

Renewable Energy 101

Ten Tools for Moving Your Campus to 100% Clean Energy



FRONTIER GROUP

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Introduction

America's institutions of higher education can play a leadership role in the fight to prevent the worst impacts of global warming. Colleges and universities across the country should aggressively deploy clean energy on campus, setting a goal to meet all their energy needs with clean renewable resources.

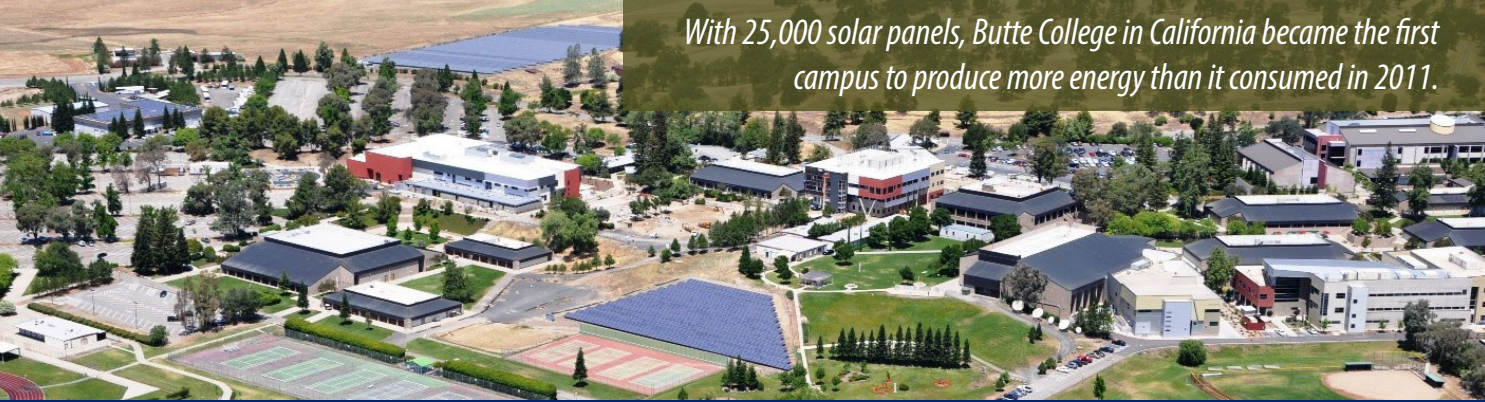
America has enough renewable energy potential from the sun and wind to power the nation several times over. Studies of the electricity system suggest that high penetrations of renewable energy are possible using technologies available today at costs that society can afford. Technological advances – including the development and commercialization of new methods of energy storage – along with continued declines in the price of renewable energy technologies such as solar power and advances in energy efficiency, suggest that a 100 percent renewable energy system can be achieved by 2050.¹

As hotspots of innovation and technical expertise, college campuses are the perfect place to implement the programs and technologies that will develop the clean energy technologies of tomorrow and accelerate the transition to a future powered entirely by 100 percent clean, renewable energy.

Environment America designed a series of 10 fact sheets as a resource for students, faculty and administrators interested in moving their campus toward sustainability. The fact sheets have been crafted to illustrate the importance, challenges and opportunities of 10 important and distinct tools associated with building a 100 percent clean, renewable energy system. Each fact sheet includes two case studies of effective action on college campuses, as well as a list of resources.

To visit our website and view the fact sheets online, please visit:

www.EnvironmentAmericaCenter.org/Campus101



With 25,000 solar panels, Butte College in California became the first campus to produce more energy than it consumed in 2011.

On-Campus Solar Energy

Moving Toward 100% Clean, Renewable Energy on Campus

On-campus solar energy systems are indispensable for America's colleges and universities to shift to 100 percent clean, renewable energy. Campuses across the U.S. are installing solar energy to save money, provide learning opportunities for students, and achieve their climate goals.

Solar Energy Is a Key Building Block of a Clean Energy Future

Pollution-free, virtually inexhaustible, safe and efficient, solar energy is a clean and renewable alternative to fossil fuels. Solar energy is so abundant that the U.S. could generate more than 100 times as much electricity from solar power installations as the nation currently consumes each year. Solar energy is a key to helping our society shift away from today's energy system built on polluting fossil fuels.

Campuses Are Benefiting from Solar Energy's Opportunities

Many campuses have installed solar arrays in open spaces like rooftops and parking lots that are perfect for solar energy projects. Solar energy offers many opportunities for colleges and universities:

- **Cost-savings:** Solar installations have dropped in price by more than two-thirds over the last eight years, and solar energy is often cheaper than energy from fossil fuels.
- **Collaboration:** Solar energy projects provide learning and training opportunities for students.
- **Innovation:** Colleges and universities played an important role in solar energy technology innovation ever since the University of Delaware established the world's first laboratory dedicated to photovoltaic research and development in 1972.²
- **Leadership:** Leadership on clean solar energy can help colleges attract and retain talented people.

Colleges and Universities Reduce Barriers to Solar Energy Use

College campuses are also uniquely suited to tackle the challenges associated with solar energy:³

- **Research:** Colleges have access to the next generation of solar cells as they are being researched and prototyped; for instance, at Penn State, researchers use inexpensive optics to concentrate sunlight onto super-efficient next generation solar cells.⁴ Students can help with these research activities.
- **Vocational Training:** Engineering programs can provide student bodies with pre-professional learning opportunities on on-campus solar farms in design, production and oversight.
- **Proximity to Energy Demand:** Colleges can install solar energy on rooftops, in parking lots and on marginal land, close to where energy is used.
- **Storage:** Energy storage systems that help campuses meet resilience and emergency preparedness goals can also support implementation of solar energy. The University of California, Riverside, uses excess solar energy to charge electric vehicles, which act as batteries and reduce energy storage needs.

Solar panels generate energy and provide shade above an ASU parking lot.

With 25,000 Solar Panels, Butte College Was the First Campus to Become “Grid Positive”

Butte College is a community college located on a beautiful campus of open spaces and grassy hills about 130 miles north-east of San Francisco, and has long demonstrated a commitment to environmental sustainability.

In 2011, Butte College became the nation’s first college campus to become “grid positive,” meaning that the college generated more electricity than it used, thanks to 25,000 solar panels installed since 2005. The project was funded in part by Clean Renewable Energy Bonds, which are low-interest loans made available through the American Recovery and Reinvestment Act. Today, Butte College has since added several new buildings, but the solar panels still supply three-quarters of the growing campus’ energy needs⁵ and avert carbon dioxide emissions equivalent to those produced by more than 1,000 passenger vehicles.

Butte College made the most of a built environment that is perfect for clean energy projects. Butte College’s solar panels are built on rooftops, in open fields and on parking lot canopies and shade structures.

The project has also created educational and economic benefits for the school and the surrounding community. Butte College offers courses that allow students to assemble and disassemble solar panels as training for future clean energy jobs. The school’s solar energy project employed local people and vendors, and will save taxpayers and the college more than \$100 million over 30 years.



