Princeton's
Campus Systems

Compiled by

The Office of Sustainability

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Buildings

Designing sustainable buildings, or “green buildings”, requires an integrative approach that links the elements of energy, water, material conservation, and indoor and outdoor environment quality. *Energy-efficient buildings* contain building envelopes and automation and control systems that reduce heat loss. Other energy-efficient options may include hot-water boilers, improved lighting and air-conditioning systems, and bioclimatic controls. *Environmentally friendly buildings* may include the use of solar-active thermal and photovoltaic systems, energy storage, ventilation systems, waste sorting, and water management systems. Furthermore, *sustainable buildings* focus on integrating the aforementioned strategies to ensure the quality of the indoor environment, residential areas, and building materials.

Eight components are taken into consideration when designing sustainable buildings at Princeton: energy systems, electrical systems, building envelope, siting/massing strategies, structural systems, mechanical systems, water systems, and interior materials. The University follows a set of Sustainability Design Standards, which has resulted in more than 560,000 square feet of new construction and major renovation projects built since 2008 according to aggressive sustainability and energy conservation guidelines. Sustainable materials are incorporated whenever possible, and a minimum of 95% of all demolition and recycling debris for all major building projects and renovations post abatement must be recycled. To encourage cycling to campus, more buildings on campus are being built with shower facilities.

Various mechanisms aid in the conservation of water in campus buildings. Low-flow plumbing fixtures save at least 45% of water on every flush when compared to conventional toilets. Water consumption is also reduced through the installation of low-flow showerheads and faucet aerators. Various buildings throughout campus have a condensate re-use system that collects water that is produced from cooling and dehumidifying the air, as well as rainwater harvesting

systems. In the Frick Chemistry Laboratory, harvested rainwater is combined with condensate, which is then used to flush all toilets in the building. Rain water recovered from the Arts and Transit Project is diverted to use in the energy plant cooling towers.

The campus building spaces and lighting controls at Princeton are engineered to maximize the use of natural sunlight. The glazed interior partition walls at the Adlinger Center for the Environment are a prime example of efficient energy-saving infrastructures. Throughout the University, energy efficient STAR appliances are used. Other energy-efficient lighting and controls include advance lighting sensors, next generation LED-based lighting, and photovoltaic solar panels, such as those found above the glass roof of the Frick Chemistry Laboratory.

Various controls are integrated into the heating and cooling systems. Cascading air flows allow laboratories and office areas to be cooled while minimizing use of air conditioning. Digital thermostats, sensors, and radiant panel heating systems adjust heating and cooling temperatures according to various factors, such as occupancy and conservation targets of heating to 68 in the winter and cooling to 78 in the summer. The Arts and Transit Project, Campus Club Renovation (2009), and Lakeside Graduate Housing projects use a geothermal system that brings up warm air in the winter and cools hot air during the summer months. Heat recovery systems for air handling units in the Adlinger Center and the Frick Chemistry Laboratory save energy by reducing heating and cooling, and provide fresh air and improved climate. Moreover, high performance exteriors, such as the exterior glass of Sherrerd Hall that provides shading from the sun with fins embedded inside the glass, maintain dry, heated/cooled, and well-ventilated interior environments. Similar high performance exteriors are also found in Peretsman Scully Hall, the Princeton Neuroscience Institute, and the Adlinger Center, and will be incorporated into the 20 Washing Road Economics and International Buildings Projects, the Arts and Transit Project, and a new childcare facility on Broadmead Street. Green roofs located in the

Adlinger Center, Arts and Transit Project, and Butler and Sherrerd Halls increase building insulation and decrease energy consumption.

References

Chwieduk, D. 2003. Towards Sustainable-energy Buildings. *Applied Energy*, 76, 211-217.

Princeton University Facilities- Sustainable Buildings. https://facilities.princeton.edu/sustainable-campus/sustainable-buildings

Princeton Office of Sustainability- Buildings Progress. https://sustain.princeton.edu/progress/buildings

Energy

In a world where the human population continues to rise at unsustainable rates (and in many contexts this growth is followed by an increase in affluent lifestyles), innovations in energy sourcing and efficiency are needed to properly and sustainably meet the growing demand. Energy sustainability integrates the issues of national and international security, fossil-fuel dependence, alternative energy sources, consumer behavior change, technological innovation, and global climate change, among others. Energy sustainability policies are being discussed at all levels of governance, and should consider an integrated approach that links the key objectives of energy supply security, climate change mitigation, and air pollution reduction.

