Renewable Energy 100

The Course to a Carbon-Free Campus

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Executive Summary

America's institutions of higher education can play a crucial 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 of getting 100 percent of their energy from clean renewable sources.

Hundreds of universities have already pledged to achieve carbon neutrality with many signing onto Second Nature's Climate Leadership Commitment. Universities that eliminate the use of fossil fuels can help to achieve the goal of the Paris Climate Agreement, which aims to keep global temperature increase below 2 degrees Celsius over pre-industrial levels.

America can get 100 percent of its energy from clean, renewable sources:

- America's renewable energy resources have the potential to provide vastly more energy than the nation currently uses. According to the U.S. Department of Energy's National Renewable Energy Laboratory, the United States can generate more than 100 times as much electricity from wind and solar power installations as the nation currently consumes each year. These resources can also supply more than enough energy to meet future electricity demand created by the adoption of electric vehicles and other clean energy technologies.
- Studies conducted by multiple academic and governmental institutions have determined America can use clean energy to affordably and reliably provide all of the nation's energy needs, largely using technologies that already exist including wind power, solar power, energy efficiency and energy storage.

College and university campuses are ideal places to lead the drive toward 100 percent renewable energy:

- America's institutions of higher education are major energy users. They serve 20 million students, representing more than 6 percent of the national population. The higher education sector spends roughly $14 billion on energy costs each year, and the education sector as a whole, including K-12 schools, consumed 10 percent of all energy used by the commercial sector in 2012.
- College and university campuses often have physical attributes that make them good locations for hosting clean energy projects. Many have space on rooftops, in parking lots and on marginal land for hosting solar panels, wind turbines and other clean energy technologies.
- Colleges can save money and hedge against volatile fossil fuel costs by investing in clean energy. By entering power purchase agreements (PPAs), colleges can purchase clean energy and drive the deployment of new installations without upfront costs.
- Colleges' roles as leaders of innovation and training make them ideally suited to lead the way toward a clean energy future. They can apply newly developed technologies on campus, and use clean energy installations as opportunities for teaching and research.
- Adopting clean energy appeals to prospective students and meets the desires of current students and faculty. The *Princeton Review* and other college guides for prospective students highlight schools that have made a commitment to sustainability.

Many college campuses are already transitioning to clean energy.

- The Environmental Protection Agency's Green Power Partnership Program lists 45 higher education institutions that get 100 percent of their electricity from renewable sources.
- The Association for the Advancement of Sustainability in Higher Education (AASHE) lists 587 solar energy installations at 330 campuses in 41 states.
- A 2011 report by the National Wildlife Federation contains examples of 160 campuses in 42 states that use geothermal energy for heating and cooling.

A diverse array of universities have taken ambitious and creative steps toward clean energy.

- In 2011, after completing the installation of 25,000 solar panels, Butte College in northern California became the nation's first college campus to become "grid positive," meaning that the college generates more electricity than it uses.
- The University of Delaware is home to a 256-foot tall wind turbine that provides more than enough electricity to power the school's entire Lewes campus, along with more than 100 nearby homes. The turbine creates research and educational opportunities, and university students have used the wind turbine to study everything from impacts on birds and bats to the corrosive impacts of salty coastal air.
- Georgetown University purchases renewable energy certificates (RECs) exceeding 100 percent of its electricity use, making it one of the leading clean energy campuses in the country. In addition to its REC procurement, Georgetown has reduced energy use through extensive energy efficiency efforts, and recently installed solar panels on campus through a collaboration between students, faculty and staff.
- At Allegheny College in Pennsylvania, the school's energy efficiency projects through the Department of Energy's "Better Buildings Challenge" have reduced building energy use by 14 percent across campus. Students have played a leading role in the efficiency projects, including proposing and creating the financial case for a geothermal system at a new residence hall on campus.
- Ball State in Indiana replaced its aging coal-fired boilers, which emitted 85,000 tons of carbon dioxide pollution per year, with an emission-free geothermal heating system. The project saves the school an estimated $2 million in operating costs each year, while the first two phases of the project created 2,300 direct and indirect jobs.
- While creating a Climate Action Plan for achieving carbon neutrality, the University of Louisville discovered that 18 percent of campus emissions were the result of commuting, since so many students and faculty commute to school by driving alone. The school made bicycling a centerpiece of its plan to reduce transportation emissions, creating a program to give students $400 vouchers for local bike shops in exchange for giving up their campus parking spot, while also building bike-friendly improvements across campus including bike lanes and bike racks.
- A number of schools across the country have created initiatives to promote energy conservation. For example, the State University of New York at Albany runs an annual 10-week long competition among residence halls to reduce energy use, and Cornell University's "Think Big, Live Green" energy conservation initiative has a goal of reducing campus electricity use by 1 percent every year.