Arizona State University, the State’s Largest Energy Consumer

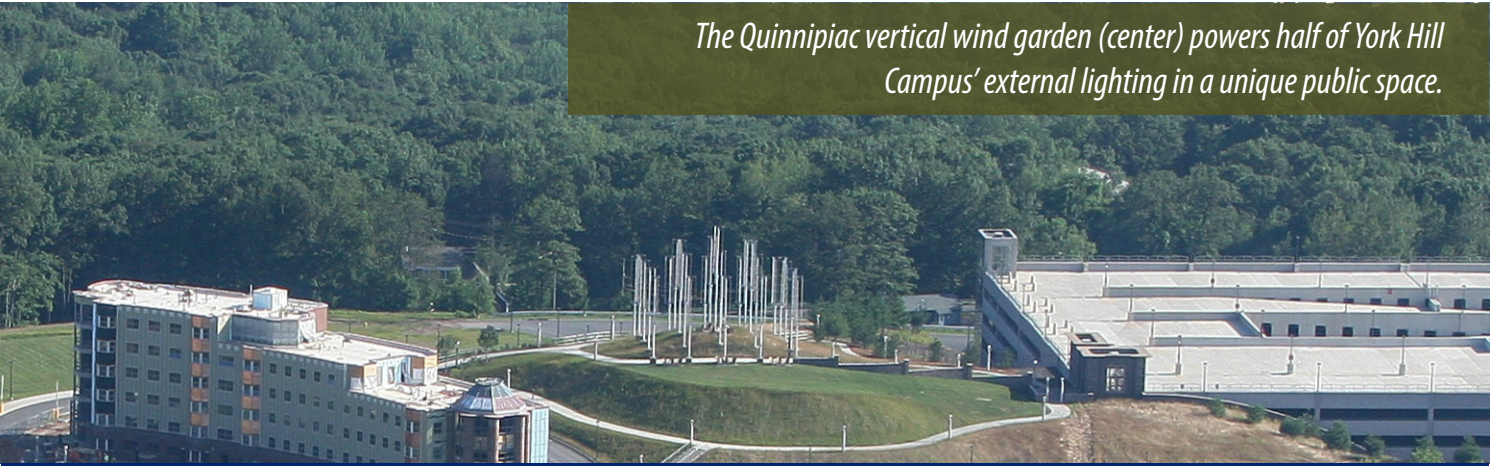
In 2016, Arizona State University (ASU) had the most solar energy of any college nationwide, producing enough solar energy to meet nearly half of its peak daytime energy demand and avoid carbon dioxide emissions equivalent to the annual emissions of nearly 5,000 cars. To do so, ASU has deployed solar panels and solar heating systems at 89 locations on its four campuses and its research park as part of its Solarization Initiative. ASU has also joined forces with a local utility to construct a 29 megawatt off-campus facility at Red Rock, Arizona, that meets an additional 30 percent of ASU’s energy needs with solar energy.

One of the original universities to sign the American College and University Presidents’ Climate Commitment, ASU takes pride in its solar installations as a physical display of its commitment to renewable energy and carbon neutrality.

List of Resources

To start your campus’ push to go solar:

- The U.S. Department of Energy SunShot Initiative provides technical and financial assistance for solar energy projects: energy.gov/eere/sunshot/sunshot-initiative
- The Solar University Network partners with students, university administrators and investors to create “shovel-ready” solar energy projects on college campuses: www.solarendowment.org
- The U.S. National Renewable Energy Laboratory provides expert analysis, solar screenings and implementation assistance, using its REopt model: reopt.nrel.gov



The Quinnipiac vertical wind garden (center) powers half of York Hill Campus' external lighting in a unique public space.

On-Campus Wind Energy

Toward 100% Clean, Renewable Energy on Campus

Installing wind energy systems on or near campuses can help America's colleges and universities shift to 100 percent clean, renewable energy. College campuses across the U.S. are investing in wind energy to reduce their electricity costs, provide learning opportunities for students, and lower their carbon emissions.

Wind Energy is Key to Building a 100% Renewable Energy System

Installing wind energy systems on campus is a great way for America's colleges and universities to lead the transition to a future of 100 percent clean, renewable energy. In 2016, wind energy across the U.S. reduced greenhouse gas emissions equivalent to taking 33.7 million cars off the road⁶ – more than all the cars in California, Texas and Florida combined.⁷ Wind energy is a key to shifting away from today's carbon-based energy system.

Wind Energy Offers Opportunities for College Campuses

College campuses are uniquely suited to wind energy:

- **Location:** Many universities have perfect locations for wind installations, and can install full-scale turbines on open fields, or micro-turbines on rooftops.
- **Cost-Effective:** On-shore wind energy has dropped in price by 90 percent since the 1980s, and is often cheaper than energy from fossil fuels, especially when accounting for tax incentives.⁸
- **Training and Research Opportunities:** On-campus wind energy also provides opportunities for training future renewable energy industry workers, and for cutting-edge research and innovation at engineering schools. Wind turbine technician is also one of the fastest-growing jobs in the U.S.⁹

Colleges and Universities Are Uniquely Equipped to Take Down Obstacles to Wind Energy

Wind energy is virtually pollution-free, inexhaustible, safe and efficient, but often faces obstacles. Colleges are uniquely suited to tackle the challenges associated with wind energy:

- **Financing:** Universities can also enter into power purchase agreements with utilities to develop wind installations on-campus without upfront capital costs.
- **Fluctuations in Energy Output:** Colleges are developing strategies to deal with varying wind speeds, like Case Western Reserve University, which treats its campus as a 'living laboratory' and uses the Department of Energy's VOLT-TRON software to mitigate variable production from its wind turbines.¹⁰
- **"Not in My Backyard" Syndrome:** Colleges can experiment with new ways to integrate wind energy on campus, like microturbines that have a smaller footprint in communities. At Quinnipiac University, 25 vertical micro wind turbines on a terrace create a kinetic sculpture garden that also powers half of the external lighting at its York Hill campus.

Carleton College sources up to 70 percent of its electricity from its two wind turbines.

University of Delaware's Big Wind Turbine Provides Power and Research Opportunities

Today, the University of Delaware campus has the only commercial sized wind turbine in Delaware, and tapping into the East Coast's immense wind energy potential is key to its clean energy goals.

Built in 2010, the wind turbine produces enough electricity to power the six buildings at the Lewes campus, as well as 108 homes in the city of Lewes. This results in the university averting carbon dioxide emissions equivalent to taking nearly 750 passenger vehicles off the road.

The University of Delaware has a long history of being at the forefront of clean energy innovation, starting the world's first lab dedicated to photovoltaic research and development in 1972.¹¹ In keeping with its history, a primary mission of the wind turbine project is to create research and educational opportunities.

To date, students have used the wind turbine to study everything from impacts on birds and bats, to the corrosive impacts of salty coastal air, important for advancing understanding of offshore wind turbines. One study resulted in the development of software called Bat Shield, which allows for modification of turbine operation to protect bats during migration season.



