population was 7,802 in 2010 and 8,330 in 2018.

The count of households, also sourced from the ACS, is included in the model for estimating the number of houses that use oil (see Residential Energy section) and the count of cars (see Transportation Sources section)

There are a number of things to keep in mind about Census data. The first and perhaps most important is that the Census is only counted every ten years. Therefore, all the years in between are just estimates from the American Community Survey (ACS) -- and sometimes vary in different ways. Another issue is that before 2013, Princeton was two different municipalities, which may have made the data somewhat inconsistent due to separate record keeping. And third is that around 30% of Princeton's population is college students, which makes the total household number an imperfect measurement when it is used in a number of calculators. That being said, we used the best available data and made the best judgments to use the data for the calculators.

Built Environment Emission Activities and Sources

To model emissions from the built environment, the model is segmented into residential, commercial and industrial sectors.

Residential Emissions

The residential model accounts for emissions from the consumption of electricity (kWh), natural gas (therms) and fuel oil (therms) for households. For houses heated by natural gas, the model simply multiplies total community kilowatt-hours and gas therms by their respective CO_2 factors. The data is sourced from PSEG (Jill Reilly is jill.reilly@pseg.com).

As for fuel oil, the first step is to calculate the average annual therms per natural gas households from the natural gas data (PSEG) divided by the number of households that use gas (ACS). This value varies from year to year depending on the heating degree days. We assume that fuel oil households use on average the same amount of therms. We then multiply the annual therms by the number of fuel oil households (ACS) to get the total therms. Please note that the number of households that use fuel oil have declined significantly from 14% in 2010 to 7% in 2018. Finally the total therms of fuel oil is multiplied by its CO_2 factor.

Commercial and Industrial Emissions

The electricity and natural gas data that we receive from PSEG is categorized by residential, commercial and industrial accounts. As such, we simply multiply the total kWh and therms for each sector by the respective CO_2 factors.

APPENDIX B - GREENHOUSE GAS INVENTORY

Transportation and Other Mobile Emission Activities and Sources

The general model for transportation takes vehicle miles traveled (VMT) by different types of vehicles (light trucks, heavy trucks, passenger cars and electric vehicles) and accounts for their respective efficiencies (miles per gallon).

For VMT data, we contacted the Metropolitan Planning Organization (MPO) for Princeton, the Delaware Valley Regional Planning Commission (DVRPC). Transportation Analyst Matthew Gates, mgates@dvrpc.org, sent us Princeton's VMT for 2010 and 2015, which were 689,000 and 787,000 miles per day respectively. These VMT numbers include all vehicles on the road including buses, motorcycles, light and heavy trucks and are based on a number of data collection tools and models to determine all VMT of a community.

There are multiple ways to measure VMT using a regional travel model. One way is to measure all the transportation activity within a jurisdiction which is called the "In Boundary" method. Another, which is the preferred method by ICLEI and DVRPC, is an "Origin-Destination Split" method. The Origin-Destination method takes every trip and applies half distance traveled to the municipality of origin and half to the municipality of destination. This method is ideal for regional analysis because you can see where travel activity comes from and goes to, but it is also good for analyzing the overall transportation activity of the town. We chose to use the Origin-Destination because it was the methodology for GHG inventories and most representative of resident travel patterns. This information is further explained in a memo provided by DVRPC.

The DVRPC only runs the regional travel model every five years. Therefore, we interpolated for the years in between 2010 and 2015. For the years after 2015, we projected the data using the growth rate between 2010 and 2015. The DVRPC should be contacted in 2020 for the VMT and adjust estimates.

To separate VMT for electric vehicles from VMT for internal combustion engines (ICE), we estimated total Princeton vehicles by multiplying the population by cars per capita. Cars per capita was estimated using 2017 total vehicles in NJ (ACS) divided by 2017 total NJ population.

We obtained annual registered electric vehicles (EV) by Princeton residents from the New Jersey Department of Environmental Protection (Brittany Pfeiffer is the contact). We were able to estimate the percentage of EV owners by dividing the EV count by the total vehicle estimate. Assuming EV owners drive on average as far as ICE owners, we then subtracted the VMT for EVs from the total VMT to get VMT for ICE vehicles. We do not estimate emissions from the electricity consumed by the EVs as that should be accounted for in the residential electricity account or in the municipal electricity account for public charging stations.

As for emissions from ICE vehicles, we calculated the gallons of gasoline used by assuming a distribution of 60% passenger vehicles 35% light trucks (SUVs are considered light trucks), and 5% heavy trucks in accordance to data available in ClearPath. The MPG for each of these classes of vehicles is from the Bureau of Transportation Statistics and varies from year to year. Grams of CO_2 generated from the burning of a gallon of gasoline divided by MPG gives a factor of CO_2 per mile. Finally, ICE VMT times CO_2 per mile gives total CO_2 emissions

Solid Waste Emission Activities and Sources

We received the Solid Waste tonnage from Phil Wagner (pwagner@mercercounty.org) at the Mercer County Improvement Authority (MCIA). Princeton has a contract with the MCIA to manage solid waste removal. In turn, MCIA has a contract with Central Jersey Waste/Solterra to collect waste and transport it to the GROWS landfill managed by Waste Management in Tullytown, PA. We recommend that Solid Waste data be collected every year from MCIA as waste composition can change year to year thereby affecting emissions.

We then calculated a factor for converting tons of waste to metric tons of CO_2 equivalents using ClearPath™. The ClearPath™ model accounts for the methane that the GROWS landfill captures. Last, note that there have been discussions about closing the GROWS landfill, which is important to keep in mind for future tracking.

Wastewater and Water Emission Activities and Sources

Princeton's wastewater is centrally processed at the Stony Brook Regional Sewer Authority. Over 99% of household sewage goes to the SBRSA, sewage from the remaining households are treated in septic tanks (Princeton Map 3M: Future Wastewater and Service Area Mercer County 2013). SBRSA is located within Princeton and services several neighboring municipalities as well. To determine the energy usage and gallons of sewage treated we took the percentage gallons of sewage pumped for Princeton (~30%) and calculated the same percentage of the energy usage.

Typically, general water supply emissions are related to the extraction, treatment, transportation and storage of water, while wastewater emissions are attributed to the energy-intensive transportation and treatment of wastewater. The ClearPath model for wastewater emissions is designed for a variety of wastewater systems, ranging from septic systems to centralized water treatment plants. And it is designed for varying levels of detail of available data. A simple model might include only the population served as the input. The most detailed model accounts for CO_2, N_2O and CH_4 emissions at each step of treatment processes, including incineration. We chose to account for the following components of the model: i) CO_2 emissions from electricity and natural gas consumption to run the plant, ii) fugitive emissions of N_2O and CH_4 from the denitrification process, iii) CO_2, N_2O and CH_4 emissions from the incineration of sludge, iv) N_2O from effluent discharge. The data inputs needed are electricity kWh (PSEG), natural gas therms (PSEG), population served (SBRSA) and tons of sludge per year (SBRSA).

PSEG provided the electricity and natural gas data. We simply multiplied kWh and therms by their respective emission factors to obtain CO_2 equivalent metric tons.

The SBRSA has aeration tanks where denitrification occurs. The ClearPath model for the fugitive N_2O emissions from the denitrification process takes population served as an input and multiplies it by a factor of 7 to get grams of N_2O per person per year. The total N_2O is then multiplied by a global warming potential factor to get CO_2 equivalent metric tons.

Similarly, the incineration model from ClearPath is simply the product of wet weight of incinerated sludge times factors for CH_4 and N_2O to get grams per person per year (9.7 and 900, respectively) times days per year times the global warming potential factor of both to get CO_2 equivalent metric tons.

Lastly, approximately 10% of nitrogen is not removed in the treatment process. The various forms of nitrogen in the effluent react downstream in the watershed producing the largest component of N_2O emissions from the overall wastewater treatment. The ClearPath model (ICLEI Community Protocol, Appendix F, equation WW12(alt)) is the following equation:

N2O emissions = P(Nload -Nuptake BOD5 load) EF 44/28
(1-Fnit/denit)365.2510-3GWPN2O

Where
P = population served
N_{load} = 0.026 nitrogen load (kg) per person per day
N_{uptake} = 0.05 = nitrogen uptake for cell growth in aerobic systems, kg N/kg BOD_5
BOD_5 *load* = 0.090 = amount of BOD_5 produced (kg) per person per day
EF = 0.005 = emission factor for kg N_2O-N/kg sewage N discharged (for streams)
44/28 = the ratio of N_2O to N_2
$F_{nit/denit}$ = 0.7 = fraction of nitrogen removed by the denitrification process
GWP_{N2O} = greenhouse warming potential of N_2O, metric tons of CO_2 equivalent