At Princeton, campus energy is derived from a variety of sources. The Princeton cogeneration plant produces electricity, steam, and chilled water that is used to heat, power, and cool the University campus. The plant is composed of steam boilers, water chillers, an electric generator, a large thermal energy storage system, and a microgrid. The electric generator is powered by a General Electric LM-600 gas turbine that runs on natural gas or diesel fuel. The plant can generate up to 15 megawatts of electricity, which is equal to Princeton's daily electricity needs. Moreover, efficiency can reach 80% through cogeneration (the recovery of wasted exhaust heat to heat water and make steam) and other waste heat recovery methods. In order to reduce costs and improve efficiency, the plant operators can instruct the generating plant to switch from natural gas to bio-diesel in accordance to price and supply fluctuations. Moreover, revenues to offset electricity costs are derived from "grid services" that include voltage and frequency adjustments. In addition to importing energy in the form of natural gas and diesel fuel, Princeton has installed 16,528 photovoltaic panels which are located 27 acres south of Lake Carnegie. The energy is transferred through a 13KV power cable and the peak output can reach 4.5 megawatts, producing 5-6% of the University's total annual energy use.

Greenhouse gas reduction is achieved through the development of aggressive initiatives and efficient practices. Princeton has saved about $5.7

million and reduced over 25,000 metric tons of emissions annually since the University Energy Master Plan was established in 2008. Direct digital control (DDC) technology is used in 125 buildings on campus, with over 80,000 control points in the system. The building automation system allows engineers to schedule equipment to run when it is needed and reduce energy allocation and consumption whenever possible. Thermostatic sensors throughout campus aid in the regulation of heating and cooling in different areas. The set point for heating occupied spaces is 68 degrees and the set point for cooling is 78 degrees, both of which can be set by room occupants on sensors that display temperatures. Compact florescent lights make up the bulk of the incandescent lighting on campus. Moreover, LED technologies are being installed and tested, most notably in Dillon and Jadwin Gymnasiums. In addition, various lighting control systems throughout campus are comprised of microprocessors and environmental sensors which turn off lights in unoccupied areas. Daylight sensors in various rooms adjust the brightness of the lights depending on the amount of light that is coming through the windows.

References

Holdren, J.P. 2007. Energy and Sustainability. *Science*, 315, 737.

McCollum, D.L., Volker, K., and Keywan, R. 2011. An integrated approach to energy sustainability. *Nature Climate Change*, 1, 428-429.

Princeton Office of Sustainability- Energy Progress.
https://sustain.princeton.edu/progress/energy

Princeton University Facilities- Energy Management Projects.
https://facilities.princeton.edu/news/energy-management-projects

Princeton University Facilities- Sustainable Energy.
https://facilities.princeton.edu/sustainable-campus/sustainable-energy

Food

Global food production has a significant impact on the environment, animals, and people, and significantly contributes to the emission of greenhouse gases. Food production worldwide is linked to critical issues such as animal welfare, biodiversity loss, habitat loss, pollution, public health, and water conservation. A sustainable food system is one that makes a valiant effort to conserve natural resources, ensure economic sustainability, and reduce environmental impact at all stages of agricultural operations, including production, processing, distribution, purchasing, and waste management. Moreover, sustainable food systems result in social benefits, healthy and safe products, and educational opportunities for the general public.

Princeton University Dining Services strives to purchase local, organic, and sustainably-produced food. About 46% of food purchased is produced locally within 250 miles of the campus- this includes produce, baked goods, cheese, milk, beef, pork, poultry, and eggs. Over 60% of all food purchases are local, organic, fair trade, socially responsible, humanely treated, or sustainable. Beef is grass feed, chicken is antibiotic-free, humanely treated, and locally produced, and fresh and smoked pork products are American Humane Association Free Farmed certified. Moreover, nearly 80% of our total seafood purchases are categorized as sustainable in accordance with the principles outlined by our business partner, the Monterey Bay Aquarium Watch program. Over 90% of coffee and tea purchased, as well as nearly all baked goods, are produced locally. The residential dining halls and the Food Gallery at Frist Campus Center serve Rainforest Alliance certified coffee, while Small World roasted coffee is sold in Witherspoon's, Woodrow Wilson Café, Chancellor Green Café, Chemistry Ca Fe, and Studio '34. Organic spring mix, organic cereals, and local, organic non-GMO tofu are available everyday across the residential dining halls, while Café Vivian serves a range of locally-produced, organic meal, snack, and drink options. Moreover, a new urban cultivator was installed at Café Vivian in 2015, which uses a hydroponic system to grow produce indoors. Since 2007, these efforts have resulted in a 64% decrease in non-local

food purchases, a 67% increase in sustainable food purchases, and a 63% increase in local food purchases.