Carleton College's Wind Turbines Supply Half of Campus' Electricity

In 2004, Carleton College became the first college in the country to own an active utility-grade wind turbine, located 1.5 miles east of campus.¹² The college added a second 1.68-megawatt turbine in 2011. Carleton's two turbines can supply 55 to 70 percent of the college's electricity demand, and avert carbon dioxide emissions equivalent to those produced by almost 1,400 passenger vehicles.¹³

Carleton used a \$150,000 grant from the Minnesota Department of Commerce to fund the first turbine, and sold the electricity and renewable energy credits to the local utility for the first 10 years until 2014, making the turbines financial winners for the college.¹⁴ The second turbine was a gift from environmentally-minded graduates celebrating their 30th wedding anniversary.¹⁵

The turbines also provide educational opportunities. Students participated in siting the first turbine, and use the turbines' computer interfaces, which track wind speeds, energy generation and turbine capacity, as learning tools in geology, energy and economics classes.¹⁶

List of Resources

To kick-start wind installation on your campus:

- Assess your local wind resource with the National Renewable Energy Laboratory's Wind Energy Resource Atlas: www.nrel.gov/gis/wind.html
- Find out if your state provides incentives or tax credits for wind installations: www.dsireusa.org
- Use the American Wind Energy Association's Wind Energy Siting Handbook to find the right site: www.awea.org/Issues/Content.aspx?ItemNumber=5726



Florida International University incorporated solar thermal tubes into its submission for the Solar Decathlon 2011 – a fully solar-powered house.

Solar Heating and Hot Water

Moving Toward 100% Clean, Renewable Energy on Campus

Installing solar heat and hot water systems on campus is a great way for America's colleges and universities to shift to 100 percent clean, renewable energy. Campuses across the U.S. are installing solar heat and hot water systems to save energy, provide learning opportunities for students, and achieve their climate goals.

Solar Heating Is a Key Building Block of a Clean Energy Future

Capturing the warmth of the sun to meet our heating and hot water needs is just common sense. It's a key piece of the puzzle to help our society shift away from today's energy system built on polluting fossil fuels. The first house to convert sunlight into energy, the Solar One House, was built by a University of Delaware researcher in 1972;¹⁷ today, solar heaters can cut hot water costs by more than half.¹⁸

How Do Solar Heat and Hot Water Work?

While solar photovoltaic panels convert sunlight directly into electricity, solar heat and hot water systems capture heat from freely available sunshine to:

- Heat up water that is pumped to a tank for use and storage, to provide hot water for cooking, bathing or laundry, or for heating campus buildings,
- Heat or cool air in buildings using solar air heat collectors,
- Heat or cool buildings through passive solar design, laying out the building, choosing materials and placing windows to best use the sun's heat without mechanical systems.¹⁹

Campuses Are Benefiting from Solar Energy Opportunities

Solar heating and hot water offer many opportunities for colleges and universities:

- **Physical Attributes:** Campuses are perfect locations for solar thermal energy projects, with open rooftops and large hot water usage in residence halls, on-campus restaurants and in athletic facilities.
- **Cost-Effectiveness:** Solar thermal energy also makes economic sense, protecting colleges from the volatile prices of fossil fuels while reducing heating costs. Colleges and universities also have strong facilities departments that can ensure regular maintenance of solar heating systems.
- **Academic and Pre-Professional Opportunities:** Solar thermal energy projects create opportunities for collaboration between students and faculty, providing learning, research and training opportunities for students, and can help universities engage with their local communities.
- **Research:** New techniques are also being developed to store solar thermal energy. At the University of South Florida, researchers have developed a latent heat storage system that could cut the cost of thermal energy storage systems by more than 80 percent.²⁰



Guilford College has nearly 200 solar thermal panels installed on nine buildings across campus, in one of the largest solar thermal energy systems installed at any U.S. college or university campus.

Solar Thermal Energy Covers Guilford College's Hot Water Needs

Guilford College in Greensboro, North Carolina, has opted for solar heating, with 200 panels on campus that produce more than 9,000 gallons of hot water each day. After an initial 12-panel array installed in 2007 resulted in lower energy bills and emissions, Guilford partnered with FLS Energy, a local solar energy provider, to install another 188 panels on another eight buildings in 2010. The combined system covers almost all the hot water needs of the campus residence and dining halls.

To fund its 2010 solar thermal array, Guilford entered into a solar energy purchase agreement with FLS Energy, whereby FLS financed the installation and maintains the system, and Guilford pays FLS a guaranteed, competitive price for clean hot water. With no upfront capital investment, Guilford was able to immediately save energy and cut down its emissions.²¹

Today, Guilford's solar thermal arrays are a symbol of the school's commitment to sustainability, visible throughout campus.²² In the words of Jon Varnell, Vice President for Administration, "Solar thermal is a no brainer; if you use a lot of hot water and you're not using solar, you're really losing out."²³

Gustavus Adolphus Adopts Solar Thermal Energy to Reduce Use of Natural Gas


In St. Peter, Minnesota, Gustavus Adolphus College uses the sun's energy year-round to heat several of campus buildings. Gustavus has deployed 100 flat plate panels on the rooftops of three buildings on campus to provide hot water for the pool and facilities at the Lund Athletic Complex and for the dining service operation at the Jackson Campus Center, and to help heat the LEED-platinum Beck Academic Hall in the winter and reheat chilled air in the summer to remove humidity.²⁴ At the Melva Lind Interpretive Center, two types of solar thermal technology – flat plate and evacuated tube solar – are installed side-by-side for demonstration purposes for students and the wider community.²⁵

Gustavus has embraced solar thermal energy to replace natural gas consumption on campus, reducing greenhouse gas emissions from natural gas heating by 15 percent since the college first signed the American College and University Presidents' Climate Commitment in 2007.

List of Resources

To start your campus' push to go solar:

- Assess the cost and energy efficiency of solar water heating systems: energy.gov/energysaver/estimating-cost-and-energy-efficiency-solar-water-heater
- Benefit from the Solar University Network's assistance to create "shovel-ready" solar energy campus projects: www.solarendowment.org
- Use the U.S. National Renewable Energy Laboratory's REopt model for expert analysis, solar screenings and implementation assistance: reopt.nrel.gov



Ball State has eliminated the use of coal and switched to geothermal energy, saving \$2 million in operating costs each year with the nation's largest geothermal energy system.

Geothermal Energy

Moving Toward 100% Clean, Renewable Energy on Campus

Geothermal energy systems on campus can help America's colleges and universities to shift to 100 percent clean, renewable energy. Campuses across the U.S. are installing geothermal power systems to save energy, provide learning opportunities for students, and achieve their climate goals.

Geothermal Energy Is a Key Building Block of a Clean Energy Future

Geothermal energy is derived from the heat of the earth, which we have learned to harness to heat and cool buildings, and to produce electricity. Virtually pollution-free, inexhaustible, safe and efficient, geothermal energy is a truly clean source of power that is also dependably constant. With an estimated conventional geothermal potential capacity of 38 gigawatts nationwide, or the energy needs of approximately 23 million homes,²⁶ geothermal energy is a key piece of the puzzle to help our society shift away from today's energy system built on polluting fossil fuels.

How Does Geothermal Energy Work?

According to a 2011 report by the National Wildlife Federation, 160 campuses in 42 states use geothermal energy for heating and cooling.²⁷ Thanks to geothermal technologies like heat pumps, campuses can use the heat of the earth or water to:²⁸

- Provide space heating or cooling across a network of buildings,
- Save energy by situating new buildings partially underground,
- Generate electricity from steam fields or hot water underground,
- Store thermal energy in aquifers for later use.