APPENDIX B - GREENHOUSE GAS INVENTORY

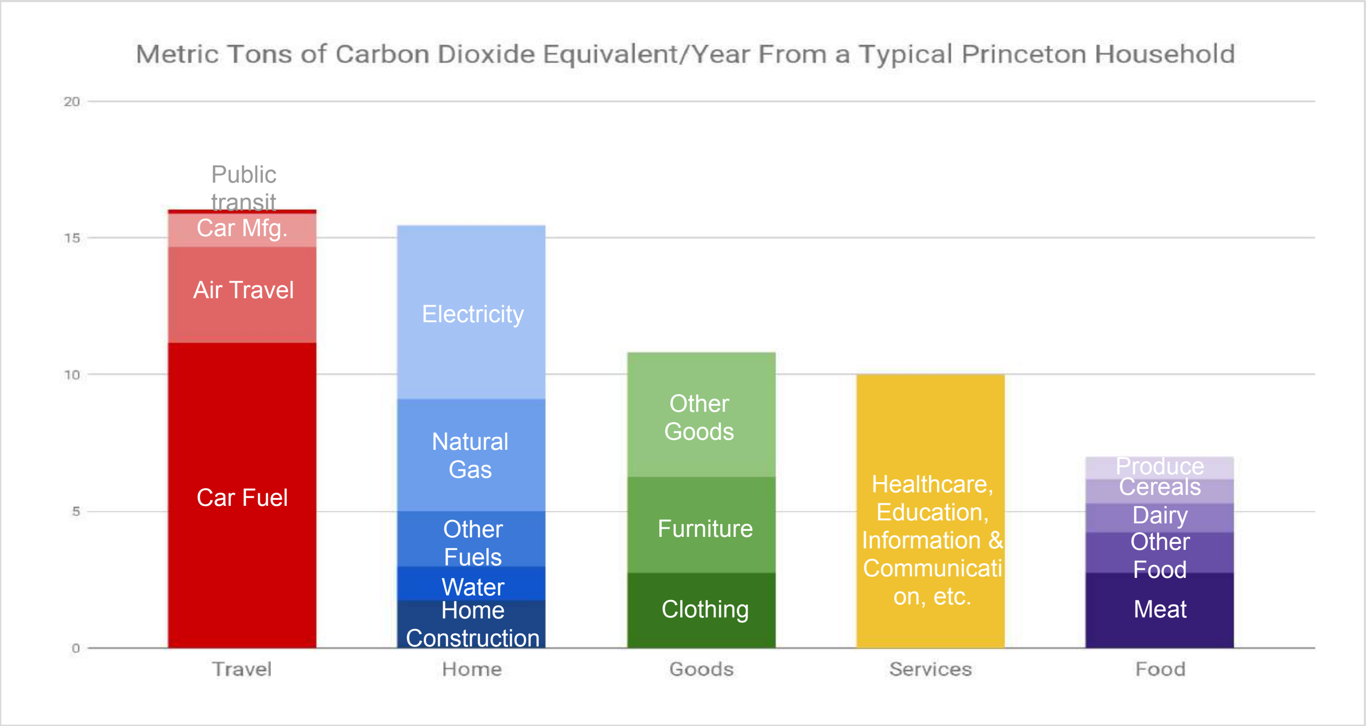
Consumption-Based Inventory

For the Consumption-Based Inventory, we used and adapted UC Berkeley's [CoolClimate Carbon Footprint Calculator] and data. This tool was recommended by the ICLEI protocol as the best readily available online product for measuring consumption-based emissions. While it is a good way to get a sense of consumption-based emissions, the model and data used for the CoolClimate tool is from 2007 and hasn't been updated since. Therefore, it is difficult to measure the variation from year to year or know how much has changed. However, one can use the change in population, and an update in the model is planned for 2018, so keep an eye for future updates. Once it's updated, it might be possible to improve the create linear estimates for the years in between.

Conducting a local consumption-based emissions survey

While it was beyond the available time of this project, we recommend Sustainable Princeton conduct a local consumption-based emissions survey. We prepared a draft survey along with this inventory. This survey asks residents and students to use the CoolClimate Calculator and provide Sustainable Princeton with the results. Sustainable Princeton could then use this data to do more local analysis of consumption-based emissions.

In regard to how we used the CoolClimate data to get a community-wide assessment, we took the average carbon footprint of a household in Princeton from the CoolClimate data and multiplied it by the number of households in Princeton.



We also created a profile carbon footprint of the average university student and multiplied that by the numbers of university students. We were able to get the per person number by dividing the overall footprint (households and students) by the number of total residents.

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Scenarios for "Pathways to Princeton's GHG Reduction Goal"

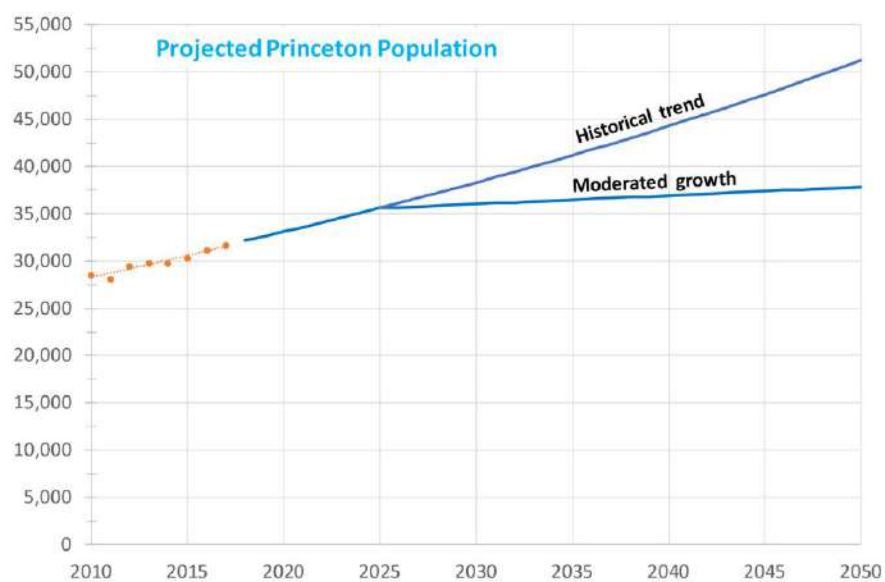
1. Emissions Grow With Population

1a. Population Growth

Projections were made for two cases of population growth:

a. **Moderated growth:** 2010-2016 growth rate of 1.47% per year continues until 2025; 2025-2050 growth rate was assumed to be 0.25%, following 2025-2045 projections from the Delaware Valley Regional Planning Committee (DVRPC).

b. **Historical trend**: 2010-2016 growth rate of 1.47% per year continues through 2050.



In both cases, the 2010-2016 growth rate was assumed to continue through 2025, to accurately capture the ongoing affordable housing projects and planned expansion of Princeton University (though the 2010-2018 growth is slightly different, the 2010-2016 growth matches better with those planned projects). Due to the uncertainty of future projects after 2025, the "Moderated growth" scenario is the default in ensuing calculations.

2. Business as Usual Efficiency Trends

2a. Effect of Climate Change on Energy Demand

As the globe warms, energy demand will be affected -- with more cooling needed in the summer and less heating needed in the winter. All the CAP scenarios account for these changes, using projections from the World Bank Climate Change Knowledge Portal. This source offers localized values from the CMIP5 ensemble of climate models, which are used in the UN IPCC's global climate change reports. From the above link, we clicked on the closest possible point to Princeton (40.38 N, 70.66 W) and read off data for monthly anomalies of heating and cooling degree days under an RCP 8.5 scenario (global business as usual). Since this anomaly measured the change from 1986-2005 (~1995) values to 2040-2059 (~2050) values, we scaled by a factor to arrive at anomalies between 2018 and 2050:

Formula: (2018->2050 anomaly) = (1995->2050 anomaly) x (2050-2018) / (2050-1995)

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Heating degree days measure the degrees Fahrenheit below 65°F for each day's average temperature (e.g. a 50°F day would have 15 "heating degree days"). Cooling degree days measure the degrees Fahrenheit above 65°F for each day (e.g. an 80°F day would have 15 "cooling degree days").

Having calculated the monthly 2018->2050 anomalies for these two metrics, we totalled the monthly numbers into annual sums and compared the numbers to current energy use. Since weather variations can affect annual heating and cooling needs substantially, we averaged CAP inventory data for 2010-2018 to estimate this baseline energy use. We then used data from the Energy Information Administration's Residential Energy Consumption Survey (EIA RECS) and Commercial Building Energy Consumption Survey (EIACBECS) to determine how much of the town's electricity and natural gas use could be attributed to heating and cooling:

Reference data from EIA Residential Energy Consumption Survey Source: EIA RECS 2015 (most recent), Table CE4.7 (Northeast) Electricity per household (Middle Atlantic average)		
Total	8,465	kWh/yr
Heating (space heating)	3,190	kWh/yr
Cooling (air conditioning)	1,101	kWh/yr
Other (water heating)	3,182	kWh/yr
Other (refrigerators)	701	kWh/yr
Other (other)	4,703	kWh/yr
% of elec. to heating	**38%**	
% of elec. to cooling	**13%**	
Natural gas per household:		
Total	675	ccf/yr
Space heating	553	ccf/yr
Other (water heating)	192	ccf/yr
Other (other)	59	ccf/yr
% of gas to heating	**82%**	
% of gas to cooling	**0%**	

EIA Commercial Building Energy Consumption Survey Source: EIA CBECS 2012 (most recent), Table E5/E7 Electricity intensity (National)		
Total	14.6	kWh/sq ft
Heating (space heating)	0.5	kWh/sq ft
Cooling (air conditioning)	2.4	kWh/sq ft
Other (ventilation)	2.4	kWh/sq ft
Other (water heating)	0.2	kWh/sq ft
Other (lighting)	2.5	kWh/sq ft
Other (cooking)	1.1	kWh/sq ft
Other (office equipment)	0.6	kWh/sq ft
Other (computing)	1.5	kWh/sq ft
Other (refrigerators)	2.7	kWh/sq ft
Other (other)	2.7	kWh/sq ft
% of elec. to heating	**3%**	
% of elec. to cooling	**16%**	
Natural gas intensity (National)		
Total	38.3	kBtu/sq ft
Space heating	27.1	kBtu/sq ft
Other (water heating)	10.7	kBtu/sq ft
Other (cooking)	15.9	kBtu/sq ft
Other (other)	10	kBtu/sq ft
% of gas to heating	**71%**	
% of gas to cooling	**0%**	

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Finally, these 2018 values were projected to 2050:
Formula: (2050 energy values) = (2018 energy values) x (2050 heating or cooling degree days/2018 heating or cooling degree days)

And to use in projections of every year between 2018 and 2050, we converted the result to a percent change value that would scale by population:

Formula: (percent change from 2018 to 2050) = (2050 energy values - 2018 energy values) / (2010-2018 energy used per capita x 2010-2018 population)

Results to be used in energy projections are below. A warming planet decreases our need for gas (and some electric) heating in the winter, but increases the need for air conditioners powered by electricity in the summer.

