NYSERDA Case Study:

University at Buffalo

FINAL REPORT

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NYSERDA Case Study: The State University of New York at Buffalo (UB)

Key Findings

- The State University of New York at Buffalo (UB) has been recognized by multiple publications as a leader for its commitment to sustainability, mainly through its Climate Action Plan (CAP) which targets net-zero emissions by 2030. In 2021 the Times Higher Education Impact Rankings rated UB No. 1 in the world in addressing the United Nations Sustainable Development Goal pertaining to climate action, which instructs organizations to "take urgent action to combat climate change and its impacts."
  - NYSERDA has played a "catalyzing" role in helping UB to develop its CAP targets and plan actionable ways to achieve them, through funding studies and direct project activities.
- Nearly ten percent of UB's total electrical demand will be met by solar installations. The majority of this electricity comes from NYSERDA-supported solar arrays at Bizer Creek and Millersport, along with rooftop installations, which combined total nearly 10.1 MW of solar capacity and generate over 12.7 million kWh annually.
  - These projects will avoid emitting roughly 6,000 tons of CO_2 , 7,000 pounds of NOx, 1,500 pounds of PM2.5,and 1,600 pounds of SO_2 annually, resulting in health and environmental benefits across the State and region.
  - UB solar projects have resulted in roughly $15.1 million in regional economic impacts and created 125 jobs during construction. UB's solar projects will generate $215,000 in regional economic impacts annually, and create nearly three full-time equivalent (FTE) positions for the duration of these projects.
- Hundreds of students have been provided with experiential learning opportunities through UB's CAP activities, and by participating in the construction and promotion of UB's GRoW home, which generates more energy than it consumes.
  - Development of UB's CAP and relocation of the GRoW home from its original construction site in California to the UB campus were supported by NYSERDA.
- NYSERDA sponsored studies have enabled UB to aggressively pursue electrification on its south campus.

1 Background on UB's Sustainability Efforts and Their Partnership with NYSERDA

The University at Buffalo, State University of New York (hereafter "UB" or "University") is New York's flagship institution and its largest public research university with over 30,000 students and a campus spread across approximately 1,300 acres.[1] UB prides itself on its many accomplishments, including being among the top 30 US institutions in hosting international students (reported by Open Doors 2022 Report on International Educational Exchange), and its commitment to research, community service, and experiential learning. [2] In addition to these accomplishments, UB has been a leader in environmental stewardship and sustainability for fifty years dating back to the 1970s, when Ralph Nader celebrated the first Earth Day at UB, and the University established an Environmental Studies Center and Air Quality Program.[3] More recently, in 2020, the University updated its aggressive Climate Action Plan (CAP) with the goal of achieving net-zero emissions by 2030.[4] To reach this goal, UB developed its "10 in 10" roadmap, which includes "…10 innovative, engaging and digestible steps…to increase

[1] University at Buffalo. 2022a. Fast Facts. https://admissions.buffalo.edu/academics/about-ub.php. Accessed July.

[2] University at Buffalo 2022b. UB in Top 25 for international students. https://www.buffalo.edu/inclusion/UBMakingaDiff/AllStories.host.html/content/shared/university/news/ub-reporter-articles/stories/2022/11/open-doors.detail.html. Accessed March.

[3] University at Buffalo. 2022c. Our Timeline. https://www.buffalo.edu/sustainability/about-us/timeline.html. Accessed July.

4 University at Buffalo. 2022d. UB's 10 in 10. https://www.buffalo.edu/climate-action/10-solutions.html. Accessed July.

climate action throughout the university and put [UB] on a path to net zero emissions by 2030."[5] In recognition of its leadership in the area of climate change, the 2021 Times Higher Education Impact Rankings ranked UB No. 1 in the world in addressing the United Nations (UN) Sustainable Development Goal pertaining to climate action, which instructs organizations to "take urgent action to combat climate change and its impacts." [6, 7]

For close to three decades, UB's commitment to sustainability has been supported by its partnership with NYSERDA who has provided several million dollars in funding to the University across nearly 100 projects. Of these, roughly 30 projects were funded in the last five years. These projects have included direct investments in building and infrastructure improvements, funding for feasibility and other technical studies, process evaluations, tech to market studies, and technology-focused research projects. NYSERDA's largest single investment to date was a $1 million grant awarded in 2017 through the Energy to Lead (ETL) program, which allowed UB to pursue an ambitious effort to develop opportunities for new solar projects both onsite at UB and with other local public entities in the greater Buffalo region (hereafter referred to as "the solar project"). At UB, the solar project ultimately generated 12 MWh of new solar energy on UB's campus. In addition to creating renewable energy jobs, the solar project will help advance UB's climate neutrality efforts, including reaching net neutrality by 2030.

To quantify the clean energy and sustainability milestones that UB has achieved and has planned for the future, and to evaluate NYSERDA's impact on UB's achievements, the evaluation team conducted this case study. The remainder of this report provides an overview of the methodology used and summarizes the case study findings, highlighting the benefits that these projects have brought to UB students, faculty and staff, the local community, and the broader region and State.