Geothermal Energy Presents Challenges and Opportunities

Geothermal technologies can benefit colleges in different ways:

- **Low Operational Costs:** Geothermal energy systems have lower operating and maintenance costs than some other conventional heating systems, which colleges use to recoup the cost of installation.²⁹
- **Scaling:** Geothermal technology may also be scaled to benefit individual buildings or whole campuses.
- **Educational Tools:** Energy dashboards have proliferated to help students and faculty monitor the performance of geothermal installations.

Colleges and universities are reducing barriers to geothermal energy:

- **Installation disturbance:** Creating a geothermal heat network may require tearing up streets to lay down piping. For example, Lake Land College in Illinois is taking it one building at a time, and performing major projects during the summer break or at night, to avoid affecting normal campus operation.³⁰
- **Innovation:** Universities research and test innovative geothermal energy applications. For example, Cornell University's research has alleviated concerns about the ecosystem impact of heat exchanges with aquifers and lakes, based on studies of its own "Lake Source Cooling" system.³¹

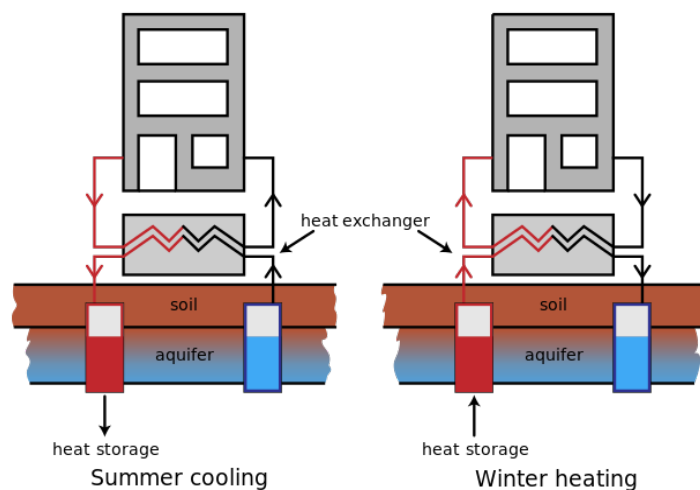
Geothermal heat pumps use the earth as a heat source in the winter or as a heat sink in the summer, benefiting from the earth's stable temperatures for renewable temperature control.

Ball State Replaces Coal-Fired Boilers with One of Nation's Largest Geothermal Energy Systems

At Ball State, a public university in Indiana with more than 20,000 students, heating historically came from four coal-fired boilers that emitted carbon dioxide, sulfur dioxide and particulate matter pollution, contaminants linked to global warming, acid rain and respiratory problems, respectively.

In 2012, those boilers were replaced by one of the nation's largest geothermal energy systems. Water travels through pipes underground, where the stable temperatures heat water in the winter and cool it in the summer, and through campus, where heat exchangers and fans regulate indoor air temperature in more than 5 million square feet of space in 47 buildings. The system improves air quality and saves the school \$2 million each year.

To pay for the initial phase of the project, Ball State repurposed \$40 million in funds for replacement boilers, along with \$5 million in federal grants and additional savings generated by the first completed section of the geothermal system. They are also selling their carbon offsets to help provide revenue through Second Nature's C2P2 program, using the revenue to further invest in energy reduction programs.³² When sales end in 2021, Ball State can claim the emissions reductions towards its clean energy goals, and move closer to its goal of achieving carbon neutrality by 2030.




Allegheny College Powers Three Buildings with Geothermal Energy Thanks to a Junior Seminar

Students have played a leading role in helping Allegheny College reduce energy consumption. In addition to undertaking energy efficiency measures as part of the U.S. Department of Energy's "Better Buildings Challenge," Allegheny College has installed clean, geothermal energy on its campus.³³ During the design of a new campus residence hall, a junior seminar of 14 students studied ways to make the building more energy efficient, ultimately suggesting measures including a geothermal heating and cooling system. Student analyses of costs and payback periods, along with case studies of similar systems at comparable facilities, convinced university faculty and facilities officials to include a geothermal system in the new building, along with energy efficiency measures. After the project was completed, the benefits of the geothermal system convinced university officials to include similar systems in two additional campus buildings.

List of Resources

To start your campus' push to adopt geothermal energy:

- Understand the principles underlying geothermal energy: www.energy.gov/eere/videos/energy-101-geothermal-energy
- Read the National Wildlife Federation's geothermal energy guide, *Going Underground on Campus: Tapping the Earth for Clean, Efficient Heating and Cooling* (2011): www.nwf.org/pdf/Reports/Geothermal%20Guide%20FINAL%203-1-11.pdf



Michigan State University entered into a 25-year Power Purchase Agreement (PPA) to buy 15,000 megawatt-hours of electricity produced each year by the largest solar carport in the U.S., located on its East Lansing campus.

Renewable Energy Purchasing

Moving Toward 100% Clean, Renewable Energy on Campus

America's colleges and universities can purchase renewable power to transition to a future of 100 percent clean, renewable energy, as well as save money and hedge against volatile fossil fuel costs. Power purchase agreements (PPAs) and renewable energy credits (RECs) enable colleges to purchase clean energy and drive the deployment of new installations without upfront costs.

Renewable Energy Purchases Accelerate the Transition to Clean Energy

While some campuses have ample opportunities to install solar and wind power, colleges with limited space or cash reserves can purchase renewable energy. Financing options like PPAs avoid upfront costs, and provide incentives for developers to build additional renewable energy capacity. Renewable energy purchasing ensures all schools can achieve their clean energy goals.

Campuses Benefit from Renewable Energy Purchases³⁴

Colleges can purchase renewable electricity in different ways:

- **Power Purchase Agreements (PPAs):** Colleges can buy clean electricity directly from electricity providers, typically at a long-term cost savings, thanks to a fixed price over a long contract term (typically 20 years), no upfront capital or maintenance costs and protection from volatile energy prices.
- **Net Metering Credit Purchase Agreements (NMAs):** Some states allow NMAs, which are like PPAs, but the electricity is generated off-site, using virtual net metering.
- **Renewable Energy Credits (RECs):** Colleges can purchase RECs to pay renewable electricity providers for the right to claim the provider's renewable electricity towards their own clean energy goals. One REC represents one megawatt-hour of clean electricity. REC sales help developers to finance renewable energy projects.

As of January 2016, 61 universities had financed over 100 megawatts of solar capacity through PPAs.³⁵ As of April 2016, 81 universities had contracts to purchase RECs.³⁶

Overcoming Challenges Associated with Renewable Energy Purchases

PPAs and NMAs are unfortunately not available in all states. What's more, if the project owner sells the associated RECs the college cannot claim the renewable energy or emissions reductions.

- **Double counting:** Improperly tracked RECs may be counted twice – once as a green energy purchase, and once by a utility to comply with a state's renewable energy standard.³⁷
- **Aging facilities:** Some RECs may be generated from aging facilities, rather than being used to install new clean energy capacity.
- **Favorable economics:** RECs purchased from states where renewable energy development is driven primarily by favorable economics may not effectively encourage new development.

Higher education institutions can use careful screening or purchase high-quality RECs that have been vetted by trusted certification systems, like Green-e, which verifies and certifies that RECs are not double counted and come from projects built within the last 15 years, among other criteria.