Campus Dining purchases plant-based compostable cups and cutlery for catering events, as well as 100% post-consumer recycled paper goods that are used at Frist Campus Center. Princeton logo water bottles are made using BPA-free rPET plastic bottles with recyclable caps. The spring fed water is sourced from the Penobscot Ridge Mountains in the Lackawanna State Forest of Pennsylvania. Students are incentivized to use their own reusable mugs by being offered a discount on beverages in Café Vivian, the Food Gallery at Frist, and the Chancellor Green, Woodrow Wilson, and Studio '34 Cafés.

In the 2011-12 academic year, all dining halls in the University became tray-free, which reduces the amount of food wasted as well as water and energy expenditures and carbon dioxide emissions. An "Interactive Menu" includes symbols to indicate carbon emissions for many food items served in the Frist Food Gallery and the dining halls. Three symbols are used to indicate low emissions, medium emissions, and high emissions. Since 2010, efficient dishwashers were installed in five of six dining halls, each saving about 300,000 gallons of water per year. Campus Dining sends its food waste to be composted about eight miles from campus at AgriArk in Hopewell, N.J. Fryer oil is collected and taken to a local plant for biodiesel production. In 2015, 2,800 gallons of oil were recycled.

References

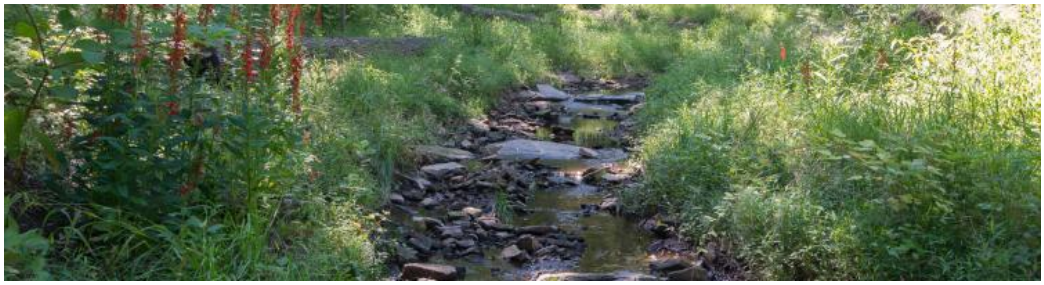
Garnett, Tara. 2013. Food Sustainability: problems, perspectives, and solutions. *Proceedings of the Nutrition Society*, 72, 29-39.

Princeton Office of Sustainability- Food Progress. https://sustain.princeton.edu/progress/food

Princeton University Campus Dining. https://www.princeton.edu/us/dining/sustain/

Landscape

Landscape sustainability can be thought of as the extent to which landscape patterns and processes persist, as well as the sustainable management of resources extracted from those landscapes (this can range from ecosystem services to habitat space, food, etc.) at various scales. From the point of view of a landscape ecologist, landscape sustainability seeks to nurture habitat patches and corridors that help to maintain viable populations of species, while taking into account abiotic factors such as soil moisture and nutrient status, and water quantity and quality, among others. *Economic sustainability* in the context of landscapes deals with maintaining the aesthetics of the landscape to sustain tourism and recreation. Moreover, *aesthetic sustainability* may further help to serve as an indicator of a healthy ecosystem or one that is properly managed. The idea of a *politically sustainable* landscape deals with the governance and management of private and public commons, while participation and inclusivity in decisions regarding landscapes falls under the idea of *social landscape sustainability*.