Change from 2018-to 2050	Electricity (kWh)	Natural gas ($MTCO_2e$)
Residential	**0.8%**	**-9.8%**
Commercial	**6.3%**	**-8.5%**

2b. Electricity Grid

The business as usual scenario assumes that the grid will have constant carbon emissions per unit of electricity generation. This value was approximately **759 lbs CO2e/MWh** in 2018. The electricity generation needed (and resulting CO_2 emissions) are then scaled by the annual changes in population and energy demand.

Though there are ongoing local and statewide efforts to reduce the grid's carbon intensity, the business as usual projection is meant to resemble a "do nothing" case. Projections that reflect New Jersey's clean electricity goals are covered in "NJ Grid Goals Met."

2c. Natural Gas Emissions from Buildings

In the business as usual scenario, natural gas emissions from buildings are influenced by continuing the current rate of energy efficiency projects. These projects are typically carried out under the New Jersey Clean Energy Program (NJCEP). For commercial buildings, the current rate of projects per year was found from NJBPU data supplied by Arif Welcher, which lists the energy savings of every project from 2006-2017. Terms D and E in the below equation were broken up by specific NJCEP incentive (e.g. Direct Install, Pay For Performance).

Formula: (commercial natural gas emissions) = (A: Previous year's emissions) x (B: % change in population) x (C: % change in energy demand) - [(D: # of projects/year) x (E: annual energy savings per project) x (F: $MTCO_2e$ / energy unit conversions)[1]]

To calculate the current rate of natural gas-saving projects in residential households (HH), we used NJBPU data on the energy efficiency programs of Home Performance with Energy Star (HPwES) and Comfort Partners (CP):

*Formula: (baseline % of HH/year that use NJCEP) = (28 HPwES/year + 1.4 CP projects/year) / (median of 9710 HH in NJCEP era) = **0.30%***

Based on survey data from APPRISE (here and here) we assumed natural gas savings of 20% after a HPwES project, and savings of 7% after a CP project. We also assumed 23% of households would be eligible for CP (which is geared towards low-income residents), based on BPU program requirements and data from the 2017 American Community Survey.

[1] For the business as usual, the conversion for electricity is 759 lbs CO2e/MWh, (as described in the Electricity Grid section) while the conversion for natural gas is 0.0053 $MTCO_2e$/therm (as described in the inventory methodology).

Oil is another common heating fuel affected by NJCEP programs, so we included oil projections in this scenario. Because oil use has nearly halved since 2010 (see inventory), we projected that oil use (and emissions) will drop to zero by 2030, starting from its 2018 value and decreasing linearly.

We started natural gas emission projections from the 2010-2018 average emissions (since annual weather-related variations overshadow any historical trends), and initially scaled them by the population and energy demand changes listed above. These influences are summarized as "emissions before NJCEP" in the following equation:

Formula: (residential natural gas and oil emissions) = (emissions before NJCEP) x [1- (0.30% of households newly using NJCEP) x (19% savings/project)], where 19% savings/project is the weighted result from the above values of participant rate and energy savings for HPwES and CP.

2d. Emissions from Vehicles

The business as usual projections for vehicle emissions account for increases in vehicle miles traveled (VMT) proportional to population growth, as well as continued improvements in gasoline fuel efficiency. The latter was assumed to improve by 1.15% per year, based on the average improvement from 2012-2016 (Transportation Energy Data Book, Table 4.3 from August 2018).

Electric vehicles (EVs) were assumed to reach 11% of Princeton's VMT in 2050, in conjunction with a national projection from the EIA. Though Princeton is currently well ahead of the national average in terms of EV adoption, this "do nothing" scenario assumes a reversion to the national average. Emissions from EV charging are estimated using the constant electricity grid scenario described above.

2e. Solid Waste and Wastewater

Solid waste emissions are assumed to be constant from their 2018 values, since the historical values have not been clearly correlated to population. Wastewater emissions are assumed to grow with population, as suggested in the ICLEI ClearPath methodology used by the inventory.

3. NJ Grid Goals Met

This scenario projects the effect of New Jersey meeting its Energy Master Plan goal of 100% carbon-free electricity by 2050. Therefore, all of Princeton's electricity emissions would go to zero by 2050. The path to get there was estimated using the state's interim goals as well as PSE&G's current electricity source mix. The state's goals for electricity sold in-state are as follows, with all Energy Years (EY) ending in June of that year:

EY 2021: 21% from Class I Renewables (most common forms of renewable energy), 2.5% from Class II Renewables (energy from waste, and hydropower plants between 3 MW and 30 MW)

EY 2025: 35% from Class I Renewables, 2.5% from Class II Renewables

EY 2030: 50% from Class I Renewables, 2.5% from Class II Renewables

EY 2050: 100% from zero-carbon sources
(exact technologies not specified)

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

The below table shows PSE&G's electricity sources in EY 2017 (June 2016-May 2017). While the fractions of renewables were much lower in EY 2018, the scenario used EY 2017 as the reference point for the changes in 2019 onward, since the fuel mix in 2017 shows the percentage of carbon-free electricity that has already been prevalent in the grid (and therefore is already technologically and economically feasible). 2018's true carbon intensity value was edited in afterwards, without affecting the projections for 2019 and on.

Source	Renewable?	% of electricity supply
Coal	No	21.84%
Natural gas	No	22.47%
Nuclear	No	39.53%
Oil	No	0.12%
Hydro "large"	No (assume >30MW)	0.04%
Captured methane	Class I	1.98%
Fuel cells	Class I	0.02%
Geothermal	Class I	0%
Hydro "small"	Class I	0.05%
Solar	Class I	2.99%
Solid waste	Class II	2.41%
Wind	Class I	8.51%
Wood/biomass	Class I	0.04%

The overall carbon intensity of the grid was then calculated as follows:

Formula: (total carbon intensity) = ∑(technology's % of electricity supply) x (technology's carbon intensity)

Nuclear and all forms of renewable energy (including large hydropower) were assumed to be zero-carbon. The carbon intensities of coal, oil, and natural gas were calculated using average heat rates from EIA as well as carbon intensities from EPA. Any discrepancies between these national constants and local plants were corrected by comparing the resulting estimate for 2017's total carbon intensity with the known value from the inventory, and scaling the former by a constant to match the latter. This constant was used in subsequent years to maintain that calibration across the dataset.

Next, the interim goals were used to project the path from 2017's electricity source mix to 2050's. Between each interim goal, the following criteria were used to assign each technology's % of electricity supply:

a. Hydropower was kept constant at 0.04%
b. Class II Renewables were linearly increased from 2017 levels to 2.5% at EY 2021 (the first interim goal), and then held constant thereafter (following the later goals)
c. Class I Renewables were linearly increased from 2017 levels to 21% at EY 2021, then linearly increased to 35% at EY 2025, then linearly increased to 50% at EY 2030, then linearly increased to 97.46% at EY 2050 (assuming a clean grid with hydro and Class I & II Renewables only). However, Class I Renewables were not assumed to outcompete nuclear at any time; if there were no fossil fuels to replace in a certain year, the portion of Class I Renewables was held constant for that year.

d. Nuclear was assumed to remain constant until the current license end dates of New Jersey's three plants (2036, 2040, and 2046).[2] In the year following each closure, nuclear's allotment was projected to drop based on the proportion of electricity that came from the corresponding plant (i.e. if a closed plant had accounted for 40% of NJ's nuclear electricity, nuclear's fraction would decrease by 40%). In this year, the portion of Class I Renewables continued its linear increase towards its next target, and natural gas filled in the rest of the lost electricity generation. These changes cause the three "blips" seen in the "Pathways to Princeton's GHG Reduction Goal" figure.

e. Fossil fuels were taken out of the electricity mix as the share of renewables increased, starting with coal and continuing to oil and natural gas. Though all fossil fuels went to zero by EY 2034 (when nuclear accounted for 40% and renewables made up the rest), natural gas returned whenever a nuclear plant closure could not be fully "covered" by the next year of increased renewables.

Using each year's allotment of electricity for each technology, the above formula was used to calculate the carbon intensity each year. This projection for electricity was used in all ensuing scenarios.

[2] This assumes that all of PSE&G's nuclear electricity is coming from the three New Jersey plants that PSEG operates. While it is possible that PSE&G receives some nuclear electricity from out-of-state plants, changing the assumption would not change the result of a clean grid in 2050. The only noticeable change in the "Pathways to Princeton's GHG Reduction Goal" charts would be a smaller set of "spikes" at the nuclear closure dates, since less of the nuclear allotment would be disappearing at any of the New Jersey plant closures.

4. Princeton University Goals Met

Princeton University's 2019 Sustainability Action Plan has a goal of zero emissions from University buildings by 2050. Since electricity already declines to zero under the above electricity grid scenario, this scenario focuses on the University's natural gas emissions. These emissions were assumed to decrease linearly to zero by 2046, from 2018's inventory value.

5. Accelerated Electric Vehicle Adoption

While the business as usual scenario assumes that EVs will make up 11% of VMT by 2050, this scenario calculates the effect of having 50% of VMTs from EVs by 2050. The other calculations mirror the initial scenario, but now use the "NJ Grid Goals Met" scenario for electricity. This change reduces the emissions from EVs substantially, since their charges are now assumed to be carbon-free by 2050.

6. Renewable Government Energy Aggregation (R-GEA)

Princeton's CAP has a goal of 100% renewables for its residential electricity use by 2025. The Town Council has already approved the hiring of consultants to begin the process of setting up an R-GEA to reach that goal. Given the pace of that planning, an R-GEA was projected to begin in 2021.

Since the exact result of market bidding is uncertain, we assumed that the initial R-GEA would resemble those of other NJ towns, which obtain 41% renewables from the regional PJM grid and the rest from Texas wind farms. Since the 41% is the only fraction that would clearly connect to our grid, we assumed that 41% of the town's electricity would now come from Class I Renewables, as opposed to the fraction previously in the "NJ Grid Goals Met" scenario (otherwise, we used the same criteria for assigning the percent of electricity supply from different sources).