Georgetown purchases renewable energy credits that exceed its electricity use to support clean electricity generation both on and off campus.

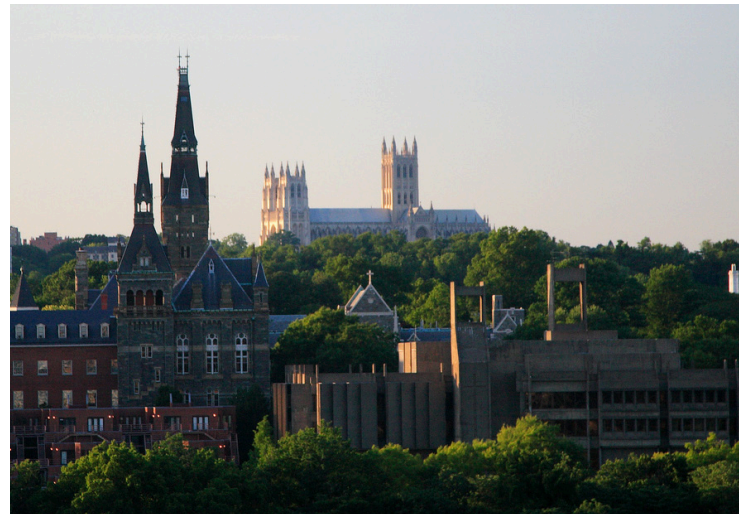
Georgetown Uses RECs and Efficiency to Exceed 100 Percent Renewable Electricity

Georgetown University's historic campus in Washington, D.C., does not have the physical space or flexibility to deploy large-scale clean energy installations on site. Yet, by procuring off-campus renewable energy, installing renewable energy on rooftops and working to aggressively reduce energy use on campus, Georgetown University has become one of the nation's top clean energy schools.

Georgetown bought RECs equivalent to 129 percent of its electricity use in the year ending in July 2016.³⁸ By exceeding 100 percent renewable power, Georgetown supports clean electricity both on and off campus. To maximize the effectiveness of these RECs in driving renewable energy adoption, Georgetown purchases RECs that have been certified by Green-e.³⁹

Clean energy adoption at Georgetown goes beyond REC purchases, and includes improving building energy efficiency, engaging people to conserve energy, and even installing solar on the roof of six historic townhouses.⁴⁰ In fiscal year 2014, Georgetown saved 500,000 kWh of energy, which is equivalent to taking more than 700 cars off the road.⁴¹

Because of its clean energy efforts, the EPA recognized Georgetown as a Green Power Partner of the Year in 2013.



Michigan State University Enters Solar PPA⁴²

In March 2017, construction began on a new solar array project at Michigan State University. Located across five different campus parking lots, the array will generate 5 percent of the campus' annual electricity needs, and is projected to save \$10 million over the next 25 years.


This project is being developed through a PPA and will be owned by Indiana solar-energy supplier Inovateus and Canadian renewable-energy developer Alterra. MSU will purchase the electricity produced by the solar array for 25 years and pay \$2.5 million to connect the arrays to the university power grid, while the investors will pay \$20 million for all other construction and maintenance costs.

The PPA-funded project will also provide research opportunities for students from the College of Engineering to explore new technologies that could be used in the solar arrays.

List of Resources

To get the most out of renewable energy purchasing:

- Learn about renewable energy procurement at other colleges: greengigawatt.org/resources/IEN_CleanEnergy_whitepaper.pdf
- Consult the National Renewable Energy Laboratory's fact sheet for solar PPAs: www.nrel.gov/docs/gen/fy16/65567.pdf
- Learn more about PPAs and NMAs for institutions: www.mass.gov/eea/docs/eea/lbe/ppa-and-nma-guidance.pdf
- Signatories to the Carbon, Climate or Resilience Commitment have access to the primers, guides and market intelligence of the Rocky Mountain Institute's Business Renewable Center: www.businessrenewables.org



West Village at University of California at Davis is the largest planned zero net energy neighborhood in the U.S.

Energy Efficiency in Campus Buildings

Moving Toward 100% Clean, Renewable Energy on Campus

The task of powering college campuses with clean energy can be made easier through aggressive steps to improve the energy efficiency of campus buildings. Energy efficiency in campus buildings can save colleges money and accelerate the transition to a clean energy future.

Building Energy Efficiency Is Key to a Clean Energy Future

Nearly half of the energy we currently consume in the U.S. is wasted.⁴³ College campuses are no different. In campus buildings, which consume more than 80% of the energy used by universities,⁴⁴ improved energy efficiency can cut up to 60 percent of overall energy use.⁴⁵ Energy efficiency measures are the cheapest way to meet many energy needs and reduce associated emissions. Many solutions are available today and can be deployed quickly.

Campuses Benefit from Improved Energy Efficiency in Their Buildings

College campuses can implement energy efficiency improvements rapidly:

- **Controlled Environment:** Campuses are highly structured, controlled environments and colleges have the ability to deploy resources quickly.
- **Environmental Awareness:** At many schools, environmentally conscious students, faculty and staff are eager to develop and implement energy efficiency solutions.
- **Innovation Hubs:** Campuses provide testing grounds to save energy, using “intelligent” information technology and experimenting with zero-net energy and passive building techniques. The Georgia Institute of Technology recently opened a carbon-neutral research lab and is designing another facility as part of the Living Building Challenge, a green building certification program.

America’s higher education institutions have already reduced their buildings’ energy consumption by 8 percent, and their energy intensity (energy used per square foot of floor space) by 14 percent since 2007.

Colleges and Universities Are Fertile Grounds for Building Energy Efficiency Improvements

Colleges still spend almost \$7 billion on energy each year, and present multiple opportunities for building energy efficiency gains.

- **Out-of-Date Infrastructure:** Many campuses have older buildings that were not designed to be energy efficient, or that rely on outdated equipment. Universities can make cost-effective investments to improve building performance, such as widespread adoption of low-energy LED lighting, and undertake building retrofits to improve insulation and upgrade heating and cooling equipment.
- **Energy-Intensive Facilities:** Certain facilities on campuses are uniquely energy-intensive and provide powerful opportunities for energy savings. Research laboratories, for example, require energy for proper ventilation to keep lab workers safe. Campuses across the country are taking measures to reduce operational costs in labs, including shutting the sash on fume hoods, using appliance timers, and storing samples at slightly higher temperatures where appropriate.

The Rafik B. Hariri Building at Georgetown University is LEED-certified silver and includes efficient lighting and ventilation features.

With Student Help, “Better Buildings” at Allegheny College Save Energy and Money

Allegheny College, a small liberal arts school in northwestern Pennsylvania, located 30 miles from Lake Erie, has successfully reduced building energy use in recent years.

In 2011, Allegheny College joined the U.S. Department of Energy’s “Better Buildings Challenge,” committing to reduce building energy intensity by 20 percent by 2020. Since then, efficiency improvements across campus have reduced energy intensity for all of Allegheny College buildings by 14 percent. One project, a renovation of Carr Hall to make room for the Allegheny College’s growing Environmental Science department, made the building 23 percent more efficient through improvements such as better heat recovery and energy-efficient lighting.

