Sustainability Actions in Higher Education

Campuses across the country are committing to sustainability, including reducing their greenhouse gas footprint and supporting renewable energy (RE). Universities are already making progress: From 2007 to 2015, universities decreased their energy consumption by 8% per square foot and reduced their carbon emissions from energy consumption by 14% (Sightlines and UNH 2016).

This brochure details common sustainability actions taken by universities to reduce their energy consumption. Some of the most common actions include energy efficiency (existing building commissioning; lighting; heating, ventilation, and air conditioning [HVAC] upgrades; plug loads) and RE (on-site or off-site solar deployment, RE procurement).[1] We focus on the costs and benefits of energy efficiency measures and RE through the brochure while highlighting resources where readers can find more information.

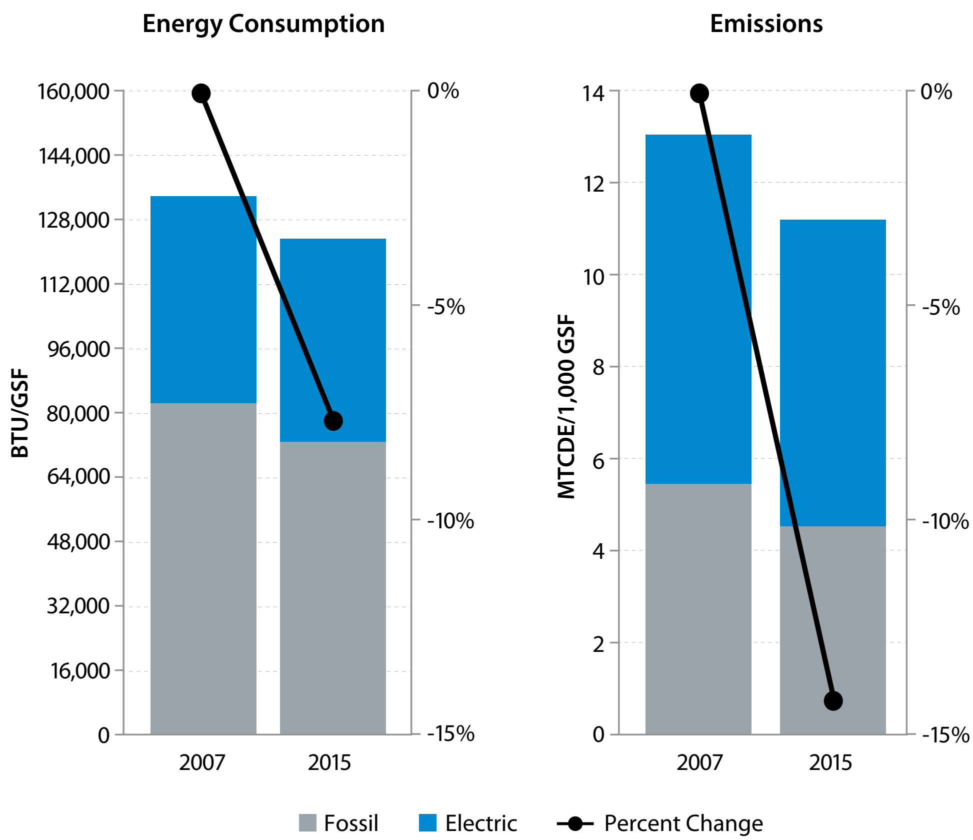

Figure 1. Decreased energy consumption (left) and greenhouse gas emissions (right) at universities (2015). *Source: Sightline and UNH (2016)*

Energy Efficiency Measures

Energy efficiency measures (EEMs) provide multiple economic and environmental benefits in higher education buildings. Often, these are the first actions that a campus takes to meet their sustainability goals. The following cost-effective EEMs are most applicable to classrooms, offices, and libraries present on university campuses.

Existing Building Commissioning

Improving building operations and maintenance processes can often lead to substantial energy savings. This process is commonly known as existing building commissioning (EBCx).[2] A Lawrence Berkeley National Laboratory study found that EBCx measures resulted in 22% energy savings in offices and 11% energy savings in educational facilities with average simple payback periods of 1.1 and 1.5 years, respectively (Mills 2009).

1. This action list was compiled by evaluating climate action plans of 15 universities in different geographical areas.
2. For more information on this process, please refer to NREL (2013) and PNNL/PECI (2011).