We further assumed that the value of 41% in 2021 would linearly increase to 100% in 2025, to show the effect of meeting the CAP goal (this is conceivable as renewables become more widespread and economical). Under this scenario, all electricity would be carbon-free starting in 2025, as opposed to a much later year.

The new annual carbon intensity of the grid was calculated in the same way as the previous grid scenario. In addition, this new scenario was added to the "Accelerated Electric Vehicle Adoption" scenario, allowing EVs to reduce their emissions even sooner with a cleaner grid.

7. Improved Rate of Commercial Energy Efficiency Projects

This scenario was designed to show the hypothetical effect of doubling the rate of commercial energy efficiency projects. This could happen as the result of increased outreach as well as new incentives and policies. The result would be a further reduction in natural gas emissions. Other than the doubled rate, the methodology matches that of the business as usual scenario for commercial buildings.

8. Residential Energy Efficiency: Audit at the Time of Sale and Electric Heat Pumps after 2035

CAP action 1.3 seeks to implement a mandatory energy audit at the time of a home's sale. Since audits may lead to energy efficiency projects, mandating audits would increase the rate of projects, decreasing natural gas emissions from homes. According to the Princeton municipal website, 3.7% of the town's residential households were sold per year, on average, in 2014-2016 (the only years with complete data). In addition, previous outreach from Ciel Power showed that about 23% of audits resulted in an NJCEP energy efficiency project. As a result, the following rate of additional projects per year was begun in 2020:

Formula: (new rate of additional projects/year) = (old rate) + ((# of HH sold/year, 2014-2016) / (average # of HH, 2014-2016)) x (23% of audits->projects)

In addition, CAP action 1.6 aims to accelerate affordable electrification of building energy systems. If natural gas heating units are replaced by electric heat pumps that run on cleaner fuels, the result would be a decrease in emissions. However, the state's Energy Master Plan draft states that heat pumps are not currently cost-competitive with natural gas. As a result, this scenario did account for heat pumps, but not until 2035 and beyond. Using the "NJ Grid Goals Met" scenario for the electricity carbon intensity, the ICLEI ClearPath tool calculated the effect of one gas unit's switch to an electric heat pump. Starting in 2035, each of the projects were assumed to make this switch, realizing the CO_2 benefits.

9. Clean In-Town Transit by 2050

This scenario shows the hypothetical impact of switching all gasoline-fueled in-town trips to clean alternatives by 2050. An "in-town trip" is a vehicle trip that starts and ends within the municipality boundaries. These trips were assumed to average 2 miles in length; for context, the municipality is roughly 4 miles by 4 miles. Traffic data from Ralph Widner (using a Databank extrapolation of U.S. Census Bureau data) was used to estimate the number of in-town commuter and non-commuter trips per day. These were converted to annual values (using a 235-day work-year[3] for commuter trips), and projected to increase annually with population. Meanwhile, the percent of these trips switching to clean alternatives was assumed to increase linearly from 0% in 2018 to 100% in 2050. The following equation was used to calculate the CO2 savings in each year:

Formula: (CO_2 savings) = (2 miles/trip) x (CO_2/mile[4]) x [(daily commutes avoided x commuting days/yr) + (daily non-commutes avoided x 365 days/yr)]

[3] The U.S. averages 8 holidays and 17 vacation days = 25 days off, so the workday estimate is for 52 weeks x 5 days/week - 25 days off = 235 workdays.

[4] CO_2/mile conversions for gasoline-powered trips were the same as in all transportation scenarios, as explained in the business as usual scenario. All accounted for a 1.15% annual improvement in gasoline fuel efficiency, as seen in 2012-2016 data.

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Emissions Reduction Potential of Selected CAP Actions

Note: In reading the below numbers of emissions reduced, keep in mind that there are substantial uncertainties in projecting economic, social, and environmental data. As a result, the CAP states these emissions reductions in terms of broader high, medium and low categories rather than specific numbers.

Action 1.1 (Accelerate NJCEP Participation)

Emission Reduction Calculations (non-PU Commercial)

1. Determine data source

The changes associated with this action are projected in "NJ Grid Goals Met" (electricity) and "Improved Rate of Commercial Energy Efficiency Projects" (natural gas). Using values from the above projections, we single out the values needed:

Formula: (non-PU commercial reduction) = (Δ$MTCO_2e$ from non-PU commercial gas) + (Δ$MTCO_2e$ from non-PU commercial electricity)

2. Find changes in $MTCO_2e$ from non-PU commercial gas

Formula: (Δ$MTCO_2e$ from non-PU commercial gas) = (commercial gas from "Improved Rate of Commercial Energy Efficiency Projects") - (commercial gas from "Business as Usual")

3. Find changes in $MTCO_2e$ from non-PU commercial electricity

Formula: (Δ$MTCO_2e$ from non-PU commercial elec) = (new electricity saved with "NJ Grid Goals Met" and "Improved Rate of Commercial Energy Efficiency Projects") - (old electricity saved from "Business as Usual")

4. Apply formula in part 1 to find total emission reductions for commercial energy efficiency programs

Emission Reduction Calculations (Residential)

1. Determine differences in residential energy efficiency programs (NJCEP)

Since Action 1.1 does not mention electric heat pumps or the audit-at-time-of-sale policy, we include a separate scenario that matches the commercial projection of double the historical participation rate. This is termed the "Outreach" scenario for residential NJCEP projects.

2. Find changes in $MTCO_2e$ from "Outreach" scenario

Formula: (Δ$MTCO_2e$) = (emissions from "Outreach" scenario) - (residential natural gas emissions from "Business as Usual")

3. Apply formula in part 1 to find total emission reductions for accelerated residential energy efficiency

Addition of residential and non-PU commercial emission reductions is the total reduction for Action 1.1:

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	6,364

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Action 1.3 (Audit at Time of Sale)

Emission Reduction Calculations

1. Determine data source

Though data was unavailable for older commercial properties, we could estimate the residential part of the action using projections for "Residential Energy Efficiency: Audit at Time of Sale." The following formula was used:

Formula: (Δ$MTCO_2e$ for residential natural gas) = ($MTCO_2e$ from audit scenario without heat pumps) - ($MTCO_2e$ from "Business as Usual")

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	1,103

Action 1.6 (Energy Efficiency of Electrification)

Emission Reduction Calculations (Heat pumps in 2035+)

1. Determine differences in heat pumps after 2035

We isolate the "Electric Heat Pumps after 2035" portion of the residential energy efficiency projections.

Formula: (Heat pump $MTCO_2e$ reduction) = (Heat pump, NJCEP, and audit reduction) - (NJCEP and audit reduction)

2. Calculate impacts of having heat pumps during and after 2035

From the year 2035 and onwards, it is estimated that heat pump installation will become more economically feasible. To determine the emissions with the addition of heat pumps, the following factors are used:

Formula: (Total $MTCO_2e$ in scenario with heat pumps, NJCEP, and audit-at-time-of-sale) = (Previous year's $MTCO_2e$) × [(heat pumps from Comfort Partners program participants) + (heat pumps from HPwES program participants)] × ($MTCO_2e$ reduction per heat pump installation)

3. Find reductions from NJCEP and audits to subtract from part 2

Formula: (Total $MTCO_2e$ in scenario with NJCEP and audit) = (Previous year's $MTCO_2e$) × [(NG residential emissions) + (oil residential emissions)] × [1 - (cumulative number of HH participating in audits) × (weighted % $MTCO_2e$ saved per HH)]

The difference of values from part 3 with part 2 is the total reduction from the scenario with heat pumps in 2035+.

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	1,104

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Action 2.1 (Community Solar)

Emission Reduction Calculations

Value	Factor	Source
80,088	NJ Median income	Data USA
64,070	LMI threshold (80% of median)	
2,785	LMI Households	Data USA
8,760	Hours in a year	N/A
130	Average number of possible subscribers/project	Community Solar Pilot Program N.J.A.C. 14:8-9
2,000	Additional # of subscribers	CAP Draft KPI
0.15	Solar capacity factor (efficiency)	Princeton estimate from NREL PV Watts tool
729.6	lbs CO2/MWh	2017 inventory value
2,205	$MTCO_2e$/lb	Quantitative conversion

1. Find the expected number of households to participate in community solar in Princeton

According to the CAP draft, 100% of LMI residents and 2,000 other subscribers are expected to participate in community solar by 2025.

4,785	Total Subscribers by 2025

2. Determine number of MW that are needed to satisfy number of subscribers

With the minimum and maximum numbers of subscribers needed for a community solar project detailed in the Community Solar Pilot Program N.J.A.C. 14:8-9, the average possible number of subscribers for each 1 MW project is 130 subscribers. Assuming all projects average 130 subscribers, division is used to determine the amount of power needed in total (37 MW). The capacity is assumed to start at 5 MW in 2021 (largest project size in first year of pilot) and then increase linearly to the CAP goal.

32	Average MW installed capacity

3. Conversion from MW to MWh

The conversion from MW to MWh requires the use of the solar capacity factor, which is based off the efficiency of the solar project itself.

Formula: (MWh value) = (MW value) × [Solar capacity factor] × [total hours/year]

48,618	MWh of solar

4. Conversion from MWh to $MTCO_2e$

Conversion to $MTCO_2e$ requires the use of the grid's annual carbon intensity, as projected in "NJ Grid Goals Met."