Students have also contributed to making buildings on Allegheny’s campus more energy efficient. For example, a group of students helped set sustainability goals for a new residential hall project and provided feedback on its design. As a result, the LEED-certified gold building has energy-efficient light fixtures controlled by sensors, energy-saving motors in building equipment, and large windows and bright paint colors that bring and reflect sunlight into student apartments and common spaces, as well as clean energy and water conservation features. Allegheny College received a bond to cover the building’s construction and will benefit from energy savings for many years to come.⁴⁶



Georgetown Makes a Commitment to Energy Efficiency and Conservation Across Campus

Clean energy adoption at Georgetown includes extensive efficiency and conservation efforts, as well as on-campus renewable energy installations and renewable energy purchases that surpass the amount of electricity the campus consumes each year.

These include a commitment to achieving LEED-Silver certification or higher for all new building construction, conducting building energy audits, and investing in energy efficiency retrofits in buildings.

A student-run \$1.5 million fund also provides grants and resources for energy efficiency projects, like LED lighting retrofits in the Hoya Court campus dining hall and in the parking lot of the Rafik B. Hariri building.

In FY2014, Georgetown’s efficiency and conservation efforts combined to save 500,000 kWh of energy annually, cutting emissions equivalent to taking more than 700 cars off the road each year.

List of Resources

To start saving energy in campus buildings:

- Benefit from ENERGY STAR resources to measure and track energy use and expenses (www.energystar.gov/benchmark), plan cost-effective building upgrades (www.energystar.gov/bldgmanual), set performance targets (www.energystar.gov/newbuildingdesign), and learn about how to manage building data (www.energystar.gov/businesstraining).
- Access free resources to reduce energy consumption in schools from the Alliance to Save Energy Coalition: www.ase.org.
- Take the Better Buildings Challenge like Allegheny College and 16 other universities: betterbuildingsolutioncenter.energy.gov/challenge.



Microgrids and Energy Storage

Moving Toward 100% Clean, Renewable Energy on Campus

Developing microgrids and energy storage systems on campus allows America's colleges and universities to help pave the way to a future of 100 percent clean and renewable energy, developing pioneering solutions that can later be adopted by other institutions and the electric grid at large. Thanks to microgrids and energy storage systems, college campuses have the capacity to integrate renewable energy in new and creative ways to increase their use of clean energy and ensure reliable access to electricity.

What Are Microgrids?

Microgrids are self-contained electric grids that can operate as an “island,” independently of the central power grid. This allows a campus to keep the lights on even if there is an outage on the main grid. But microgrids powered by renewable energy come with challenges:⁴⁷

- **Intermittent electricity generation:** Wind and solar power generation is variable, depends on weather conditions, and may not be available at the same time as energy is used during the day.
- **Distribution protection:** The presence of generation within the distribution system means energy flows both ways, which makes it hard to regulate voltage.

To address these issues, colleges can combine microgrids with:

- Energy storage to save excess clean energy for periods when production is low,
- Smart technology to match renewable energy supply and demand.

For example, the Illinois Institute of Technology microgrid stores excess power in batteries and uses smart software to avoid blackouts in labs containing important research.⁴⁸

Colleges and Universities Are Uniquely Placed to Benefit from Microgrids

College campuses are well suited to develop microgrids:

- **Islanding:** The already self-contained nature of many campuses makes colleges perfect candidates for developing microgrids.
- **Increased Reliability:** Microgrids can continue to function even during central grid outages. This resiliency can be an important benefit to colleges concerned about power outages affecting the function of research facilities.
- **Expert Knowledge:** Schools can benefit from expert faculty knowledge and motivated student bodies to manage both energy supply and demand within a microgrid.
- **Living Labs:** Colleges may also use smart technology at the building level, analyzing sensor data to predict and smooth energy consumption to better meet supply. Universities equipped with meteorological stations, like Santa Clara University, may use weather reports to optimize clean power generation.

Deploying microgrids allows universities to demonstrate the practicability of high penetrations of variable renewable energy sources like wind and solar power, while improving overall reliability.

After Hurricane Sandy, SUNY New Paltz began to develop a state-of-the-art microgrid that incorporates solar power and battery storage to make its campus more resilient.

SUNY New Paltz Combines Clean Energy and Energy Storage to Avoid Blackouts

After universities like Princeton and Rutgers lost power during Hurricane Sandy, colleges were motivated to secure their campus power supply to be more resilient in the face of central grid power outages.

The State University of New York (SUNY) at New Paltz has partnered with state agencies and utilities to build a state-of-the-art hybrid solar panel and battery storage energy system on a microgrid. The new system will generate clean energy from 217 kilowatts of solar panels installed on a campus gym and library. The hybrid microgrid's battery storage system will be in the gym's basement, and will help mitigate the variability of solar power production. Thus, the hybrid solar energy system will act as a reliable back-up energy source for emergency use, keeping the 7,800-student campus safe from weather-induced blackouts or cyber-attacks.

SUNY's hybrid microgrid will also test a smart technology that manages the complexity of having power being both used and produced locally. This technology helps SUNY to better deal with intermittent power production and successfully incorporate the solar energy into its grid.



Las Positas Community College's Microgrid

Las Positas Community College, located in Livermore, California, is using a \$15 million grant from the California Energy Commission to establish a campus-wide microgrid to be completed in 2018, combining solar generation, battery and thermal storage systems, net metering, and energy management applications.⁴⁹

The microgrid relies on existing solar arrays that supply 55 percent of campus electricity.⁵⁰ Adding storage capability will allow Las Positas to store excess solar energy for use in the evening and at night. By optimizing the value of solar energy throughout the day and improving the microgrid's reliability, Las Positas anticipates the microgrid will help reduce its annual energy costs by \$100,000.⁵¹

The Las Positas microgrid rolls out a new concept of the "Internet of Energy," integrating numerous sources of power generation and different applications to smoothly manage intermittent energy flows and variable energy loads. The Las Positas Community College microgrid automation project aspires to be a blueprint for campus microgrids across the country.⁵²

List of Resources

To start your campus on the path to energy resiliency:

- Read the Department of Defense's report, "Feasibility and Guidelines for the Development of Microgrids in Campus-Type Facilities" (April 2012), available here: www.serdp-estcp.org
- The Microgrid Institute provides project development support and advisory services: www.microgridinstitute.org
- Find a microgrid close to your campus: microgridprojects.com



Plug-in electric vehicles charging at the University of Colorado, Boulder.

Electric Transportation

Moving Toward 100% Clean, Renewable Energy on Campus

Rapid advances in technology and declining costs make electric transportation a feasible option for colleges and universities. Campuses across the U.S. are realizing the synergy between clean energy and electric vehicles and the indispensable role they can play in shifting to 100 percent clean, renewable energy on campus.

Transportation Electrification Is Key to a Clean Energy Future

Transportation surpassed electricity generation as the leading source of greenhouse gas emissions in the United States in 2016.⁵³ Electric vehicles that run on clean energy are essential to reducing the use of fossil fuels for moving people to, from and around college campuses. America's vast renewable electricity potential is more than sufficient to meet future demand created by the adoption of electric vehicles on college campuses.