Colleges and universities have long played a leading role in bringing technological changes to society. Colleges and universities across the country should commit to getting 100 percent of their energy – including for transportation and heating – from clean, renewable sources. They should do so on ambitious timelines, while sharing data and lessons from their experience, working with surrounding communities, and engaging their students in the process.

Introduction

The first fully functional digital computer took up 1,800 square feet at the University of Pennsylvania when it was installed in 1946. The first message ever sent over the internet was the letters "L" and "O," sent 350 miles from a computer at UCLA to one at Stanford in 1969. The first human images created by a magnetic resonance imaging, or MRI, machine were produced at the State University of New York Downstate in 1977.

Colleges and universities have long played a leading role in sparking technological shifts that transformed American life and helped create our modern world. Yet the modern world has brought with it new challenges; chief among them is climate change, which threatens to disrupt our world and harm global populations and the environment.

Taking on climate change will require universities to once again spark a technological revolution in American society. Already, universities have played an enormous role, advancing climate science, warning of climate change impacts, crafting policy solutions to reduce emissions, and promoting clean energy technologies like wind and solar power and high-capacity batteries.

The biggest challenges, however, are yet to come. On April 22, 2016, the United States signed the Paris Climate Agreement, with the central aim of keeping global temperature increases under 2 degrees Celsius above pre-industrial levels in order to limit the worst impacts of global warming. Achieving this goal will require a rapid and near-total transition away from fossil fuels, which are responsible for the vast majority of carbon dioxide emissions and other climate pollution.

This transition will require colleges and universities to continue to expand their climate leadership. This report looks at how higher education institutions can become leaders in the development and deployment of clean energy technology, including wind and solar power, energy efficiency, and clean transportation. By doing so, colleges can protect the future of the people that they serve while setting an example for their students, their communities, and the world, to follow.

100% Renewable Energy Is Within Our Reach

Switching to 100 percent renewable energy is essential. To preserve the climate conditions on earth in which our species was able to evolve, we must stop using the dirty fuels that are heating our planet. The Paris Climate Agreement, supported by almost every country on the earth, sends the clearest signal yet that a full global transition to clean energy is necessary and that we must leave most of our coal, oil and gas reserves in the ground. Achieving the promise of the Paris Agreement requires immediate action.

Moving to 100 percent renewable energy means transitioning our entire economy away from dependence on fossil fuels. That includes electricity generation, which today is responsible for about 40 percent of our energy consumption, as well as transportation, industry and heating and cooling.[1] Fortunately, America's clean energy resources are capable of producing vastly more energy than the nation currently uses.

According to the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), the United States could generate more than 100 times as much electricity from solar power installations as the nation currently consumes each year.[2] Wind energy could produce more than 10 times as much electricity as America currently consumes every year.[3] These resources could also supply more than enough energy to meet future electricity demand created by electrification of transportation, heating and cooling, and other sources of energy demand.

The task of repowering America can be made easier through aggressive energy efficiency. More than 60 percent of the energy we currently consume in the United States is wasted, and the American Council for an Energy-Efficient Economy (ACEEE) estimates that we can reduce our overall energy use by 40 to 60 percent below current levels even with a growing economy.[4]

In recent years, the cost of clean energy technology has plummeted: The price per kilowatt of solar and wind power dropped by 85 percent and 66 percent from 2009 to 2016, respectively.[5] Meanwhile, technology has dramatically improved. Today's solar panels and wind turbines are able to generate more electricity, more reliably, than ever before, while new "intelligent" energy efficiency technology can save energy by harnessing the power of information technology.

Studies from numerous educational and governmental institutions have determined America can use clean energy to affordably and reliably provide all of the nation's energy needs, largely using technologies that already exist including wind power, solar power, energy efficiency and geothermal energy. For example:

- Stanford University Professor Mark Jacobson has developed models for every state in the United States, as well as for 139 countries around the world, to meet 100 percent of their energy needs using energy from the wind, water and sunlight.[6]

- Researchers at the National Oceanic and Atmospheric Administration and the University of Colorado found that it is possible to cut carbon pollution from U.S. power generation by almost 80 percent by 2030 at costs similar to what we pay today.[7]
- NREL's Renewable Electricity Futures Study assessed the electric grid impacts and energy supply challenges of a scenario in which renewable energy supplies 80 percent of U.S. electricity generation.[8] The study concluded that, using technologies that are commercially available today along with a more flexible electric grid, such a system could balance electricity supply and demand while reliably meeting electricity demand in every region of the country.

America has the tools to get the energy it needs from clean, renewable sources. But getting there will require leadership, innovation and investment. Colleges and universities can play an important role in accelerating and leading that transition, all while advancing their core missions of academic and research achievement.