Formula: ($MTCO_2e$) = (MWh) × [lbs CO_2/MWh] × 1/[Conversion of lbs/MT]

2934	MTCO2e

Annual reduction:

Estimated Reduction (MTCO2e) Annual Average for 2019-2050	2934

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Action 2.2 (Renewable Government Energy Aggregation; RGEA)

Emission Reduction Calculations

1. Determine emission sources that would be reduced by a townwide R-GEA program

The changes which would have effects with emission reduction are differences in the grid and electric vehicles. Using values from the CAPERS future GHG scenarios (R-GEA case), we source the following factors:

Formula: (Reduction from R-GEA) = (ΔMTCO₂e from new grid) + (ΔMTCO₂e from new EVs)

2. Find changes in $MTCO_2$ from new carbon intensity of the grid

Formula: (ΔMTCO₂e from new grid) = (new grid - old grid from "NJ Grid Goals Met")

3. Find changes in $MTCO_2$ from new emissions from EVs that are powered by the grid

Formula: (ΔMTCO₂e from new EVs) = (new EVs - old EVs from "Accelerate EV Adoption")

4. Apply formula in part 1 to find total emission reductions for the R-GEA program

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	5529

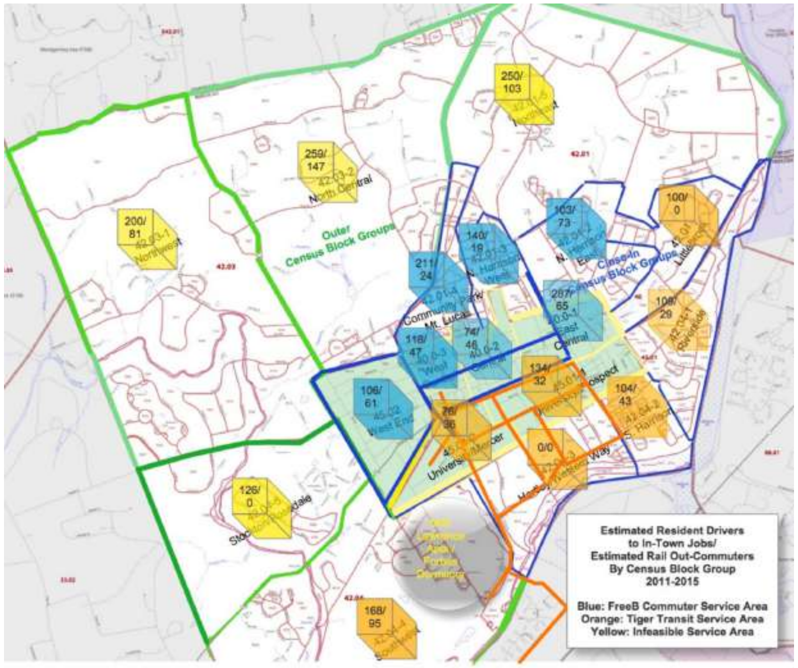
Action 4.1 (TDM programs)

Emission Reduction Calculations (Bike/Walk TDM Program)

1. Estimate enrollment in bike/walk program as part of a community-wide TDM program

From Databank extrapolation of U.S. Census Bureau data, 37.3% of RWIT (residents who work in town) bike (8.5%) or walk (28.85%) as their mode of commute. Also, 70% of the residents who do currently bike to work live in central/campus area. This is important to note, because residents in this area will be most likely to enroll in a bike/walk TDM program. Most TDM research shows that the increase of bike/walk commute due to TDM programs is usually 20-60% depending on the infrastructure. Since 37.7% of RWIT already bike/walk, it suggests this mode of commute is prevalent in the community and is relatively primed to increase. The choice of 50% of drivers who will switch to bike/walk TDM programs is selected with these factors in consideration.

APPENDIX C - EMISSIONS REDUCTION ANALYSIS



urce: 2011-2015 American Community Survey, U.S. Census Bureau; Modes to Work tables.

The above graphic shows the number of RWIT who drive by census block. To determine the number of resident drivers to in-town jobs of the central/campus area (blue and orange on the graphic), the numbers in each block were added together. Using the 50% as the percentage of drivers who switch to bike/walk TDM programs, there are 691 drivers from the central/campus area who are estimated to switch.

As for areas that are yellow in the above graphic, drivers from those areas are less likely to convert to bike/walk TDM programs due to the current number of people who do. Due to this, instead of a 50% conversion rate, a 15% rate is estimated instead.

With this number, there are 125 drivers from these farther areas who are estimated to switch to bike/walk programs

Total difference: 691 + 125 = 816 total estimated enrollees

2. Determine potential miles saved from bike/walk enrollment

REVISE YOUR RIDE (Effective Oct 2017)	Enrolled	Permits Saved		Gas & Main. Dollars Saved (To Date)	Miles Avoided (To Date)	CO2e Avoided (mtCO2e) (To Date)
Bike/Walk	649	649	$	79,343	661,193	238
Bus Pass (Faculty & Staff)	45	19	$	31,101	259,178	79
Bus Pass (Graduate Students)	5	3	$	1,035	8,623	3
Mass Transit (Faculty & Staff)	103	26	$	214,225	1,785,209	338
Mass Transit (Graduate Students)	58	9	$	137,258	1,143,820	217
Carpool	142	44	$	61,523	512,694	184
Vanpool	2	0	$	886	7,383	3
Total	1004	750	$	105,088	4,378,101	1,061

Source: Kim Jackson, *Revise Your Ride (RYR)* program at Princeton University

It has been about 1.5 years since RYR began. For bike/walk, the total miles saved over the course of the 1.5 years is 661,193. If this is converted to a daily amount (using a 235-day work year), there are 1,875.72 miles are saved per commute day per bike/walk. Seeing that there are 649 enrollees, the result is an average of 2.89 miles are saved per commute day per enrollee. With the result from part 1, which states there are an estimated 816 enrollees in the program, there will be on average 2358.24 miles saved for each commute day.

3. $MTCO_2e$ reduction from bike/walk TDM program

Value	Factor	Source
0.00043	$MTCO_2$/mile (2019 constant)	ICLEI
235	Number of commute days/year	Typical work schedule estimations
816	Estimated number of enrollees	Calculations from step 1
2,358.24	Miles saved each commute day	Calculations from step 2

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Formula: ($MTCO_2e$) = (Miles saved each commute day) × ($MTCO_2e$/mile) × (Number of commute days/year) = 238.3 $MTCO_2e$/year.

With the assumption that enrollment in the bike/walk TDM will happen at a constant rate over 10 years, starting in 2019 and ending in 2028, 2028 would be the first year in which the estimated number of enrollees is reached. With this process, the final value is scaled by 86%, which accounts for the 10% development each year from 2019.

Final bike/walk TDM reduction: 205 $MTCO_2e$/year

Emission Reduction Calculations (Large Employers TDM)

Value	Factor	Source
549	Princeton University (PU) employees who switched to mass transit	RYR program
6,900	Total number of PU employees	Princeton University Facts & Figures
15%	Assumed % who work for large employers	Assumption
32,766	Princeton's daily workforce	Ralph Widner; Databank extrapolation of U.S. Census Bureau data
18,525	Average number of miles saved/member over a 1.5 year period	Kim Jackson, RYR at Princeton University
0.00043	$MTCO_2$/mile (2019 constant)	ICLEI

1. Estimate number of people in the town of Princeton who will enroll in community-wide mass transit

By providing the option of mass transit enrollment to large employers (have greater than 50 employees), the numbers from the current mass transit program enacted in Princeton University can be scaled to fit the entire town.

Formula: (Princeton employees who will switch) = (*[PU employees who switched] / [Total number of PU employees]) × [Princeton's daily workforce] × [Assumed % who work for large employers]* = 393 mass transit members from Princeton

2. Determine number of miles saved total by incorporating membership

Using PU data from their mass transit program, an estimated number of miles traveled for each member is found by averaging the distances faculty and graduate students travel. This number of miles is applied for each member in the town of Princeton. Note that this may be an overestimate since the distance PU employees travel to work may be greater than those of other workers who travel to large employers.

Formula: (Total miles saved) = (*[Average number of miles per member saved over a 1.5 year period] /[1.5 years]) × (Mass transit members from Princeton)* = 4853550 VMT/year reduced

3. Calculate amount of $MTCO_2e$ reduced from VMT reduced

Formula: ($MTCO_2e$) = (Miles saved/year) × ($MTCO_2e$/mile) = 2087.03 $MTCO_2e$/year reduced

With the assumption that enrollment in the mass transit TDM will happen at a constant rate over 10 years, starting in 2019 and ending in 2028, 2028 would be the first year in which the estimated number of enrollees is reached. With this process, the final value is scaled by 86%, which accounts for the 10% development each year from 2019.

Final mass transit TDM reduction: 1793.5 $MTCO_2e$/year reduced

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Annual reduction:

Estimated Reduction (MTCO2e) Annual Average for 2019-2050	1999

Action 4.5 (Bicycle Mobility Plan)

Projections of Increased Bicycle Ridership

When Princeton's Bicycle Mobility Plan (BMP) is implemented, bike ridership will increase. We used ICLEI ClearPath methodology to estimate that level of increase based on the current ridership, which was determined from census block data on population density and the current "bike-friendliness" of each census block.

Each census block's population density was placed into one of the five density classes below. In addition, each block was rated for "bike-friendliness" using the following categories. The full definitions for "bike-friendliness" categories can be found on the ICLEI ClearPath methodology page.