An ecosystem approach that integrates water conservation, chemical use reduction, soil conservation, and ecological function restoration is used to apply principles of sustainability to Princeton's 635-acre campus. South of campus behind Windor and Rickerson Fields, the Campus Grounds Staff maintains a nursery and multiple greenhouses, the first of which was started in 1935. All plantings, most of which include native trees and shrubs, are selected in accordance with Princeton's hardiness zone standards as defined by the U.S. Department of Agriculture. This ensures that plantings can thrive and expand, and that natural flows and cycles are renewed and maintained. Since 2007, there has been a net increase of about 2,370 trees, as well as nearly 12 acres of woodlands and five acres of open green space. The landscape is maintained through planting grass species that require less maintenance and through using minimally-invasive techniques such as zero-turn mowers that reduce mowing time, adjusted mowing heights that reduce mowing frequency, and an increase in the use of mulching

mowers. Moreover, the use of integrated pest management, which incorporates releasing beneficial insects to eliminate various pests and using pest-resistant plants, has resulted in a decrease in pesticide use of about 30% since 2007.

Nearly all vegetative products including fallen leaves, trees, or excavated soils are recycled into mulch, compost, and soil to use in the University gardens and various landscaping projects. Topsoil from construction projects is mixed with on-site sand and organic compost to make high-quality soil products. These recycled materials and products are stored at a mulch yard near the University greenhouses south of campus. Since 2008, an average volume of 4,500 cubic yards of vegetative products have been composted per year. Moreover, the Grounds staff is currently experimenting with the use of organic fertilizers and compost teas, which are concentrated water-based solutions that extract microbes and nutrients from compost.

Various methods are used for storm water management, including green roofs, rain gardens, detention basins, and a groundwater recharge system. Green roofs grow on Butler and Sherrerd Hall, and underground buildings with greenspace lawns over their structures include Whitman College, Firestone Library, McCormick Hall, Fine Hall, and Lewis Thomas Laboratory. Butler's green roof comprises 58% of a 113,000 square foot roof and has 14 varieties of hardy sedum planted. Various systems relocate water run-off into perforated pipes that direct water into the soil, rain gardens, and condensate collection systems for reuse in toilets, landscape irrigation, and/or groundwater recharge. Rain gardens are found in various buildings throughout campus including Frick Chemistry Laboratory, the new Neuroscience Institute, and Peretsman-Scully Hall. There are six detention basins, which are pond-shaped depressions that function as rain gardens without vegetation plantings, with locations that range from Frick Chemistry Laboratory to near the Lot 7 Garage. Storm water loads are also absorbed by mowed that have been converted to woodland buffers. Moreover, groundwater recharge systems direct rain into subsurface gravel and sand beds. These systems are found beneath Princeton Stadium, Roberts Stadium, 1952 Stadium, Finney Field, Campbell Field, and other athletic fields. The

implementation of permeable surfaces around the University campus has increased the bio-filtration of surface runoff and improved water quality.

References

Princeton Office of Sustainability- Landscape Progress. https://sustain.princeton.edu/progress/landscape

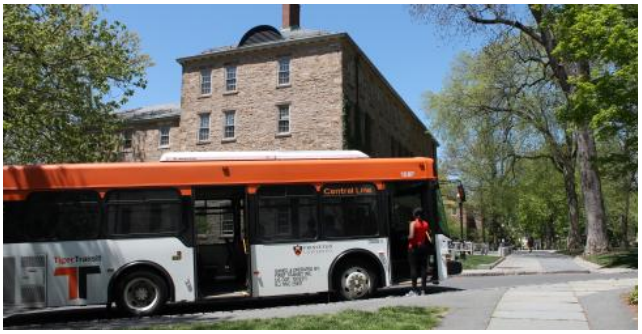
Princeton University Facilities- Sustainable Practices. http://facilities.princeton.edu/sustainable-campus/sustainable-practices

Selman, P. 2008. What do we mean by sustainable landscape? *Sustainability: Science, Practice, & Policy*, 4, 23-38.

Wu, J., and Hobbs, R. 2002. Key issues and research priorities in landscape ecology: an idiosyncratic synthesis. *Landscape Ecology*, 17, 355-365.

Transportation

Transportation sustainability considers the impacts that transportation systems have on the environment, economy, and public well-being. Traditionally, there has been a focus on managing the built environment and identifying fossil-fuel alternatives, but sustainability initiatives are now shifting to further integrate the roles of issues such as economic incentives, institutional reforms, improved travel choices, and technological advances. Moreover, sustainability frameworks are testing various process-based approaches that involve community representatives and other stakeholders in transportation planning. These approaches place an emphasis on educating the general public and influencing behavior change.