What Is Clean, Renewable Energy?

Not all renewable energy sources have an equal benefit for the environment. Some forms of biomass and hydroelectric power, for example, can create environmental problems. Colleges moving away from fossil fuels should ensure that they transition to truly clean, renewable energy, including energy sources that are:

- Virtually pollution-free, producing little to no global warming pollution or health-threatening pollution;
- Inexhaustible, coming from natural sources that are regenerative or practically unlimited. No matter how much we use, there will always be more;
- Safe, with minimal impacts on the environment, community safety and public health, and those impacts that do occur are temporary, not permanent; and,
- Efficient, representing a wise use of resources.

Although all energy sources must be deployed responsibly, solar and wind energy meet these criteria, as do many types of ocean, tidal, river current and geothermal energy. Energy efficiency technologies also count as "clean energy" – delivering continuous environmental benefit at limited to no environmental cost.

College Campuses Are Ideal Places for 100 Percent Renewable Energy

To prevent the worst impacts of global warming, America must transition to an efficient 100 percent clean energy economy, powered entirely by renewable sources like wind and solar energy. College campuses are ideal places to start.

Colleges Are Major Energy Users

The nearly 5,000 colleges and universities in the U.S. are major consumers of energy.[9] They serve 20 million students, representing more than 6 percent of the national population.[10] They operate tens of thousands of buildings, which must be heated, cooled and powered, including energy-intensive research facilities. Students and faculty require transportation between classes, offices and residences, sometimes on sprawling campuses the size of small cities. All told, the higher education sector spends roughly $14 billion on energy costs each year, and the education sector as a whole, including K-12 schools, consumed 10 percent of all energy used by the commercial sector in 2012.[11]

Higher education sector energy use is also on the rise, in part as a result of a campus building boom. In 2015, colleges and universities spent a record $11.5 billion on construction, paying for 21 million square feet of new space.[12] A study of 267 campuses by Sightlines and the University of New Hampshire found that energy consumption increased by 3 percent on those campuses from 2010 to 2014 and attributed most of the increase to the addition of new buildings and increased physical footprints.[13]

Like the nation as a whole, energy consumed by higher education institutions largely comes from fossil fuels. Almost two-thirds of power for the U.S. electric grid, which still supplies almost all of the electricity consumed by universities, comes from coal and natural gas, and the vast majority of vehicles are powered by petroleum.[14] Among the institutions included in the Sightlines study, energy use at the average institution resulted in emissions of more than 45,000 metric tons of carbon dioxide equivalent in 2014, equivalent to the emissions released by more than 9,500 passenger vehicles.[15]

Almost two-thirds of power for the U.S. electric grid, which still supplies almost all of the electricity consumed by universities, comes from coal and natural gas.

Physical and Organizational Aspects of Campuses Are Conducive to Clean Energy

Colleges are highly structured, controlled environments, whose large and varied campuses offer an enormous range of opportunities for clean energy and efficiency projects. Combined with the ability to run effective energy-related social initiatives, college campuses are ideal places for the rapid adoption of 100 percent clean energy.

Campuses with Available Space Can Host On-Site Clean Energy

Many college campuses contain perfect locations for clean energy projects: rooftops, parking lots and open fields can host solar panels, wind turbines and other clean energy technologies. Data on existing solar energy installations on college campuses supports the idea that they are good places for high-capacity clean energy systems. Among the 592 solar energy installations contained in a database hosted by the Association for the Advancement of Sustainability in Higher Education (AASHE), the average campus solar installation has a capacity of 424 kilowatts, enough to power about 70 average American homes.[16] On-site solar installations across the University of California system total 36.5 megawatts, enough to power nearly 6,000 average homes.[17]

Self-Contained Campuses Can Deploy Resilient "Microgrids"

The self-contained nature of many college campuses affords colleges increased flexibility for the deployment of clean energy systems, including through "microgrids." Microgrids are self-contained electric grids that can function independently of the central power grid while taking advantage of "smart" technology to match renewable energy supply and demand. These systems can allow increased efficiency, as well as increased reliability since microgrids can continue to function even during central grid outages. This resiliency can be an important benefit to colleges concerned about power outages leaving students stranded, or affecting the function of research facilities.

Many college campuses contain perfect locations for clean energy projects: rooftops, parking lots and open fields can host solar panels, wind turbines and other clean energy technologies.