Lighting, HVAC Systems, and Plug Loads

Table 1 describes commonly implemented EEMs for lighting, HVAC systems, and plug loads.[3] These measures have high energy savings potential, high cost-effectiveness, and use of off-the-shelf technology. These EEMs, combined with best practices for integrated design, procurement, controls, and monitoring, can considerably increase energy savings.[4]

Retrofit packages recommend a set of different EEMs that interact with each other to improve overall cost-effectiveness. The packages result in higher energy savings and lower payback periods than for individual measures.[5] The energy savings from retrofit packages are not necessarily a sum of the individual measures. While using these retrofit packages, potential synergies between a mix of measures can improve their total cost-effectiveness.

Renewable Energy

To meet their sustainability goals, campuses are finding that they need to implement energy efficiency measures but also begin procuring RE. The use of renewables at universities increased by 4% from 2007 to 2012 (Sightlines and UNH 2016). As of 2015, universities have installed approximately 306 megawatts (MW) of solar photovoltaic (PV) capacity.[6] According to a study by the National Renewable Energy Laboratory (NREL), if all universities in the country deploy distributed PV to meet 25% of their annual electricity consumption, the total technical potential of university campuses in the country would be over 50 times the amount of PV deployed on campuses today. In this section, we provide an overview of solar costs and benefits.

Table 1. Energy and Cost Savings of Cost-Effective EEMs Applicable for Higher Education Facilities

System	Measure Description	Savings as Percentage of Total Site Usage (%)[a]	Simple Payback Period (Years)
Lighting	Install lower-wattage, high-efficiency lighting such as compact fluorescent lamps, light-emitting diodes (LEDs), and electronic ballasts.	0.3–8.9	0.4–11.8
	Install automatic demand-based controls such as occupancy sensors (motion or aural signal response) to reduce unwanted or unnecessary lighting use.	0.6–2.6	0.5–11
	Install more efficient exterior lighting lamps and add exterior lighting sensors and controls.	0.5–2.5	3.1–16
HVAC	Install variable speed drives on pumps of hydronic systems.	- 0.2–1.2	0.7–4.1
	Widen the temperature between the zone heating and cooling temperature setpoints.	6.6–10.6	4–11
Plug Loads	Replace appliances with ENERGY STAR® models.[b]	0.5–1.0	7.2–25.5
	Add advanced on/off control of office equipment.	1.2–2.2	12–19

a. Values presented in the table are total savings from the reference building baseline usage.

b. EPA has developed savings calculators that universities can use to assess the life cycle and annual costs and savings of ENERGY-STAR-labeled products, available at *https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/save-energy/purchase-energy-saving-products*. ENERGY STAR models of office equipment such as laptops, desktops, printers, and copiers have an immediate payback period while producing savings between 15% and 72%.

Data sources: PNNL/PECI (2011); NREL (2013)

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3. The estimated cost and energy savings for individual EEMs in Table 1 are based on results of building energy simulations (for different building types) in five climate zones for each EEM. The cost of individual measures can vary greatly depending on the age and condition of the equipment and building, cost structure, financing terms, tax incentives, local weather conditions, and work involved in implementing the measures.

4. For case studies on universities implementing EEMs, please refer to BTO (2013); Mercado, Parrish, and Regnier (2013); and Regnier, Harding, and Robinson (2015).

5. The energy savings from standard retrofit-recommended packages for offices and schools can be estimated as 22%–43% with a payback time period of 2–7 years.

6. These numbers are based on self-reported data from universities on installed PV systems as reported to the Association for Advancement of Sustainability in Higher Education (AASHE) and Second Nature (Holm and Chernyakhovskiy 2016).

Solar Costs

Many campuses may not realize that installed solar costs are declining rapidly. Installed costs for commercial solar PV have declined by over 59% from 2009 to 2016 (Figure 2).[7] NREL benchmarks 2016 installed costs for commercial solar PV at $2.13/W$_{dc}$.[8] Figure 3 shows the cost variation of commercial solar PV by system size (10 kW to 2 MW) and by state.[9] Installed cost of community solar is $2–$2.5/W$_{dc}$ (EERE 2016).

Other costs such as **fixed operations and maintenance (O&M) costs** affect the levelized cost of electricity (LCOE) from solar PV systems ($/kWh) but not the installed cost ($/W). Solar PV O&M costs are small compared to the installation cost and are approximately $14/kW-yr to $19/kW-yr, or 1% of system initial cost per year for PV systems sized 10 kW to 10 MW (NREL 2016a, 2016b; NREL/Sandia/Sunspec Alliance 2016). These costs vary with location, climate, system size, plant architecture, ease of site access, and other factors. Variable O&M costs for solar are negligible. Solar PV systems are eligible for federal, state, and utility **financial incentives** such as grants, rebates, loans, tax incentives, and performance-based incentives.[10]

Solar Procurement

Universities can procure solar energy in two ways: by deploying solar energy systems on-site or off-site or by purchasing renewable electricity.