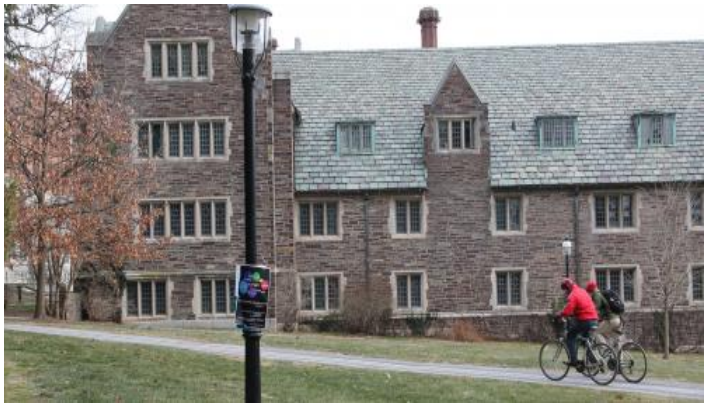


Princeton uses various strategies and policies to reduce the number of single occupancy vehicles coming to campus, including promoting walking and biking, encouraging the use of public mass transit, developing and promoting car and vanpools, improving and integrating the on-campus transit system (TigerTransit), exploring telecommuting and flex time programs, and instituting new vehicle registration programs for members of the Princeton community parking on campus. The application of these strategies is known as Transportation Demand Management (TDM), which aims to maximize the use of existing infrastructure, reduce traffic congestion, and improve air quality. By 2020, the University seeks to reduce the number of vehicles parking on campus by 500.

The TigerTransit fleet is comprised of fully accessible buses that have low floors and flip-out ramps. The buses are also equipped with a front load rack that holds two bikes, and run on B20 biodiesel fuel. Each bus has the capacity to transport two wheelchairs, 33 seated passengers, and 15 standing passengers. A web-based GPS real-time tracking system, the TigerTracker, can be used to locate the buses at various locations and stops including academic and administrative buildings; faculty, staff, graduate, and undergraduate student housing; Nassau Street; and the Forrestal Campus and Princeton Plasma Physics Laboratory. The Princeton FreeB, a free bus that loops around Princeton during commuter hours,

makes stops throughout the community and at the NJ Transit Princeton train station. Furthermore, the Princeton Station "Dinky" is a small commuter train operated by NJ Transit that provides shuttle service to Princeton Junction Station on the Northeast Corridor Line.

Members of the Princeton community are required to register their bikes with Transportation and Parking Services. More than 3,600 bike parking spaces are available throughout the campus, and bike locks can be purchased for $30 at the Transportation and Parking office. Students can store their bikes in the summer through the Moving & Storage Agency, which provides bike pick-up and storage for $50, with an optional $5 insurance fee. Any unwanted bikes can be donated to The Princeton Tour Company (donates bikes to families in Africa), Pedals4Progress (donates bikes to partner organizations in 32 developing countries), and the Boys and Girls Club of Mercer County Bike Exchange. Moreover, the Princeton University Bike Sharing Program allows students, faculty, staff, and visitors to rent a bike through a smartphone app. Members pay a one-time fee of $20, can ride for free when bikes are rented for less than two hours, and after that are charged $2 per hour for any additional hours up to $20. Campus Bike Share locations include Princeton Station, Firestone Library, Forbes College, Friend Center, Frist Campus Center, Lakeside Apartments, Lawrence Apartments, Alexander Hall, and the Forrestal Campus in Plainsboro.



Various opportunities exist for car and vanpooling to campus. The Rideshare Carpool Service provides faculty and staff with a match list of other community members who are interested in carpooling to campus. Incentives to participate include eligibility to receive a $50 gas card every three months the carpool remains in operation, parking in any carpool-designated preferred parking space, and legibility for the Guaranteed Ride Home program, which provides subsidized occasional rides home to commuters who use alternative modes of transportation to work. Faculty and staff can participate in vanpooling, which is more suitable for longer commutes and requires a minimum of five riders. Vans are provided by a third-party vendor, VPSI, Inc., and fuel costs are split among each member of the group except the driver. Students can take part in Princeton Rides Home, which serves as a ride-matching service to students

during school breaks or weekend trips. The Enterprise CarShare Program provides vehicles throughout campus that are available 24 hours a day, seven days a week. Students, faculty, and staff apply for membership online and are able to reserve cars at rates of $5 per hour. Enterprise CarShare Locations include Frist Campus Center, Graduate College, Lawrence Apartments, Dillon Gym, Olden House, Princeton Station, and Lakeside Apartments.