Deploying microgrids can also allow universities to demonstrate the practicability of high penetrations of variable renewable energy (e.g., wind and solar power). Many universities are already moving toward such systems. Santa Clara University, for example, is building a microgrid system that will use weather reports to maximize renewable energy reliance and will rely on sensors in campus buildings to monitor energy use.[18]

Colleges Can Run Effective Social Initiatives to Reduce Energy Use

The highly social and networked nature of college campuses creates opportunities for reducing energy use through social initiatives. Past initiatives have included placing signs on campus reminding students to turn off their lights, energy-saving competitions between dormitories, and campus-wide reminders for students to unplug appliances before winter breaks. What's more, the enthusiasm of today's youth for tackling environmental problems and shifting to modern technologies can provide additional leverage for bold action.

Colleges Can Save Money by Investing in Clean Energy

By committing to clean energy, many colleges and universities have saved money while protecting the environment. In 2013, 72 percent of the institutions that submitted data to Second Nature reported saving money through their sustainability initiatives.[19]

Some types of clean energy projects – including many measures to reduce energy use – have long been smart financial investments for universities. Today, following recent price declines, colleges and universities may also be able to save money by deploying technologies that were once prohibitively expensive. Wind and solar installations, for example, have dropped in price by 85 percent and 66 percent over the last seven years, respectively.[20] As a result, energy from the wind and sun is often cheaper than energy from fossil fuels, especially when accounting for federal tax credits and other incentives.[21]

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Although clean energy projects often bring long-term savings, they also typically require an up-front capital investment. To benefit from clean energy without negatively impacting short-term finances, colleges and universities can take advantage of a wide variety of options for financing clean energy, including options that avoid upfront costs.

Under a power purchase agreement (PPA), colleges and universities can obtain clean energy without upfront costs and without any need for future spending on maintenance or operation by agreeing to purchase energy from a clean energy provider for a predetermined price and length of time. Colleges and universities can be particularly well-suited for PPAs because many are established institutions that can enter into long-term contracts. Long-term PPAs (typically 20 years) allow institutions to hedge against future fluctuations in energy prices and help drive renewable energy growth by providing certainty to developers.

For schools with available cash reserves, one of the most popular financing mechanisms for funding clean energy projects is a green revolving fund (GRF). GRFs are internal funds created with an upfront pool of capital. After an initial investment in clean energy projects, GRFs are replenished through savings generated by the project.[22] As of 2012, investments made through GRFs reported a median annual return on investment of 28 percent, outperforming external investments.[23]

Colleges can see additional cost savings by obtaining funding from external sources, including grants from government, nonprofit and corporate sources. Through 2013, Second Nature reported that participating institutions had secured more than $300 million in external funding for clean energy projects and efforts to reduce energy consumption.[24]

Clean Energy on Campus Can Provide Opportunities for Research and Learning

Colleges and universities have long played an important role in developing and researching clean energy technologies. For example, in 1972 the University of Delaware established the world's first laboratory dedicated to photovoltaic research and development, where researchers later developed solar panels that broke new records for efficiency and built some of the world's first solar-powered homes.[25] Today, colleges are hotbeds of renewable energy innovation and training, and by deploying clean energy they can provide opportunities for on-campus research and learning.

Cutting edge renewable energy research is taking place at universities across the country. The Interstate Renewable Energy Council lists more than 270 academic and technical institutions offering educational programs for renewable energy and sustainability, in almost every state.[26] Massachusetts Institute of Technology (MIT) researchers are developing transparent solar cells that allow products like windows and electronics to generate power.[27] The University of Michigan's Battery Fabrication and Characterization User Facility, better known as the "Battery Lab," is developing high-capacity batteries with the goal of advancing vehicle electrification and energy storage.[28] Stanford researchers are developing policy tools and pathways for getting the U.S. and the world to 100 percent renewable energy.[29] At Maine's College of the Atlantic, where 100 percent of the school's electricity comes from wind and solar power, three quarters of the faculty are engaged in sustainability research and more than a third of the school's classes are related to environmentalism.[30]

Many colleges have already demonstrated the research and educational benefits of clean energy installations. At Allegheny College in Pennsylvania, students played a leading role in proposing energy efficiency projects undertaken through the Department of Energy's "Better Buildings Challenge." Butte College in northern California, powered by 25,000 solar panels, offers courses that allow students to assemble and disassemble solar panels as training for future clean energy jobs.[31] Students at the University of Louisville have conducted surveys and analyses of university initiatives that aim to reduce transportation emissions by encouraging bicycling.[32] And at the University of Delaware, a 2-megawatt wind turbine installed on campus has become an important research tool for the campus; university students have used the wind turbine to study everything from turbine impacts on birds and bats to the corrosive impacts of salty coastal air.[33]

Colleges are hotbeds of renewable energy innovation and training, and by deploying clean energy they can provide opportunities for on-campus research and learning.

Students and Faculty Want Clean Energy

Competition for students and faculty among colleges and universities is often intense. Leadership on clean energy and climate change, along with broader sustainability efforts, is among the ways that colleges can help to attract and retain talented people.