On-campus or off-campus solar energy deployment: Universities primarily use three financing mechanisms to finance solar on campus or off campus. These include power purchase agreements (PPAs), institution-owned business models, and leases.[11]

Mechanisms to purchase green power: Universities can purchase electricity generated from RE sources to achieve their sustainability goals. In this case, the university procures environmental attributes of renewable electricity—or renewable energy certificates (RECs)—which may or may not be bundled with the purchase of the underlying electricity. Figure 4 and Table 2 detail common mechanisms used to purchase renewable electricity.[12]

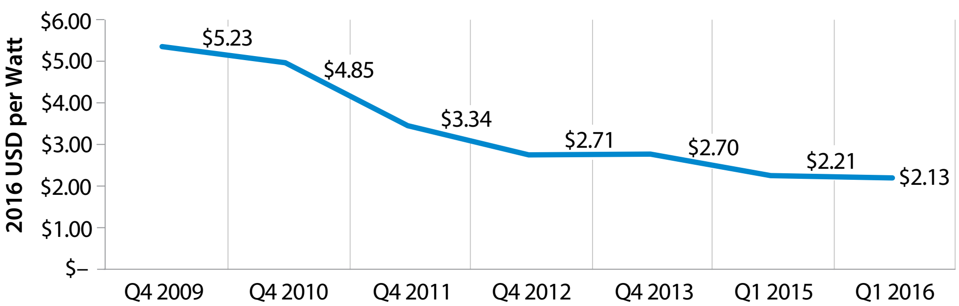

Figure 2. Historical commercial solar PV installed costs (2009–2016). *Source: Fu et al. (2016)*

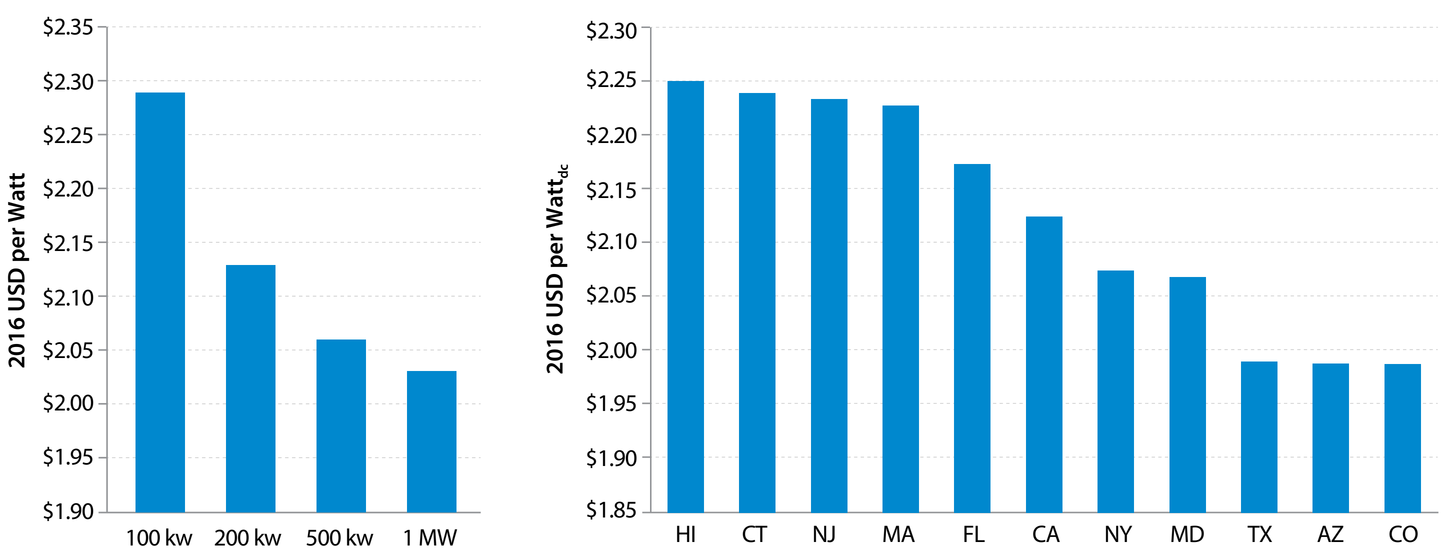

Figure 3. Commercial solar PV system installed cost by system size (left) and by state (right) (2016). *Source: Fu et al. (2016)*

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7. In the context of this report, commercial solar PV is defined as solar PV systems with a generation capacity between 10 kW and 2 MW (Fu et al. 2016).