Area Population Density	No Amenities	A	B	C
0-500K	.3%	1.5%	2.7%	5.0%
500-2K	.3%	1.5%	2.7%	5.0%
2K-4K	.3%	1.5%	2.7%	5.0%
4K-10K	.4%	2.1%	3.7%	6.8%
>10K	.8%	4.4%	7.6%	14.0%
All	.4%	2.2%	3.9%	7.4%

The percentages under each category in the table represent the estimated proportion of trips that are taken by bike. These estimates by census block were aggregated by density class:

% of pop in low density	8.8%
% of pop in low-mid density	31.6%
% of pop in mid density	33.4%
% of pop in mid-high density	14.6%
% of pop in high density	11.7%
%trips by bike now, low d.	2.2%
%trips by bike now, low-mid d.	0.3%
%trips by bike now, mid d.	1.4%
%trips by bike now, mid-hi d.	0.4%
%trips by bike now, hi d.	0.8%

Finally, the Bicycle Mobility Plan was consulted to understand how each census block might improve its biking infrastructure. Based on the ICLEI ClearPath category definitions, the following changes were estimated:

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Block	Bike rating now	Bike rating future
	N, A, B, C	N, A, B, C
Northwest + North Central	N	N
Northeast	N	N
Community Park/Mt. Lucas	N	N
N. Harrison West	N	B
N. Harrison East	N	B
Stockton/Rosedale	N	N
West End (north tip)	N	N
West End	N	A
West Central	N	A
Central	N	A
East Central	N	B
Littlebrook	N	A
University/Mercer	N	N
University (middle)	B	C
University/Prospect	A	B
Southwest	N	N
Hartley/Western Way	B	B
S. Harrison	N	A
Riverside	N	A

Using the above table that equates these ICLEI ClearPath categories to bike ridership percentages, we assigned a new bike ridership percentage for each census block and aggregated by density class:

%trips by bike post, low d.	4.0%
%trips by bike post, low-mid d.	0.5%
%trips by bike post, mid d.	2.4%
%trips by bike post, mid-hi d.	2.0%
%trips by bike post, hi d.	4.4%

Emission Reduction Calculations

ICLEI ClearPath methods were used to convert these ridership changes to a reduction in vehicle miles traveled (VMT). Other inputs in 2018 used inventory values and ICLEI ClearPath defaults:

Population	31,386
Trips/person/day	3

After dividing the total population into each density class, calculating the change in bike ridership by subtracting post-BMP values from current values, and then calculating a weighted average from the change in each density class, the following change in VMT was estimated after BMP implementation, using 2018 population:

Avg trip length (mi)	2
#of years for implementation	10
Change in VMT after BMP	-831,973

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

BMP implementation was assumed to happen at a constant rate over 10 years, starting in 2019 and ending in 2028. As a result, 2028 is the first year that would realize the full change in VMT.

Finally, annual reductions in CO_2 were calculated based on each year's reduction in VMT. Only population, gasoline fuel efficiency, and BMP completeness were assumed to change (using above projections in "Business as Usual"). Potential changes in population density (due to smart growth or other factors) were not included, due to pending litigation and other uncertainties associated with development in Princeton. The following formula was used:

Formula: ($MTCO_2$ reduced) = (Change in VMT after BMP) × ([That year's population]/[Population in 2018]) × (lb CO2/vehicle mile) × ($MTCO_2$/$lbCO_2$) × (% of BMP complete)

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	278

Action 4.6 (Car/Bike Share)

Emission Reduction Calculations

Value	Factor	Source
265,549	People in Jersey City	U.S. Census Bureau (2017)
31,386	People in Princeton	U.S. Census Bureau (2017)
650	Vehicles avoided in Jersey City from Greenspot's program	Brett Muney of Greenspot Smart Mobility
4,500,000	Reduced VMT from Greenspot's program per year	Brett Muney of Greenspot Smart Mobility
0.00043	$MTCO_2$/mile (2019 constant)	ICLEI ClearPath

1. Scale Jersey City's Greenspot Smart Mobility Program's results to the town of Princeton based on population

Data from Jersey City's implementation of its Greenspot Smart Mobility program, provided by Brett Muney, stated that this program removed a total of 650 vehicles, altogether reducing 4.5 million VMT each year.

Formula: (Vehicles avoided in Princeton) = ([Vehicles avoided in Jersey City/][People in Jersey City]) × [People in Princeton]

= 77 estimated vehicles avoided

2. Use proportion of reduced VMT from Jersey City and apply to Princeton

Formula: (Reduced VMT in Princeton) = ([Reduced VMT from Jersey City]/[Vehicles avoided in Jersey City]) × (Vehicles avoided in Princeton) = 521,051 reduced VMT/year

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

3. Convert from VMT to $MTCO_2e$

Formula: (reduced $MTCO_2e$/year) = (reduced VMT/year) × [$MTCO_2$/mile (2019 constant)]

= 224 $MTCO_2e$/year

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	224

Action 5.4 (Zero Emission Transition Fleet/Public Transit)

Although we do not have data on all municipal fleets, we conducted an initial analysis on the school district's buses.

Emission Reduction Calculations (Transition Fleet)

Value	Factor	Source
10,000	Annual mileage of small bus	PPS Transportation Coordinator
14,000	Annual mileage of passenger bus	PPS Transportation Coordinator
22	# of small unleaded fuel buses	PPS Transportation Coordinator
4	# of large unleaded fuel buses	PPS Transportation Coordinator
6	# of diesel buses	PPS Transportation Coordinator
7.6	MPG of small bus	PPS Transportation Coordinator
6	Average MPG of big bus	PPS Transportation Coordinator
0.01018	Diesel conversion (MTCO2/gallon)	EPA GHG Equivalencies Calculator
0.008887	Unleaded fuel conversion (MTCO2/gallon)	EPA GHG Equivalencies Calculator
1.15%	Annual projected gasoline improvement	Pathways to Princeton's GHG Reduction Goal

Formula (varies for each bus type): ($MTCO_2e$ released) = [amount of bus type] × ([average bus type mileage]/[MPG of bus type]) × [Conversion to $MTCO_2$ from gallons]

Large diesel bus emissions = 142.52 $MTCO_2e$
Small unleaded fuel bus emissions = 257.26 $MTCO_2e$
Large unleaded fuel bus emissions = 82.95 $MTCO_2e$

With the state's goal of an emissions-free electricity grid (and therefore emissions-free electric buses), the emission reduction in 2050 will be 482.73 $MTCO_2e$.

However, gasoline is projected to improve in the future. Using the annual gasoline improvement value of 1.15% from the Pathways to Princeton's GHG Reduction Goal, the emission reduction in the future years after 2019 includes gasoline improvement.
Formula: (next year's emission reduction) = (current year's emission reduction) × (1 - [annual projected gasoline improvement])

With these values, there is now an emission reduction value for each year that varies due to the gasoline improvement. The next step is to include the emissions from the electric buses that are projected to reach 0 by 2050 due to the emissions-free electricity grid. The emissions from the electric buses are calculated using the values of carbon intensity of electricity, which are from the "NJ Grid Goals Met" scenario.
Formula: (total emission reduction) = (current year's emission reduction) - (emissions from electric buses)

With the assumption that replacing diesel and unleaded fuel buses will happen at a constant rate over 10 years, starting in 2019 and ending in 2028, 2028 would be the first year in which all buses run on electricity. With this process, the final value is scaled by 86%, which accounts for the 10% development each year from 2019.

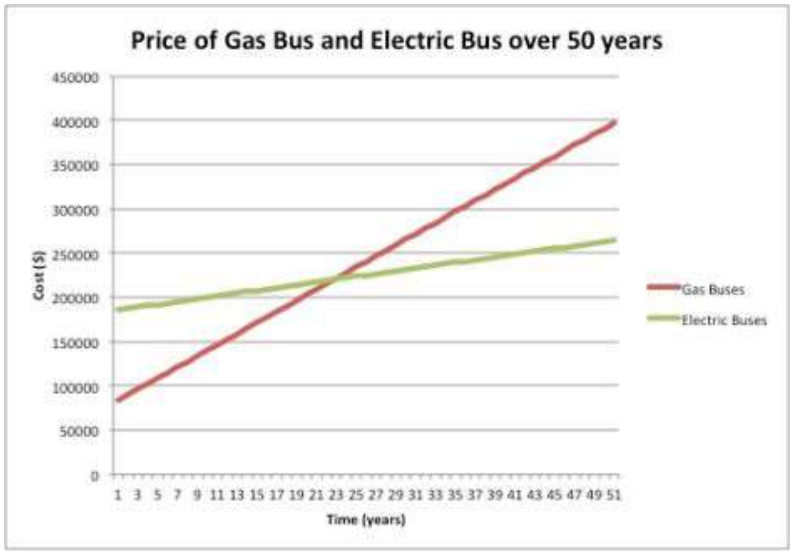
APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Annual reduction:

Estimated Reduction (MTCO2e) Annual Average for 2019-2050	314.5

Cost and Payback Calculations

Value	Factor	Source
83,686.59	Initial cost for a gas bus ($)	PPS Transportation Coordinator
185,731.05	Initial cost for an electric bus ($)	U.S. PIRG
6,265.969	Annual maintenance and fuel costs for gas bus ($)	PPS Transportation Coordinator
1,574	Annual maintenance and fuel costs for electric bus ($)	U.S. PIRG



Simple payback period for one gas bus and one electric bus

From this graph intersection, the total initial and maintenance costs for both buses will be equal 21.75 years from adopting electric buses. The cost for one bus of each type at 21.75 years is a total of $219,963.57.

Payback: 21.75 years

Action 6.1 (Open Space/Conservation Elements Master Plan)

Emission Reduction Calculations (Reforestation & Carbon Storage)

Value	Factor	Source
727,000	Overall long-term $MTCO_2e$ stored in trees (Princeton)	i-Tree survey of Princeton
10	Average acres per year available for reforestation	Estimate
0.553	Proportion of Princeton land area covered by trees	USDA i-Tree assessment report
11,750	Total current acres of trees	Wikipedia

Formula: ($MTCO_2e$ total stored through reforestation) = [Acres reforested per year] × [$MTCO_2e$ stored in trees (Princeton)]/([Coverage provided by trees]× [Total current acres])
= 1119 $MTCO_2$

Annual reduction:

Estimated Reduction ($MTCO_2e$) Annual Average for 2019-2050	1,119

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Action 6.5 (Lawn Maintenance Equipment)

Emission Reduction Calculations (Replacing Lawn Equipment)

Value	Factor	Source
30,762	Mercer County emissions from lawn equipment	Adam Beam from DVRPC (abeam@dvrpc.org)
372,733	People in Mercer County	U.S. Census Bureau (2017)
23,717	People in Princeton, excluding students	U.S. Census Bureau (2017) and Princeton University website
129,546	Households in Mercer County	U.S. Census Bureau (2017)
9,997	Households in Princeton	U.S. Census Bureau (2017)
289,769	People in Mercer County, excluding people in Trenton	U.S. Census Bureau (2017)
102,401	Households in Mercer County, excluding households in Trenton	U.S. Census Bureau (2017)