Young Americans have the most to lose from global warming, and polling indicates that they want something done about it. A 2015 Pew Research Center poll found that Americans ages 18-29 are more likely than older Americans to see global warming as a

"very serious problem," to believe it will affect them personally, and to support actions to limit global warming pollution.[34]

With young people increasingly concerned about climate change, guides for prospective students looking for a new university often highlight sustainability initiatives. The *Princeton Review*, which provides college advice to prospective college students, maintains a database of schools with a commitment to sustainability and has a ranking of "The Top 50 Greenest Schools."[35] The Sierra Club publishes a similar ranking.[36] Both lists place much of their focus on schools that are working to reduce global warming pollution.

Clean energy also meets the demands of existing students, many of whom are calling for clean energy on and off campus. The first renewable energy installation at Northwestern University, a solar panel system covering the roof of the Ford Motor Company Engineering Design Center, was the result of two years of planning and fundraising by university students.[37] Off campus, students have been critical actors in clean energy and climate change activism; for example, tens of thousands of students from more than 300 college campuses joined the People's Climate March in New York City in 2014.[38]

The adoption of clean energy can also appeal to faculty. The American Association of University Professors, the leading national organization representing higher education staff, and which represents faculty and academic professionals at more than 300 institutions across the country, voted in 2016 to "create a committee charged to determine how American colleges and universities can best address the grave threat posed by climate change."[39]

Colleges Can Work with Local Communities to Expand Clean Energy

Moving toward clean energy on campus can help drive the adoption of clean energy in local communities, helping speed the nation as a whole in a transition away from fossil fuels. Campuses can build partnerships with local communities to expand clean energy and campus deployment can create new supply chains, develop clean energy jobs and expertise, and bring down costs.

The Clean Energy Extension program at University of Massachusetts, Amherst, works with cities and towns to help accelerate the adoption of clean energy, recently providing technical assistance that helped the town of Greenfield reduce energy consumption by 20 percent from 2008 to 2016.[40] Almost every clean energy project has the potential to create local jobs. At Ball State in Indiana, the installation of a geothermal energy system was estimated to create 2,300 direct and indirect jobs.[41]

College Campuses Are Leading the Transition to Renewable Energy

College campuses around the country are already taking ambitious steps toward 100 percent renewable energy. They are doing so by adopting a wide variety of clean energy technologies, strategies and goals.

- The Environmental Protection Agency's Green Power Partnership Program lists 45 higher education institutions that get 100 percent or more of their electricity use from "green power" (the EPA defines green power as "electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources").[42]
- At least 330 college campuses in 41 states have installed a total of 587 solar energy systems, according to a database maintained by the Association for the Advancement of Sustainability in Higher Education (AASHE).[43]
- As of 2011, 160 campuses in 42 states used geothermal energy for efficient heating and cooling, according to a report by the National Wildlife Federation.[44]
- More than 600 colleges and universities have committed to take action on climate as signatories of Second Nature's Climate Leadership Commitments; the majority of these schools have committed to go carbon neutral.[45]
- The number of green revolving funds, a financing mechanism for clean energy projects, roughly quadrupled from 2008 to 2013, according to a database of such funds maintained by AASHE.[46]

The following case studies represent a small sampling of the campuses and college networks that have taken notable strides toward 100 percent clean energy.

With 25,000 Solar Panels, Butte College in California Is First Campus to Become "Grid Positive"

With the installation of more than 25,000 solar panels, Butte College became the nation's first college campus to become "grid positive," meaning that the college was able to generate more electricity than it uszed. Credit: Butte College

Butte College is a community college located on a beautiful campus of open spaces and grassy hills about 130 miles northeast of San Francisco. When the school was being developed in the early 1970s, its campus was designated a wildlife refuge to protect the wide variety of habitats and wildlife located there.

Perhaps encouraged by its beautiful natural setting, Butte College has long demonstrated a commitment to environmental sustainability. The school recycles more than three quarters of the waste that it creates and operates as its own self-contained city with an internally operated water and sewage system.[47]

In 2011, after years of planning and construction, Butte College became the nation's first college campus to become "grid positive," meaning that the college was able to generate more electricity than it used. It accomplished this with 25,000 solar panels that were installed over three construction phases beginning in 2005. The final and largest phase of the project was funded in part by Clean Renewable Energy Bonds, which are low-interest loans that were made available through the American Recovery and Reinvestment Act.

Butte College was able to accomplish this using one of the advantages held by many college campuses: a built environment that is perfect for clean energy projects.[48] Butte College's solar panels are built on rooftops, in open fields and on parking lot canopies and shade structures.