8. These costs are calculated using a bottom-up methodology, accounting for all system and project development costs incurred during the installation (Fu et al. 2016).

9. For more information on solar costs, see SEIA/GTM (2017) and Barbose and Darghouth (2016).

10. For details on state solar policies on interconnection standards, net metering, user fees, financial incentives, and third-party ownership policies, see Tian et al. (2016).

11. For more information on solar deployment at universities using PPA financing models and non-PPA financing models, please see NREL (2016c) and NREL (2016d), respectively.

12. For details on these mechanisms, please see O'Shaughnessy, Liu, and Heeter (2016). The resources procured in these mechanisms include wind, landfill gas, biomass, and hydro along with solar.

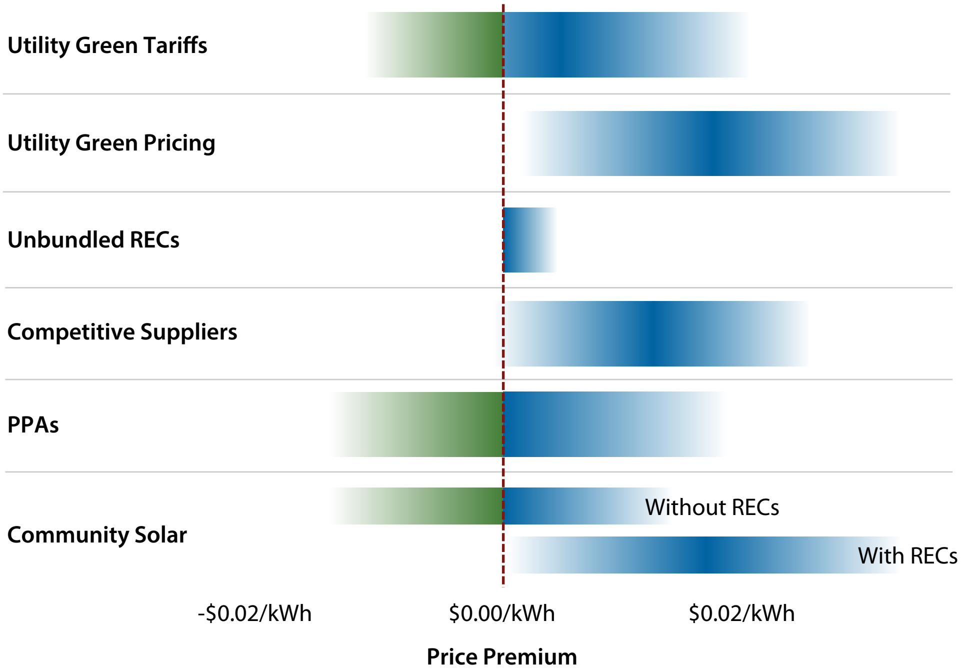

Figure 4. Green power price premium

The figure shows green power pricing premiums relative to the incumbent utility rate as per existing market trends. Some green power products can be cheaper than existing utility rates.

Table 2. Green Power Purchasing Mechanisms for Universities

Mechanism	Description	Pricing
Utility green tariffs (regulated utility markets)	Universities can procure energy and RECs from a particular RE source and project through their utility (under a PPA) by paying a modified green tariff rate.	Can be cost-competitive with standard electricity supply, depending on the cost of the renewables and the credit mechanisms.
Utility green pricing programs (regulated utility markets)	Green pricing programs allow customers to pay a premium to procure renewable electricity. The customers own the RECs and pay the utility for them.	Most utility green pricing premiums are in the range of 1¢–2¢/kWh (O'Shaughnessy, Liu, and Heeter 2016).
Unbundled REC markets	Universities can purchase unbundled RECs (separated from the underlying electricity) from the unbundled REC markets.	Voluntary REC prices in 2016 ranged from 0.03¢/kWh to 0.04¢/kWh.
Competitive suppliers (deregulated markets)	Customers can buy renewable electricity by switching from their utility to competitive suppliers offering RE products or by purchasing RE products offered by their current provider.	No comprehensive data set exists on green power pricing of competitive suppliers. Some deregulated states have a database of product offers, including RE offers.[a]
PPAs	Customers procure green power at a negotiated PPA rate through a long-term contract with an on-site or off-site RE provider.	Average PPA rates vary geographically between 9¢/kWh and 13¢/kWh for system sizes 100 kW-5 MW.[b]
Community solar	A utility or third-party project developer develops a solar project and sells the output (capacity purchases [$/kW] or PPA [$/kWh]) to multiple subscribers.	Community solar LCOE is estimated to be 6.2¢–10.8¢/kWh.[c] Bill credits for customers of community solar projects can vary between 4¢/kWh and 30¢/kWh.[d] Some projects offer a 4%–10% discount to the consumer's electricity bill.[e] Prices are dependent on utility type, contract type, term length, geography, and system capacity, among other factors.

