NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL Screens Universities for Solar and Battery Storage Potential

In support of the U.S. Department of Energy's SunShot initiative, NREL provided solar photovoltaic (PV) screenings in 2016 and 2017 for universities seeking to go solar. Fifteen universities were selected for screenings based on campus solar and sustainability goals, plans for future solar projects and solar deployment capacity (megawatts), regional diversity, energy costs, and availability of campus energy data for the analysis.

NREL conducted an initial techno-economic assessment of PV and storage feasibility at the selected universities using the REopt model, an energy-planning platform that can be used to evaluate RE options, estimate costs, and suggest a mix of RE technologies to meet defined assumptions and constraints. NREL's analysis considered utility rates; RE resources; technology cost and performance; state, utility, and federal incentives; and economic parameters (discount rate, inflation rates).

Universities provided one year of 15-minute electric interval data and detailed utility rate tariffs including demand, transmission and energy charges, and time-of-use and seasonal cost considerations. NREL used this information along with resource information and other datasets.

NREL provided each university with customized results, including the cost-effectiveness of PV and storage, recommended system size, estimated capital cost to implement the technology, and estimated life cycle cost savings.

Photovoltaic and Storage Recommendations

NREL evaluated PV at all 15 universities and storage at five. PV appeared cost-effective at 10 of the 15 universities. Storage was cost-effective at all five universities where it was evaluated. The sites evaluated for storage were selected because of high demand charges and significant time-of-use rate components, and it should not be concluded that batteries are always cost-effective at universities. A high electricity rate was also a selection criteria; thus the rate of cost-effective PV projects may be higher for these 15 universities than in general.

PV projects recommended ranged from 19 kW to 16 MW; the total size recommended was 29.2 MW. Many of these projects were limited by the land and roof area suitable for RE projects. These projects would generate 42.3 GWh of renewable electricity. Storage projects recommended ranged from 11 kW:14 kWh to 0.58 MW:2.3 MWh. The total net present value, or savings over the 25-year analysis period, of all these projects is $8.1 million (compared to the $514 million total life cycle cost—see Table 1).

15 Universities Selected
Location; Energy Use

Beloit College
Beloit, WI; 8.9 GWh/year

Fairleigh Dickenson University
Hackensack, NJ; 24 GWh/year

Georgia Tech
Atlanta, GA; 316 GWh/year

Lake Superior College
Duluth, MN; 5 GWh/year

Lane Community College
Eugene, OR; 12 GWh/year

Luther College
Decorah, IA; 14 GWh/year

Northern Arizona University
Flagstaff, AZ; 64 GWh/year

Milwaukee Area Technical College
Milwaukee, WI; 29 GWh/year

South Central College
North Mankato, MN; 2.25 GWh/year

Thomas College
Waterville, ME; 2.9 GWh/year

Tuskegee University
Tuskegee, AL; 26 GWh/year

University of California—Riverside
Riverside, CA; 113 GWh/year

University of Colorado–Colorado Springs
Colorado Springs, CO; 23 GWh/year

University of Minnesota—Duluth
Duluth, MN; 40 GWh/year

Washington and Lee University
Lexington, VA; 16 GWh/year

Table 1. Summary Results for Round One of Solar PV + Storage Screenings

	Solar PV	Battery Storage
Universities Evaluated	15	5
Projects Recommended	10	5
Combined Project Size	29.2 MW	1.5 MW:4.9 MWh
Energy Generated	42.3 GWh	n/a
Base Case Life Cycle Cost	$514 million in electricity costs (life cycle cost of electricity over 25 years)	
Net Present Value (PV + Storage)	**$8.1 million in electricity cost savings** (savings achieved over 25 years by adding PV + storage)	

REopt Assessment in Action: Luther College

Luther College in Decorah, Iowa, installed a PV system last year, and is interested in installing additional PV at an area that can host up to 3 MW. They also want to consider a battery to lower demand charges and limit electricity export to the grid. The site's utility bill consists of an energy charge of about $0.05/kWh and a demand charge which varies based on season and time of day and ranges between $8–$23/kW.