Today, Butte College's green power use averts carbon dioxide emissions equivalent to those produced by more than 1,000 passenger vehicles.[49] 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.[50] And as quoted on the Butte College website, Mike Miller, Butte College Director of Facilities, Planning and Management, said: "This project directly employs local people, local vendors and provides a huge economic shot in the arm for Butte County. This is a sustainable project for everyone and saves money for taxpayers. All of Butte College's solar projects are projected to save the college over $100 million net over 30 years."

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

University of Delaware's wind turbine generates enough electricity to power the six buildings at the Lewes campus over the course of a year, with enough electricity left over to power approximately 108 homes in the city of Lewes. Credit: University of Delaware

The East Coast of the United States has immense potential to obtain clean energy from the winds blowing along and off its shores. Today, the University of Delaware campus in the coastal city of Lewes is tapping into that energy with a wind turbine that towers 256 feet over its campus, with 144-foot long blades.[51]

Built in 2010, the wind turbine showcases the enormous power generation possible with modern wind technology, producing enough electricity to power the six buildings at the Lewes campus over the course of a year, with enough energy left over to power approximately 108 homes in the city of Lewes.[52] Since it began operation, the turbine has averted approximately 3,500 metric tons of carbon pollution each year, equivalent to taking nearly 750 passenger vehicles off the road.[53]

The University of Delaware has a long history of being at the forefront of clean energy innovation; in 1972, the school's Institute of Energy Conversion became the world's first lab dedicated to photovoltaic research and development.[54] Keeping with its history, a primary mission of the wind turbine project is to create research and educational opportunities, particularly for students at the College of Earth, Ocean, and Environment, and the College of Engineering.

To date, university 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.[55] One study resulted in the development of software called Bat Shield, which allows for modification of turbine operation to protect bats during migration season.[56]

Clean Energy Procurement and Efficiency Efforts Push Georgetown to 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.

According to the Environmental Protection Agency's Green Power Partnership program, which tracks and rewards the use of clean energy by businesses, universities and other institutions, Georgetown bought green power credits equivalent to 129 percent of its electricity use in the year ending in July 2016 (the EPA defines green power as "electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources").[57] By exceeding 100 percent green power, Georgetown supports clean electricity both on and off campus.

Georgetown's renewable electricity comes primarily from the purchase of renewable energy certificates (RECs), which are a tradable certificates representing the environmental benefits of one megawatt of renewable electricity. To maximize the effectiveness of these RECs in driving renewable energy adoption, Georgetown purchases RECs that have been certified by the company Green-e as bringing environmental benefits.[58]

Clean energy adoption at Georgetown goes beyond REC purchases and includes extensive efficiency and conservation efforts, as well as on-site clean energy where feasible.[59] These include a commitment to achieving LEED Silver certification or higher for all new building construction, conducting building energy audits, investing in energy efficiency retrofits in buildings, and engaging students through programs like the "Switch It Off Challenge," an energy-saving competition among residence halls.[60] 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.[61] As of 2013, Georgetown also generates solar energy at its own on-campus installation. A collaboration between students and faculty resulted in the installation of solar photovoltaic panels across the rooftops of six historic townhouses.[62]

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

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

Allegheny College's renovation of Carr Hall made the building 23 percent more efficient through improvements such as better heat recovery and energy-efficient lighting. Photo credit: Courtesy of Allegheny College

America has vast potential to do more with less energy. Eliminating waste saves money, making energy efficiency measures the cheapest way to meet many energy needs. Many energy efficiency solutions are available today and can be deployed quickly. For these reasons, experts often call efficiency the "first resource."

One school that has been successful in reducing energy use in recent years is Allegheny College, a small liberal arts school in northwestern Pennsylvania, located 30 miles from Lake Erie. In particular, Allegheny College has focused on reducing energy used in its buildings. 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 (energy intensity is the energy used per square foot of building floor space).

Students have played a leading role in helping the school reduce energy consumption. For example, 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.[63] 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.[64] After the project was completed, the benefits of the geothermal system convinced university officials to include similar systems in two additional campus buildings.[65]

Since undertaking the "Better Building Challenge," Allegheny College has improved building efficiency over its entire campus; to date, at least 17 buildings on campus have reduced energy intensity by more than 10 percent.[66] 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.[67] Through 2017, efficiency improvements across campus have reduced energy intensity for all of Allegheny College buildings by 14 percent.[68]

Allegheny College's efficiency efforts are part of a larger campus-wide effort to increase sustainability as part of the school's commitment to achieve carbon neutrality as a signatory to the Climate Leadership Commitments. As of January 1, 2011, Allegheny College purchased enough wind renewable energy credits (RECs) to cover all of its electricity use, effectively meaning that the school is powered by 100 percent wind energy.[69]

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

Ball State replaced coal-fired boilers with one of the nation's largest geothermal energy systems, which today provides heating and cooling to more than 5 million square feet of space in 47 buildings. Credit: Courtesy of Ball State University

Heating a large college campus requires a large amount of energy, which typically involves burning polluting fossil fuels.