The Transportation & Parking Services Mass Transit Subsidy (MTS) Program provides University employees and graduate students a 50% subsidy on monthly transit passes. Any faculty or staff member participating in the MTS Program is not eligible for an annual parking pass. Undergraduate and graduate students are eligible to receive a 25% discount on a regular rail, bus, or light rail monthly pass when enrolled through NJ Transit's Quik-Tik program.

References

Litman, T. and D. Burwell. 2006. Issues in Sustainable Transportation. *International Journal of Global Environmental Issues*, 6, 331-347.

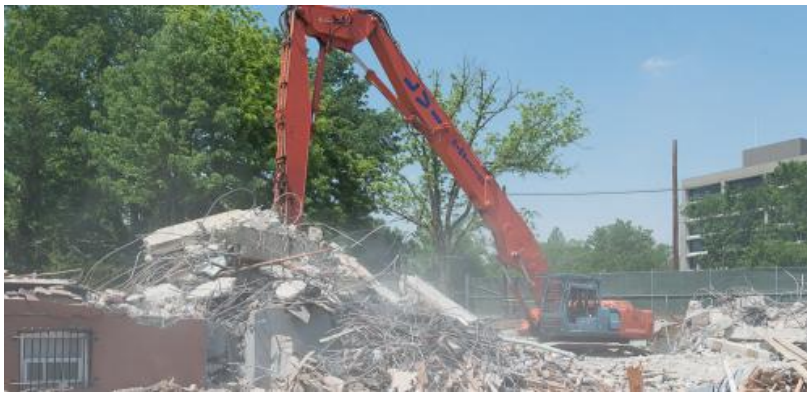
Mihyeon Jeon, C. and A. Amekudzi. 2005. Addressing Sustainability in Transportation Systems: Definitions, Indicators, and Metrics. *Journal of Infrastructure Systems*, 11, 31-50.

Princeton Office of Sustainability- Transportation Progress. https://sustain.princeton.edu/progress/transportation

Princeton University Transportation and Parking Services. http://www.princeton.edu/parking/mtincentives/index.html

Waste

Waste management is comprised of three parts: generation, collection, and disposal systems. Sustainable waste systems focus on processes, incorporate feedback loops, are adaptable, and divert wastes from disposal. Sustainable waste collection and treatment options should include waste prevention, recycling, energy recovery, and environmentally sound land filling mechanisms. Moreover, a variety of stakeholders should be included in waste management, including waste generators (households, industries, agriculture, etc.), waste processors (private and public recyclers), and governing bodies (governmental regulators, waste managers, urban planners, etc.). Industries play a major role in designing products that are recyclable after consumption. The idea of integrated solid waste management requires the integration of the following aspects for implementing sustainable solutions: technical, environmental, legal, economic, and financial.



A variety of waste streams operate on Princeton's campus, with the goal of reducing overall campus waste by 40% between 2006 and 2020. Since 2013, the University has participated in a mixed recycling program that is coupled with a waste reduction educational campaign. All acceptable recycles can be mixed into any recycling bin, including mixed paper and cardboard, plastic, glass, and metal. The Office of Sustainability maintains the University's Mixed Recycling Guidelines on its website. Items that cannot be recycled include napkins, paper towels, and tissues; paper contaminated with food; food; alkaline batteries (can be thrown in regular trash bins); tetra paks; plastic- or wax-coated paper, cardboard, and cartons; and metal-lined shelf-stable "aseptic" containers (e.g. milk, soup). Large dumpsters across campus have been replaced with smaller carts to transport waste. This has resulted in a decrease in gasoline consumption and an enhancement of the overall aesthetics of the campus.

Clothing, furniture, and household items can be recycled and traded through a variety of platforms. The University Surplus Program allows staff, faculty, and

other members of the Princeton community to make surplus items available to the public for sale or donation. Office items are made available at no cost to University departments. The program is based at the warehouse located at 755 Alexander Road. Other platforms include the Free and For Sale Facebook page, Tiger-Trade, and the Free Office Supplies Listserv. In 2016, the Office of Sustainability, in cooperation with the Office of the Dean of Undergraduate Students and The Office of the Graduate School, implemented its first Sustainable Cap and Gown Initiative. The graduating class of 2016 became the first to wear 100% recycled caps, gowns, and tassels during Commencement, which were sourced from GreenWeaver College Caps & Gowns. Members of the graduating class were given the option to upcycle their gowns by depositing them in collection bins located throughout designated areas on campus.