NREL compared the business as usual case with two alternate scenarios where the university would install additional PV, or PV and batteries. When PV alone was evaluated, NREL found 3 MW of PV would reduce the life cycle cost of energy from $29.0 million to $27.1 million. The majority of annual savings is from reduced energy costs ($218,000 annual savings) though the PV would also lower the demand charges ($28,000 annual savings). When the combination of PV and battery storage was evaluated, NREL found 3 MW of PV along with a 0.58 MW:3.2 MWh battery would minimize the life cycle cost of energy. While the total energy savings in this case decreased slightly due to losses in the round trip efficiency of the battery ($195,000 savings compared to $218,000 in the PV-only scenario) the demand savings are significantly increased to $157,000 per year. This results in life cycle cost savings of $3.4 million (see Table 2).

Figure 1 shows how PV and storage are dispatched at Luther College during a week in February. The electric load is shown with a black line. This load is met in each time step by either the grid (light grey) PV (orange), or the battery (blue). The PV system charges the battery during hours when PV produces more energy than the site load (red). The battery meets the load in the evenings when the PV system is no longer generating electricity but the load is still high. Two different plateaus can be seen in the grid purchases, one slightly under 1,500 kW earlier in the day, and one slightly over 1,500 kW in the evening. The demand charges are higher during the middle of the day and lower in the evening; to optimize the total energy costs the model is dispatching the battery to push demand lower during the higher cost hours.

Table 2. Technology Comparison for Luther College

Technologies Evaluated	Business as Usual	Add PV	Add PV and Battery Storage
Additional PV Size	n/a	3 MW	3 MW
Battery Size	n/a	n/a	0.58 MW:3.2 MWh
Total Cost	n/a	$5.6 million	$7.8 million
Annual Energy Costs	$487,000	$269,000 ($218,000 savings)	$292,000 ($195,000 savings)
Annual Demand Costs	$679,000	$652,000 ($28,000 savings)	$522,000 ($157,000 savings)
Life Cycle Cost	$29.0 million	$27.1 million	$25.6 million
Net Present Value	n/a	$1.9 million	$3.4 million

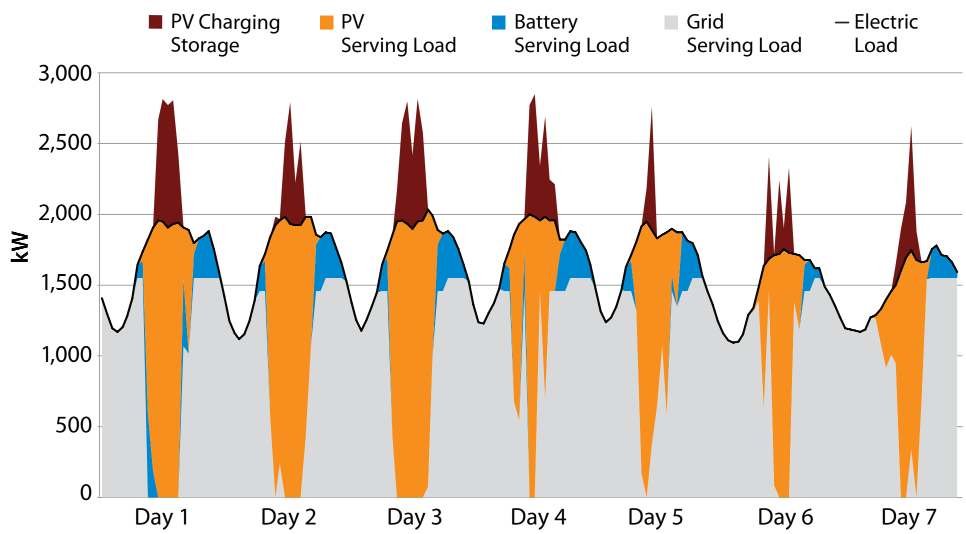

Figure 1. PV and storage reduce peak demand at Luther College during a week in February

Learn More

Find out more about how NREL supports DOE's SunShot initiative through no-cost technical assistance for universities seeking to go solar at *www.nrel.gov/technical-assistance/universities.html*.

For more information about NREL's REopt energy planning platform, visit *reopt.nrel.gov*, or contact us at *reopt@nrel.gov*.

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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

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