At Ball State, a public university in Indiana with more than 20,000 students, heating historically came from four coal-fired boilers. Installed in the early 1940s, each year these boilers burned around 36,000 tons of coal, emitting 85,000 tons of carbon dioxide pollution along with 1,400 tons of sulfur dioxide, which causes acid rain, and 200 tons of particulate matter, which can cause respiratory problems.[70]

Today, those boilers have been shut down.[71] In their place is one of the nation's largest geothermal energy systems, which began operation in 2012. The system runs water through pipes traveling underground, installed by drilling 3,600 boreholes around campus.[72] The stable temperature underground heats water in the winter, or acts as a heat sink in the summer to provide cooling. The system provides heating and cooling to more than 5 million square feet of space in 47 buildings.[73]

To pay for the initial phase of the project, Ball State used $40 million in funds that had been designated to pay for replacement boilers, along with $5 million in federal stimulus grants made available through the American Recovery and Reinvestment Act.[74] Later phases of the project were paid for in part through savings generated by the first completed section of the geothermal system.[75]

The geothermal system has brought benefits to the school and community beyond reduced pollution and improved air quality. The project saves the school an estimated $2 million in operating costs each year, while the first two phases of the project created 2,300 direct and indirect jobs.[76] The geothermal system has also brought positive attention to the school, including through news reports and recognition in the *Princeton Review's* guide to green colleges.[77]

To Reduce Transportation Emissions, University of Louisville Embraces Bicycles

University of Louisville is working to reduce transportation emissions by encouraging bicycling, through initiatives including its Earn-a-Bike voucher program, and the installation of bike-friendly amenities across campus. Photo credit: Courtesy of University of Louisville

In order to achieve 100 percent renewable energy, college campuses must address energy used for transportation. In 2016, transportation surpassed electricity generation as the leading source of global warming pollution in the United States; cars and other passenger vehicles used for everyday travel were responsible for the majority of transportation emissions.[78]

For college transportation, fossil fuel emissions can come from services provided through the university, like buses and employee travel, and from students and other private travelers getting to and from campus. Many strategies exist for reducing these emissions, including transitioning to electric vehicles, expanding public transportation, and encouraging walking and biking.

Biking in particular is an ideal fit for many college campuses, where travel distances are short and students may struggle to afford owning a car. The University of Louisville made bikes a centerpiece of its efforts to reduce reliance on fossil fuels after signing the Second Nature Climate Leadership Commitment

in 2008, with a pledge to achieve carbon neutrality by 2050.[79] Research conducted while creating a Climate Action Plan revealed that 18 percent of campus emissions were the result of commuting.[80] The high transportation emissions were a result of car dependence: 79 percent of employees and 65 percent of students were driving to campus alone.[81]

To encourage students and faculty to give up their cars, in 2012 the University of Louisville launched Earn-a-Bike, a program in which students sign up to receive a $400 voucher toward local bike shops, in exchange for forgoing their right to a vehicle parking permit for the following two years.[82] The voucher program immediately proved popular, with hundreds of students applying for the program in each of its first five years. Commuter polls conducted before and after the program (in 2010 and 2015) found that the percentage of students who commute primarily by bike has nearly doubled from 4.1 percent to 7.9 percent.[83] The program was also widely covered in media reports, while similar programs spread to other campuses across the country, including the University of Kentucky.

A key to the program's success was the larger commitment the university made to biking alongside its voucher program. The school used funds committed to achieving its Climate Action Plan to install more than 600 new bike racks, bike fix-it stations containing tools and tire air pumps, bike lanes, and even a campus bikeshare program.[84]

Since launching its bike voucher program, the University of Louisville has expanded its commitment to reduce transportation emissions 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 consider a variety of transportation options, including buses and carpools.[85]

College Efforts to Promote Conservation Save Energy, Reduce Emissions

College administrations have powerful lines of communication with their students and faculty. They can place signs and posters around campus, send mass email alerts, post announcements in campus newspapers, and maintain contact with students through faculty and student leaders both in class and in residence halls.