Colleges and Universities Benefit from Electrifying Transportation

Going electric benefits campuses in multiple ways:

- **Renewable Energy Integration:** Adopting electric vehicles makes it easier to integrate more wind and solar power on college campuses.⁵⁴
- **Quality of Life:** Going electric cuts fossil fuel use, which means less exhaust, heat and noise.⁵⁵
- **Cost:** Driving on electricity is cheaper than using gas in all 50 states.⁵⁶
- **Research opportunities:** Students at University of Michigan can use the state-of-the-art equipment and collaborate with industry experts through its "Battery Lab."⁵⁷

Colleges and Universities Are Taking on the Challenges of Electrification

Colleges are uniquely suited to tackle the challenges of electrifying their transportation options:

- **Cost:** Battery prices fell by 80 percent in six years, but their upfront cost still makes electric vehicles prohibitively expensive for many buyers.⁵⁸ Universities can leverage funding from several sources, including federal and private funds, to absorb the upfront cost of electric vehicles, which can be defrayed by lower energy and operating costs over time.
- **Charging:** Electric vehicles must often charge for hours to reach full capacity. Campus shuttles may charge at night in a campus garage, or even on their actual route. Campuses like University of Madison Wisconsin have added fast-charge stations for electric vehicles, and Utah State University has pioneered a new "charge-as-you-go" technology⁵⁹ that is ideal for campuses buses that make frequent stops on fixed routes.⁶⁰



University of California, Irvine, Is First Campus in the U.S. to Convert to All-Electric Bus Fleet

In the 2017-2018 academic year, 20 all-electric buses are rolling onto the University of California, Irvine (UCI) campus, making it the first campus in the U.S. to completely phase out fossil fuels in its on-campus transportation services.⁶¹ This initiative was voted for and is funded by students, who will pay up to \$40 each quarter to student services to cover the bus purchase and operating costs.⁶² Individual rides on the shuttle service, the Anteater Express, are free.

Electrifying the bus fleet is part of UCI's larger Sustainable Transportation program to decrease private vehicle trips around campus. As well as offering a clean energy shuttle service, UCI encourages students, faculty and staff to walk, bike, and car-pool.

Converting to an all-electric fleet improves air quality, decreases street noise, and helps UCI towards its goal to emit zero greenhouse gases from campus buildings and transportation by 2025.⁶³ UCI has made the Princeton Review's Green College Honor Roll for four consecutive years, earning a perfect score on the 2017 list, in recognition of the university's commitment to clean energy and environmental sustainability.⁶⁴

After studying low-carbon and zero-emission bus technologies in a 2013 workshop (above), UC Irvine is switching to an all-electric bus fleet.

Western Michigan University Is One of the Best U.S. Campuses for Electric Cars

Western Michigan University has garnered a reputation for support of electric vehicles, ranking fourth in the nation in 2014 for the number of electric vehicle charging stations on campus.⁶⁵

The campus is equipped with 22 electric vehicle charging stations, 15 of which are powered by a 50-kilowatt solar array.⁶⁶ The panels generate enough solar energy each day to fully charge 11 Chevrolet Volts, and excess solar energy is stored in vehicle batteries for later use.⁶⁷ The charging stations are available to anyone around the clock free of charge.⁶⁸ A \$700,000 state grant funded the solar-powered charging stations, as well as the purchase of five electric vans and a hybrid-hydraulic truck.⁶⁹

WMU's solar-powered charging stations support research, providing real-time data on solar energy production and electric vehicle energy use. WMU is also known for its strong electrical engineering department, which offers courses on fuel cells and alternative energy sources, automotive electrical systems, and automotive design and life cycle performance.⁷⁰

List of Resources

To electrify campus transportation:

- Check out George Washington University's fleet electrification toolbox: provost.gwu.edu/fleet-electrification-toolbox-0
- Benefit from public funding opportunities: energy.gov/eere/vehicles/funding-opportunities
- Learn about laws and incentives in your state: www.afdc.energy.gov/laws
- Locate alternative fueling stations near campus: www.afdc.energy.gov/locator/stations



In 2010, Cornell launched Big Red Bikes, one of the first free university bikeshare programs.

Sustainable Transportation

Moving Toward 100% Clean, Renewable Energy on Campus

Transportation is a major source of energy consumption on campus, with much of that energy coming from fossil fuels. Promoting transportation options that use less energy like public transportation, and walking and biking, will play a key role in shifting America's colleges and universities to 100 percent renewables.

Sustainable Transportation Is Key to a Clean Energy Future

Transportation accounts for 30 percent of energy demand in the U.S., and surpassed electricity generation as the leading source of greenhouse gas emissions in the United States in 2016.⁷¹ While electricity gets cleaner, many vehicles used for everyday travel still rely on dirty fossil fuels. Expanding existing transit services and developing new transportation options is key to reduce the dependency of campuses on fossil fuels.

Campuses Are Reaping the Benefits of Sustainable Transportation

Reducing vehicle trips benefits universities in several ways:⁷²

- **Quality of Life:** Fewer cars make campuses cleaner and more enjoyable, with less noise and exhaust in the air.
- **Town-Gown Relations:** Reducing driving can help avoid the seasonal influx of student cars and the resulting traffic in neighborhoods close to campus.
- **Recognition:** Sustainable transportation boosts colleges' green credentials and makes them more attractive.
- **Accessibility:** Many colleges offer free or discounted access to transit services, as well as their own shuttle bus and night-time transportation services.

Colleges and Universities Are Well-Positioned to Take on Transportation Challenges

College campuses are perfect places to develop sustainable transportation:

- **Physical Attributes:** Campuses are dense hubs of activity that concentrate living, working and learning spaces. Walking and biking can often be the quickest and most convenient mode of travel between campus buildings.
- **Convenience:** Biking is an ideal fit for many college campuses, where travel distances are short and students tend to have limited incomes and low rates of car ownership. College towns have some of the highest rates of bicycle commuting in the country, and at least 90 universities have developed bikeshare programs.⁷³
- **Real Estate:** Many universities also have strong motivations for limiting the use of cars – which consume valuable campus real estate. Instead of building parking lots, campuses can focus on buildings and public spaces.
- **Safety:** Cars can make campuses less pleasant and more dangerous. As a result, universities are creating car-free spaces that are walkable, bikeable, convenient and safe.

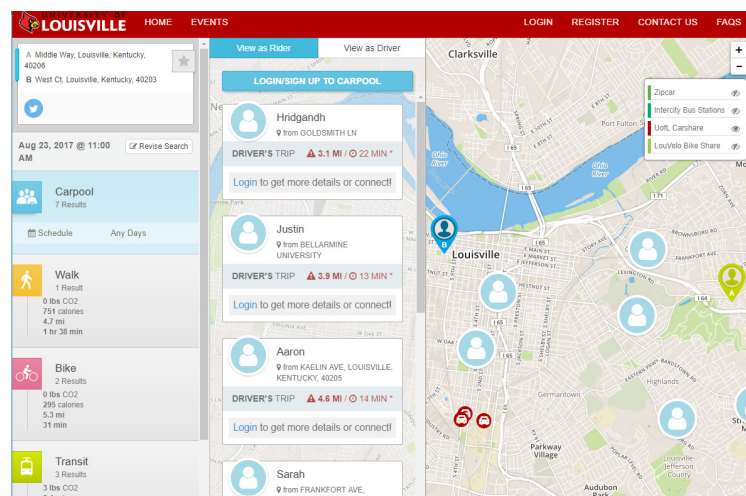
Students, faculty and staff at University of Louisville can use the Cardinal Directions service to plan local trips and find carpools

To Reduce Transportation Emissions, University of Louisville Embraces Bicycles

The University of Louisville has made bikes a centerpiece of its efforts to reduce reliance on fossil fuels.