Calculation 1: Scaling Mercer County's lawn equipment emissions to those of Princeton with population
Assuming each person contributes the same amount to lawn emissions, we use the proportion of Mercer County's emissions to its population to calculate the projected emissions from Princeton.
Formula: (Princeton's emissions) = [Mercer County emissions/People in Mercer County] × (People in Princeton) = 1,947 $MTCO_2e$

Calculation 2: Scaling Mercer County's lawn equipment emissions to those of Princeton with households
Assuming each household contributes the same amount to lawn emissions, we use the proportion of Mercer County's emissions to its households to calculate the projected emissions from Princeton.
Formula: (Princeton's emissions) = [Mercer County emissions/Households in Mercer County] × (Households in Princeton) = 2,374 $MTCO_2e$

Calculation 3: Scaling a specific area of Mercer County's lawn equipment emissions to those of Princeton with population
Assuming each person contributes the same amount to lawn emissions, we use the proportion of Mercer County's emissions to its population to calculate the projected emissions from Princeton. In this case, since Trenton is a relatively urban area, there is also the assumption that the people in the area of Trenton do not use lawn equipment.
Formula: (Princeton's emissions) = [Mercer County emissions/People in Mercer County, excluding Trenton] × (People in Princeton) = 2,518 $MTCO_2e$

APPENDIX C - EMISSIONS REDUCTION ANALYSIS

Calculation 4: Scaling a specific area of Mercer County's lawn equipment emissions to those of Princeton with households
Assuming each household contributes the same amount to lawn emissions, we use the proportion of Mercer County's emissions to its households to calculate the projected emissions from Princeton. In this case, since Trenton is a relatively urban area, there is also the assumption that the households in the area of Trenton do not use lawn equipment.
Formula: (Princeton's emissions) = [Mercer County emissions/Households in Mercer County, excluding Trenton] × (Households in Princeton) = 3,003 $MTCO_2e$

With the assumption that replacing lawn equipment will happen at a constant rate over 10 years, starting in 2019 and ending

Emission Reduction Calculations (Low Maintenance Lawns)

Value	**Factor**	**Source**
11,584	Princeton land area	U.S. Census Bureau (2017)
143,718.4	Mercer County land area	U.S. Census Bureau (2017)
1.90%	% land used for landscaping	https://link.springer.com/article/10.1007%2Fs00267-004-0316-2
0.09524	Low maintenance lawn emissions ratio ($MTCO_2e$/acre)	Bedford, NY Climate Action Plan

Formula: ($MTCO_2e$ reduction) = [Princeton land area] × [% land used for landscaping] × [low maintenance lawn emissions ratio] = 20.9 $MTCO_2e$

With the assumption that changing to low-maintenance lawns will happen at a constant rate over 10 years, starting in 2019 and ending in 2028, 2028 would be the first year in which all lawns become low-maintenance. With this process, the final value is scaled by 86%, which accounts for the 10% development each year from 2019.

Final low maintenance reduction: 18 $MTCO_2e$

Annual reduction:

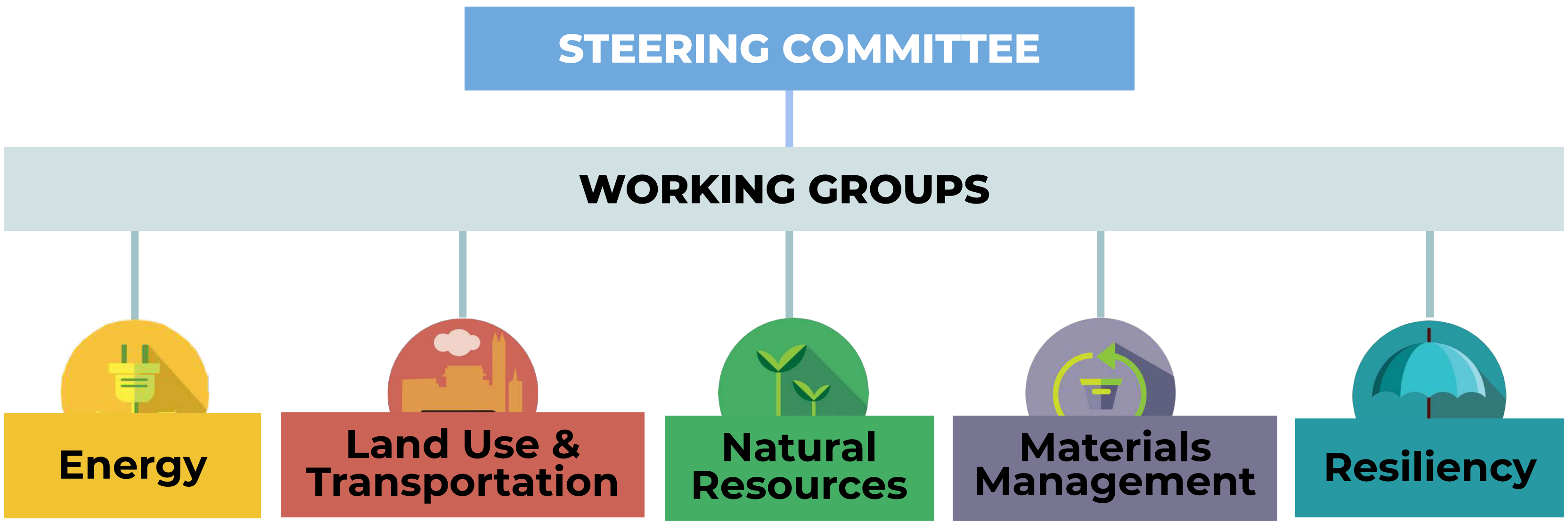
Estimated Reduction (MTCO2e) Annual Average for 2019-2050	2133

APPENDIX D - PLAN DEVELOPMENT PROCESS

Five Working Groups were also organized by subject matter: Energy, Resiliency, Land Use and Transportation, Natural Resources, and Materials Management. Each Working Group met at least four times, between April 2018 and March 2019. Working Groups were composed of approximately 7-10 members each, for a total of 41 committee member volunteers. Each Working Group reviewed proposed strategies, generated new measures, eliminated ideas deemed not feasible, and prioritized strategies based on feasibility and applicability to Princeton.

As each Working Group finalized the objectives and strategies for their focus area, representatives from the Working Group presented their findings to the Steering Committee for feedback and guidance. Later sessions of the Steering Committee also addressed CAPERS team emission and cost analyses.

On March 9, 2019 all 54 CAP Committee members were invited to attending a CAP Steering Committee and Working Group Workshop. At this event, members of each Working Group were charged with a careful review of each action item, identifying its co-benefits, lead and supporting organizations or departments, related plans, sources of funding, levers, and a rudimentary indication of GHG potential, anticipated cost, and anticipated feedback. Furthermore, they were asked to identify Key Performance Indicators for each focus area. Finally, to ensure the plan was comprehensive, the Steering Committee was then tasked with reviewing all Working Group strategies in their entirety.

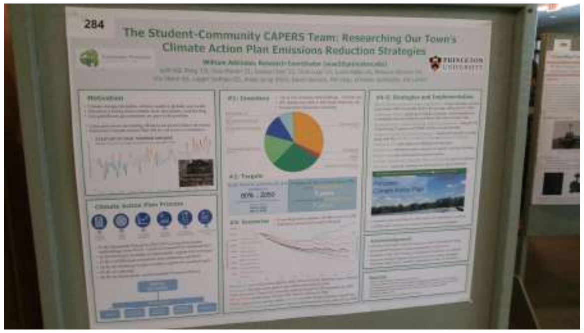


Identifying Targets and Interim Goals

The Steering Committee was tasked with identifying a target for GHG reductions, as well as interim goals. In order to establish these targets, the Committee first reviewed the targets being considered around the country and by the state of New Jersey. They also considered recent science reports, including the Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC). After considerable deliberation, the Steering Committee established an ambitious goal of 80x50. In other words, the CAP proposes that we reduce our GHG emissions by 80% of 2010 levels by 2050 while pursuing efforts to reduce emissions 100% by 2050.

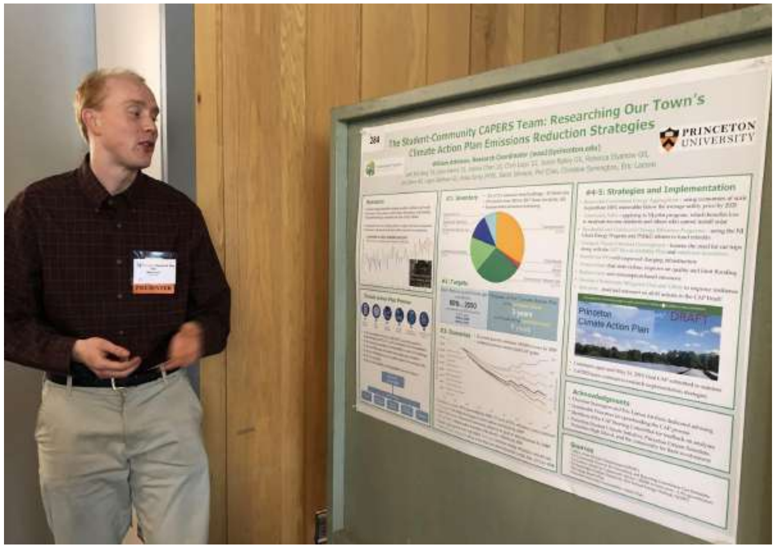
Data analysis from the Climate Action Plan Emission Reduction Strategies (CAPERS) team suggested that much of this goal is possible; however, the Committee recognized there is no silver bullet in the plan; no one action that can achieve this goal. Rather every recommendation must be considered and acted upon. The Committee is also aware that we may not achieve the goal with every action identified thus far; however, the update and revision plan for the CAP allows for future considerations of new strategies and technologies.

Similarly, interim goals of 50x30 and 65x40 were determined based on the CAPERS team data analysis and to ensure that progress toward the 80x50 goal begins in this decade.



CAPERS Princeton University's 2019 Research Day poster

The CAPERS team met weekly during the CAP development period to determine the emissions reduction potential of proposed CAP actions and combinations of actions.