These lines of communication can be used for running effective initiatives to reduce energy use. Such initiatives are not only relatively cheap and easy to implement, they can also foster long-term awareness of energy use and the climate impacts of energy consumption among students and faculty. Recent initiatives include:

- The State University of New York at Albany runs an annual 10-week long competition among residence halls to reduce energy use.[86] Energy use is monitored throughout the competition and after its completion the winner is announced. The university also publicizes how money saved through the competition is put to use; in 2010, the Office of Sustainability announced it was starting a bike share system with the savings.[87] In 2015, the competition resulted in a 14 percent reduction in energy use by residence halls, with the winning apartment building reducing its energy use by 32 percent.[88]

- Cornell University's "Think Big, Live Green" campaign aims to "build a culture of conservation at Cornell" through a variety of social and educational initiatives, with the goal of reducing campus electric use by 1 percent each year.[89] A "Cornell Building Dashboard" provides real-time data on building energy use allowing dormitories

to set goals. The campaign's "College Engagement Program" offers energy conservation posters for placing around campus. Another program uses a point system to certify "Green Offices" around campus for offices that register and complete a sustainability checklist.

- At Harvard, research laboratories account for 44 percent of energy use while accounting for only 20 percent of space.[90] Harvard University's Green Labs Program works with students, staff and faculty to reduce energy use and has launched a variety of sustainability initiatives including a competition to reduce energy use from fume hoods (winners are awarded the chance at a pizza party), and the distribution of strategies for reducing energy use from freezers.

Ensuring the Benefits of Off-Campus Renewable Energy Procurement

On-campus clean energy installations deliver obvious benefits to the environment by offsetting dirty energy the college would otherwise need to generate or purchase. For clean energy procured off campus, however, environmental benefits are not a given, and can be more complicated to assess. This is particularly true for renewable energy certificate (REC) purchases. A REC is a tradeable commodity that represents the environmental benefit of generating one megawatt-hour of renewable electricity.

In principle, RECs constitute an investment in renewable energy. However, the true environmental impact of a REC purchase is dependent on a number of factors, including the geographical area, vintage and broker the REC is purchased from, the type of renewable energy generation the REC represents, and how the REC is counted. Under the right circumstances, RECs can provide important financing that helps clean energy projects move forward; some REC brokers also reinvest profits in new clean energy projects. Other RECs have more ambiguous benefits. Improperly tracked RECs may be counted twice – once as a green energy purchase, and once by a utility to meet a renewable energy compliance obligation.[91] Some RECs may represent electricity generated by aging facilities with limited ability to spark new projects. And RECs purchased from states where renewable energy development is driven primarily by favorable economics may not effectively encourage new development.

Fortunately, a number of resources exist for universities to retain their own RECs and also effectively procure off-campus renewable energy. For example, the company Green-e certifies that RECs are not double counted and come from projects built within the last 15 years, among other criteria. Despite the challenges in ensuring the benefits of off-campus procurement, higher education institutions can use careful screening to ensure that their investments spark new renewable energy development.

Recommendations

Institutions of higher education have long played a leading role in bringing technological changes to society. That role is now critically important as the world works to prevent the worst impacts of global warming.

By deploying clean energy, colleges and universities can bolster learning and research, drive innovation, attract new students, and save money – all while setting an example for the nation and reducing their own environmental impact. Therefore, colleges and universities should become active and ambitious actors in the deployment of clean energy; to do so effectively, they should:

- Set ambitious and transparent clean energy goals. Colleges should commit to supplying 100 percent of their energy from clean, renewable sources like wind, solar and geothermal, and to reduce overall energy use by increasing efficiency. Commitments to clean energy should account for all energy uses, including electricity, transportation and heating and cooling, and colleges should put systems in place to ensure that energy use for all activities is measured and reported.
- Where appropriate, deploy clean energy on-site. Colleges with the ability to do so should take advantage of suitable open space on campus, including rooftops, vacant lots and parking lot canopies, to install clean energy on campus. On-campus installations can be the fastest ways to expand clean energy capacity while also increasing reliability and resilience. For colleges with less available sites or larger electrical loads, there are a variety of options for adopting clean energy without installing on-campus systems, including purchasing verified renewable energy credits, building clean energy systems offsite, and entering power purchase agreements for energy from offsite locations.
- Get energy from truly clean, renewable sources. Not all renewable energy sources have an equal benefit for the environment. Some forms of biomass and hydroelectric power, for example, can create environmental problems. Colleges should get their energy from sources that are virtually pollution-free, inexhaustible, safe and efficient. Solar, wind and geothermal energy generally meet these criteria, as do energy efficiency measures.
- Share data and lessons. With the ability to develop new technology, and to adopt 100 percent clean energy faster than other segments of society, campuses can supply critical information for helping to bring clean energy to the nation as a whole. In addition to sharing data, colleges that develop clean energy expertise can provide direct technical assistance and advice to their communities.
- Engage students in the deployment of clean energy. Colleges deploying clean energy technology should take advantage of the unique opportunities for engaging students in the process, from developing technology, to conducting economic and environmental analyses, to learning how to install, maintain and operate the equipment.

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