a. See, for example, Illinois (*https://www.pluginillinois.org/*), New York (*http://www.newyorkpowertochoose.com/*), Ohio (*http://www.energychoice.ohio.gov/*), Pennsylvania (*http://www.papowerswitch.com/*), and Texas (*http://www.powertochoose.org/*).

b. This range of PPA rates is based on regional PPA rates calculated for the West (11¢/kWh), Midwest (13¢/kWh), Northeast (13¢/kWh), and South (9¢/kWh). The regional estimates are based on non-weighted state averages. The data are a representative sample sourced from Mercatus (NREL 2016c).

c. Assumptions in calculating LCOE: capital cost as $2,000–$2,800/kW; fixed O&M as $12–$16/kW; capacity factor as 20%–25%; facility life as 30 years; investment tax credit as 30% (Lazard 2016).

d. These estimates are based on bill credits offered by programs in Massachusetts, Colorado, Minnesota, and California. For more information, please refer to GTM (2017).

e. This estimate is based on savings offered by nine projects in the community solar marketplace (Energysage 2009).

Solar Benefits

On-site or off-site PV systems can realize energy and demand savings, which can offset installation costs for university-owned systems or result in net energy bill savings for leased or PPA systems. These savings are dependent on system size and net metering policies and rates (if a university exports electricity to the grid). A 2016 NREL study found that at universities, the average reduction of the electric bills per kilowatt-hour of PV electricity for the first year is 10¢/kWh.[13] Universities typically have large demand charges and may be able to reduce their demand charges by installing solar PV.[14] Further, solar PV PPAs help universities hedge against uncertain future energy costs.

Along with cost benefits, universities reduce their carbon emissions by deploying or procuring solar. GHG emissions reduced depend on PV system size, avoided electricity consumption, renewable electricity procured, and location of energy consumption. According to the World Resources Institute (WRI) guidance, two methodologies can be used for calculating Scope 2 emissions: a market-based method and a location-based method. The market-based method is based on the supplier- and product-specific emissions rates. In this method, each megawatt-hour of consumed electricity is multiplied by emissions factors associated with contractual instruments. The location-based method calculates the average emissions intensity of the grid where the energy consumption occurs. In this method, each megawatt-hour of consumed electricity is multiplied by the average grid emissions factor (Sotos 2015).

Existing Tools and Resources

Relevant Programs and Organizations

NREL's Solar Screenings and Implementation Assistance Program: Offers resources and no-cost technical assistance to universities deploying solar.

Better Buildings Alliance–Higher Education: Works toward improving energy efficiency in commercial buildings with a focus on higher education.

Green Power Partnership: A voluntary program that encourages organizations to use green power.

Association for the Advancement of Sustainability in Higher Education (AASHE): An organization working with higher education faculty, administrators, staff, and students to drive sustainability innovation.

Solar Project Design Assistance Tools

System Advisor Model (SAM): Tool calculating performance parameters and cost-of-energy estimates for grid-connected power projects based on costs and design default or user inputs.

PVWatts Calculator: Web-based tool estimating performance of a grid-connected roof- or ground-mounted PV system based on default inputs or user inputs.

State & Local Energy Data (SLED): Tool providing data on electric generation, fuel source quantity and costs, policies, and RE technical potential based on location inputs. It also provides relevant clean energy resources.

Policy Database

Database of State Incentives for Renewables & Efficiency (DSIRE): Comprehensive database of RE and energy efficiency incentives and policies in the United States.

Energy Efficiency Database

Commercial Buildings Resource Database: Resources to support the adoption of energy-saving building technologies.

13. Bird, Gagnon, and Heeter (2016) researched seven public and private universities of different sizes in the Midwest, West, and South census regions. They evaluated PV systems reducing the annual energy consumption at the university by 25%. The bill savings estimates are for the first year but not for the solar PV lifetime; therefore, it cannot be used alone to judge the value of a PPA.

14. Demand charges are based on the peak demand of a building. The study found that bill savings decrease as system size is increased. The initial increase in bill savings is due to demand charge reduction, after which the bill savings decrease.

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