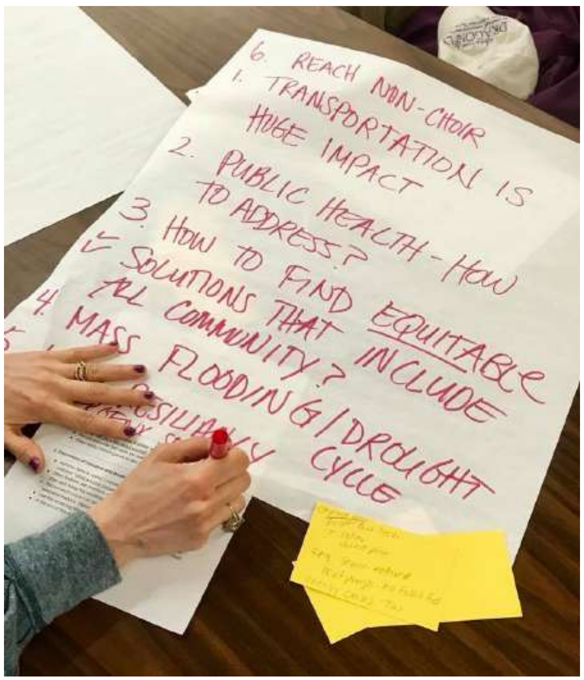


CAPERS team lead Will Atkinson '18 presented the team's work at Princeton University's 2019 Research Day.

APPENDIX D - PLAN DEVELOPMENT PROCESS

In the spring of 2018, as the Steering Committee and Working Groups were beginning to meet, Sustainable Princeton hosted three different public workshops dubbed "Let's Talk Climate." These workshops were devised to engage the community around the issues of Princeton's changing climate, and listen to the community's concerns and suggestions.

During these community conversations, participants first spent a few minutes meeting fellow attendees so that they might become more comfortable in the room. Afterward, attendees received a short, focused presentation on the concept of climate change and how scientists predict climate change will impact Princeton. Local photos of downed trees and flooded train stations were shared to exemplify the concerns described. The concept of the Climate Action Plan was then briefly introduced.



Following this presentation, attendees were asked to work in small groups to discuss climate change and the issues they considered to be most pressing. Table facilitators recorded their concerns, and then took turns reporting their concerns back to the room.

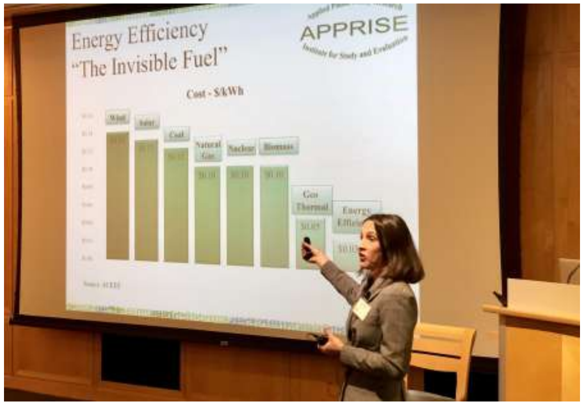
After this discussion, results from Princeton's GHG inventory were shared, as well as a few potential CAP solutions. Participants then engaged in a second discussion in their groups to consider solutions they felt should be incorporated into the CAP and acted upon. Table facilitators again recorded these solution ideas and they were shared back to the room.

These three programs garnered over 600 recorded comments from approximately 65 participants. To increase our reach, a similar program with slight modifications was taken to every 7th-grade class at John Witherspoon Middle School, as well as to a neighborhood meeting of the Witherspoon Jackson Neighborhood Association, yielding an additional 1100 comments from 250 participants.

APPENDIX D - PLAN DEVELOPMENT PROCESS

In 2018, Sustainable Princeton's Great Ideas series began to focus on various aspects of the Climate Action Plan. These seminars were hosted in the Princeton Public Library's Community Room and routinely attracted 75-100 members of the public, often including the Mayor and/or Council members.

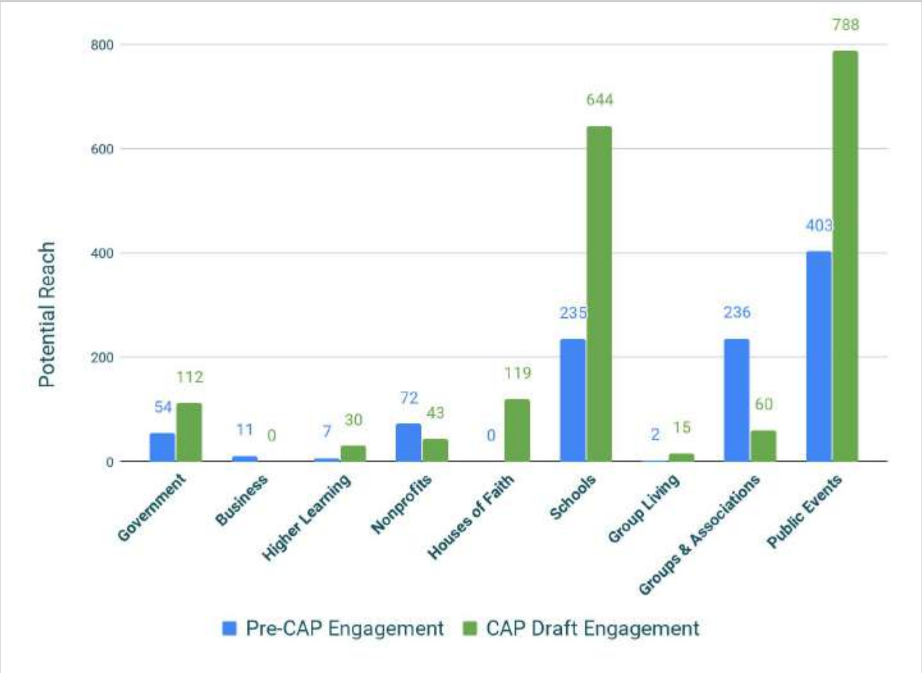
- **Princeton's Community Carbon Footprint:** What is our impact on climate change? Sustainable Princeton shared the results of a greenhouse gas inventory for the Princeton community and discussed potential actions to reduce our collective emissions.
- **What is a Climate Action Plan and Why Does Princeton Need One?** Drawing on the work already completed around the country, Sustainable Princeton described the CAP and one might be accomplished in Princeton.
- **Princeton's Energy Future: Can We Be Carbon Free?** Industry experts described how communities like Princeton are transitioning to a cleaner energy future.
- **Why Is It Too Far To Walk? Building a Climate-Friendly Princeton**: Transportation and urban planning experts described how we might build pedestrian- and transit-oriented neighborhoods and give residents access to low carbon transportation.
- **What is Princeton Doing to be Climate Resilient?** Industry specialists discussed what might be done to mitigate the effects of climate change and reduce the associated economic burden.
- **What Is a Changing Climate Doing to Princeton's Natural Resources?** Our trees, vegetation and natural habitats provide invaluable environmental benefits and also reduce our contribution to climate change by storing and sequestering carbon emissions. Find out what Princeton must do to reduce stress on our natural resources and make them more resilient to climate change.

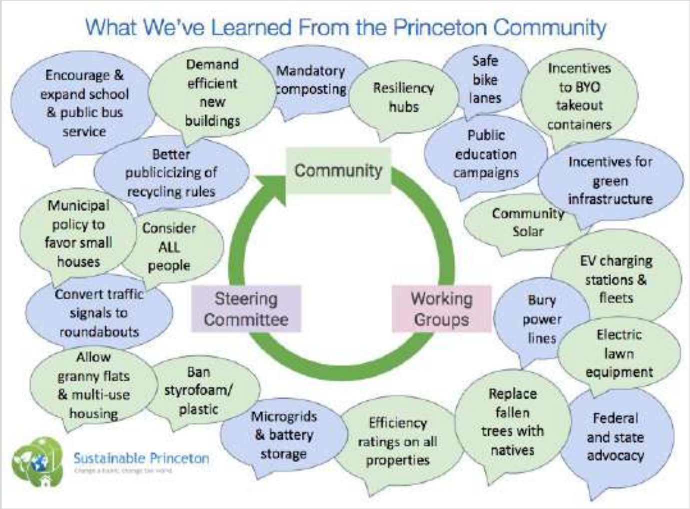


APPENDIX D - PLAN DEVELOPMENT PROCESS

A number of outreach events for the public to engage with the CAP draft occurred during the months of April and May 2019. The draft in its entirety posted online, allowing residents to review it and add their comments. Second, a survey was distributed to determine residents' willingness to act on and support CAP actions. The survey was made available at events and online. Also, several workshops and two open houses were held around the community to review the CAP and provide similar feedback in person.

After feedback was received on the CAP Draft, the Steering Committee reconvened to consider if the CAP required any major revisions for the final draft of the CAP.





"The public has got to, effectively, be the plan, because without them living the plan it won't go anywhere."

– UN-Habitat: Guiding Principles for Climate Action Planning

APPENDIX E - LITERATURE CITED

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Figure 1. Mercer County, NJ temperature data 1895-2018.
Source: Office of the NJ State Climatologist (ONJSC)
https://climate.rutgers.edu/stateclim/

Figure 2. Mercer County, NJ precipitation data 1895-2018.
Source: Office of the NJ State Climatologist (ONJSC)
https://climate.rutgers.edu/stateclim/

Figure 3. Princeton's production-based greenhouse gas inventory 2018.
See Appendix B.

Figure 4. Princeton's annual greenhouse gas emissions 2010-2018.
See Appendix B.

Figure 5. Comparison of Princeton's annual average production-based GHG emissions vs. consumption-based. *Source: CoolClimate; See Appendix B*

Figure 6. A typical Princeton household's consumption-based GHG emissions. *CoolClimate; See Appendix B.*

Figure 7. Princeton's climate action plan greenhouse gas emissions goal projection. *See Appendix C.*

Figure 8. GHG emissions reduction strategy projections.
See Appendix C.

APPENDIX F - FIGURES & TABLES