Cell phones, cell phone chargers, and rechargeable batteries can be recycled at a Wireless Alliance recycling box located on the 100 level of Frist Campus Center. Most computer clusters contain ink and toner cartridge recycling bins. Writing utensil can be recycled at the GreenSpace Kiosk in Frist, which are then sent to Terracycle and upcycled and recycled into various products. Used CFL light bulbs are collected and recycled by Building Services. All food waste from the dining halls and prep scraps from Frist are sent to AgriArk in Hopewell, NJ, to be composted. Graduate students have the opportunity to compost in their apartment complexes.

References

Anderson, D.D., and Burnham, L. 1992. Toward Sustainable Waste Management. *Issues in Science and Technology*, 9, 65-72.

Princeton Office of Sustainability- Recycle. https://sustain.princeton.edu/recycle

Princeton Office of Sustainability- Waste Reduction Progress. https://sustain.princeton.edu/progress/waste-reduction

Princeton University Facilities- Sustainable Practices. https://facilities.princeton.edu/sustainable-campus/sustainable-practices

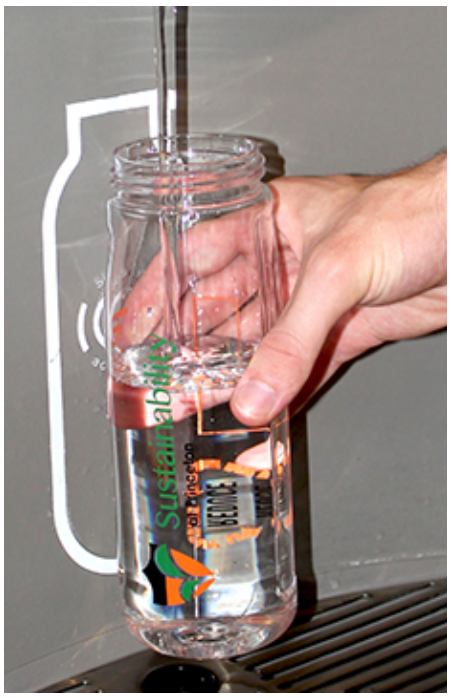
Princeton University Facilities- University Surplus Program. https://facilities.princeton.edu/services/university-surplus-program

Seadon, J.K. 2010. Sustainable Waste Management Systems. *Journal of Cleaner Production*, 16, 1639-1651.

Water

Water covers 70% of the world's surface, but freshwater is extremely limited, with only less than 0.5% of it being usable for consumption. The availability of freshwater resources is dictated by three factors: population growth, economic growth, and global climate change. The world's population is reaching 7 billion, and demand for freshwater resources is increasing exponentially as the human population continues to grow. Economic growth results in a greater demand for water, especially in metropolitan areas that are usually water-scarce. Furthermore, climate change affects the global freshwater supply through droughts, flooding, and increases in sea levels. Solutions for the sustainable management of water resources include but are not limited to the following: integrated planning among various stakeholders, consumption and conservation behavior change strategies, reuse of non-potable water, and efficient wastewater treatment and management.

Princeton's water is drawn from the NJ American Water Company. The water is mainly sourced from the confluence of the Millstone and Raritan Rivers and the Delaware and Raritan Canal, while a small portion is sourced from local wells located next to the Princeton Institute Woods. The Millstone River is part of the Stony Brook-Millstone Watershed, which spans 265 square miles. The 30.6-mile-long river originates in Monmouth County, about 22 miles away from Princeton's campus, and feeds into Lake Carnegie (which is available for public ice skating and fishing). The Stony Brook-Millstone Watershed is home to over 700 species of wildlife, including more than 80 species of birds and 300 species of plants.



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References

McCarthy, D. 2008. Water sustainability: a looming global challenge. *American Water Works Association*, 100, 46-47.

Princeton Office of Sustainability- Water Progress. https://sustain.princeton.edu/progress/water

Princeton University Facilities- Sustainable Campus. https://facilities.princeton.edu/sustainable-campus/sustainable-buildings

Princeton University Campus Plan- Connecting the Campus. http://www.princeton.edu/campusplan/about/history/pdf/ch5-c-ConnectingTheCampus.pdf

Raskin, P.D., Hansen, E., and Margolis, R.M. 1996. Water and sustainability-global patterns and long-range problems. *Natural Resources Forum*, 20, 1-15.