Upon finding that 79 percent of employees and 65 percent of students were driving to campus alone, the university launched Earn-a-Bike in 2012.⁷⁴ Under this program, students give up their right to a vehicle parking permit for two years in exchange for a \$400 voucher towards local bike shops.⁷⁵ The program received widespread media coverage and inspired similar programs at other schools. The university also installed more than 600 new bike racks, bike fix-it stations containing tools and tire air pumps, bike lanes, and a campus bikeshare program. As a result, the percentage of students who commute primarily by bike doubled from 4 percent in 2010 to 8 percent in 2015.⁷⁶

Since launching its bike voucher program, the University of Louisville has expanded its commitment to further shift away from fossil fuels and to reduce the number of students and faculty who commute to school in their car alone. In 2016, for example, the university launched an online transportation portal allowing students to gain access to a wider variety of transportation options, including buses and carpools.



Cornell Relies on Public Transportation for Sustainable Commuting

Cornell University works to reduce vehicle usage to cut down on energy waste and keep its campus free from congestion and pollution.

Cornell combines restrictive on-campus parking with free bus passes and easy membership access to the fuel-efficient vehicles of the Ithaca CarShare service to reduce the need for personal vehicles on campus.⁷⁷ The university has a RideShare program for faculty, and encourages students to use the ride-sharing app Zimride for rides home.⁷⁸

As well as providing motorized alternatives to individual vehicles, Cornell has a student-run bikeshare program and promotes walking to get around its beautiful Ithaca campus.⁷⁹

Cornell is also part of Way2Go, a community mobility program that educates the community on available mobility options at the county level and provides transportation professionals opportunities to learn from the community and understand its needs.⁸⁰

Today, 89 percent of students and 47 percent of staff commute sustainably around Cornell's campus.⁸¹

List of Resources

To develop sustainable transportation options on campus:

- Check out these 10 ways to encourage biking around campus: njbikeped.org/the-top-10-ways-to-encourage-bicycling-among-college-students
- Access the transportation toolkit and resources of the Association for the Advancement of Sustainability in Higher Education: hub.aashe.org/browse/topics/transportation



State University of New York at Albany runs a 10-week long competition each year to save energy and help develop lasting energy-conscious habits.

Energy Conservation

Moving Toward 100% Clean, Renewable Energy on Campus

Conservation is an important part of the transition to clean, renewable energy. By promoting initiatives to encourage and assist the campus community to adopt less energy-intensive lifestyles, colleges can save money, reduce their environmental impact, and ease the shift to 100 percent renewable energy.

Conservation Is a Key Building Block of a Clean Energy Future

Moving toward a clean energy future depends on both boosting clean energy supply and reducing energy demand. Energy conservation is a powerful tool to reduce energy demand, particularly when paired with smart technologies. Simple shifts in how people use energy on campus could save as much as 20 percent of energy consumption, and help colleges achieve their clean energy goals.⁸²

Colleges Across the U.S. Are Promoting Energy Conservation

Many campuses have developed energy conservation programs that often combine:

- **Community Initiatives:** Social interaction programs, like competitions, are relatively cheap and easy to implement, foster energy conservation awareness and help students and faculty to reduce their energy use.
- **Smart Technology:** Many colleges, such as Hamilton College and Brandeis University, use smart sensors and real-time feedback displays to show students, faculty and university administrators their energy use in real time – and help them to understand the powerful benefits of using energy wisely.

Colleges Are Uniquely Suited to Change Energy Consumption Behaviors

Colleges have tested different strategies to help people use energy more wisely:

- **Motivation:** A main obstacle to people reducing their energy use is the lack of frequent and intuitive feedback about their energy consumption.⁸³ At Oberlin College, students who received real-time depictions of their electricity consumption reduced their electricity use by 32 percent over two weeks.⁸⁴
- **Norms:** People will often change their behavior to align with those around them – for better or for worse. Schools are building “cultures of conservation,” like Cornell with its Think Big, Live Green program that encourages students, faculty and staff to use energy thoughtfully.
- **Capacity-Building:** Students may not know all the ways they can save energy. At University of California, Merced, the Green Campus team has effectively used social networks, digital media and one-on-one conversations to share efficiency tips, reducing energy use in student residence halls by 3.7 percent.⁸⁵ Conservation strategies learned in college can be carried on into life after graduation.

Many schools, like Harvard University, the University of Kansas and University of California, Davis, have used “Shut the Sash” programs to challenge lab workers to turn off fume hoods and save energy.

Friendly Competition at the State University of New York at Albany Cuts Energy Use

The State University of New York at Albany has been running a 10-week long competition among residence halls and some academic buildings to reduce energy use every fall since 2006. The goal of the competition is to reduce electricity use by 10 percent compared to a 2005 baseline during the competition, and to develop lasting energy-conscious habits. Data on energy use is made available to the campaign participants through an online energy dashboard. Weekly emails reinforce positive progress, call out residential halls that are lagging, and send energy-saving reminders such as, “Did you unplug your phone charger this morning?”⁸⁶

The energy campaigns cost only \$2,000 each year and save approximately \$100,000 annually. The university publicizes how savings are used; part of those savings go back to the residence buildings to fund green amenities and sustainability programming. In 2010, for example, the Office of Sustainability started a bikeshare system using savings from the energy campaign. In 2016, the competition resulted in a 15 percent reduction in energy use by residence halls, with the winning apartment building reducing its energy use by 38 percent.⁸⁷



Harvard Uses Competitions and Peer Education to Encourage Behavior Change

At Harvard, research laboratories account for 44 percent of energy use but occupy only 20 percent of space. The Green Labs Program works with students, staff and faculty to reduce energy use through a variety of sustainability initiatives. For instance, three labs were sub-metered to track energy use and competed in annual two-week campaigns turn off lights. The efforts yielded an annual reduction in energy used for lighting of 36.4 percent the first year, and 50.9 percent the second year.⁸⁸

Harvard also assigns each dorm a student environmental liaison who disseminates information about environmentally sound habits – and distributes free LED light bulbs. The liaisons monitor energy use and advocate conservation measures, particularly during the Harvard Green Cup, which awards cash prizes for participation and savings.⁸⁹

List of Resources

To shift energy use behaviors on your campus:

- Consult the U.S. Department of Energy’s article on energy-efficient college life: energy.gov/energysaver/articles/energy-efficient-college-life
- Learn how Allegheny College challenged its community to save energy through the U.S. Department of Energy’s Better Buildings Initiative: betterbuildingsinitiative.energy.gov/implementation-models/campus-energy-efficiency-challenges
- Follow steps to develop an energy management program with the eBook “Anyone Can Effectively Manage Energy Efficiency Programs in Schools” from SchoolDude: www.schooldude.com/Portals/0/Public%20Content/eBook/energy-ebook13.pdf

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