2 Methodology

The evaluation team engaged with NYSERDA staff in preliminary conversations to understand NYSERDA's 30-plus year relationship with UB in supporting its clean energy projects. This included a review of NYSERDA-funded/assisted projects at UB, and meeting with NYSERDA staff who worked directly with the University. Six in-depth interviews were then conducted with UB faculty and staff, and other stakeholders engaged with UB, including interviews with staff at Erie County, a regional solar developer, and a former NYSERDA staff member who worked closely with UB. The evaluation team also conducted a literature review to better understand UB's recent achievements in sustainability, including reviewing materials provided by interview participants, UB, and NYSERDA staff, and articles found through a broader search of publications highlighting UB's achievements.

3 Benefits of UB Projects

The benefits examined as part of the case study are shown in Table 1 and include energy, environmental, economic, educational/awareness, and replication benefits.

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[5] University at Buffalo. 2022d.

[6] Hill, D. 2021. UB's climate action efforts rank No. 1 in the world in THE Impact Rankings. https://www.buffalo.edu/news/releases/2021/04/017.html. Apr. 22.

[7] United Nations. 2022. Sustainable Development Goals: The 17 Goals. https://sdgs.un.org/goals. Accessed Dec.

TABLE 1. BENEFITS OF UB PROJECTS

Category	General Benefit	Who Benefits
Energy	Clean energy capacity	Society
	Clean energy generation	UB, Society
	Avoided fuel consumption	UB students and staff, regional partners, society
Environmental	GHG emissions avoided and associated health and environmental Benefits	Society
	Criteria emissions reductions and associated health and environmental benefits	Region
Economic	Public/private investment	UB, Solar Developer
	Jobs	Region
	Regional economic benefits	Region
	Cost-savings/efficiency	UB students and staff, regional partners
Educational/ Awareness Benefits	Experiential learning from the UB solar projects	UB students, campus visitors
	Increased educational opportunities created by the GRoW home	UB students, potential UB students, regional population
	Awards/Recognition	UB students, potential UB students, regional partners
	Increased awareness of UB's carbon footprint and engagement in climate change activities	UB students, potential UB students, local community, other universities
Replication	RFP design consistency/ Planning Replication	UB students and staff, regional partners
	Project(s) completed at UB serve as a model for other educational institutions	Other NYS and national colleges and universities, society

These benefits are discussed in detail below.

3.1 Energy

NYSERDA provided support for UB to redesign their CAP, which included developing a roadmap for reaching the University's aggressive target of achieving net-zero emissions by 2030. According to UB staff, NYSERDA's funding and technical support were instrumental in developing UB's new plan. The new CAP replaced a 2009 plan that was underutilized, underfunded and lacked a clear communications strategy. "In terms of climate, it is not a coincidence we have a succinct strategy and many ongoing initiatives, and NYSERDA is our number one partner in that. They play a catalyzing role," stated a member of UB's Sustainability Office. "[Prior to NYSERDA's support] there was no way to take the tasks of the [previous] climate action plan and turn them into actionable items," explained another UB staff.

The development and implementation of the current CAP involved a number of NYSERDA-assisted projects that have helped UB to lower its energy use and carbon footprint, and will provide additional energy benefits into the future. The projects include:

- Three large, ground-mounted solar arrays [Millersport (often referred to as the Solar Stroll), Creekside, and Bizer Creek];[8]
- Four rooftop solar projects;
- An electrification study, that is expected to increase efficiency and lead to a large-scale effort to transition the heating to clean and renewable sources of all 46 buildings and 2.8 million square feet of space on UB's South campus; and;[9]
- The GRoW Clean Energy Center, a net energy-positive, 1,100 square foot demonstration home that serves as a clean energy center for the UB campus, providing experiential learning opportunities for students and the public[10]. The GRoW Clean Energy Center was designed by UB students and faculty and entered in the U.S. Department of Energy's 2015 Solar Decathlon competition where it came in second overall (and relocated to the UB campus in 2021).

3.1.1 Clean Energy Capacity and Generation

NYSERDA ETL and NYSERDA's REV Campus Challenge (now the Clean Green Campuses initiative) directly assisted UB with all of its new ground-mounted arrays and rooftop solar projects. Combined, these NYSERDA-assisted projects account for 10.1 MW of capacity and are expected to generate over 12.7 million kWh/year, giving UB the largest solar capacity of any institution within the SUNY system at the time of this writing.[11] Altogether, UB's solar projects have the capability to generate roughly 18 million kWh/yr.[12]

Table 2 shows the system capacities and generation for these projects, which were all connected to the grid by December 2022. At the time of this writing, the Solar Stroll and Bizer Creek rank among the

[8] For more information on these installations, see: https://www.buffalo.edu/sustainability/news/latest-news.host.html/content/shared/www/sustainability/articles/news-articles/UB-Advances-Clean-Energy-Commitment-Solar-Arrays.detail.html

[9] UB is also in the process of applying for funding to conduct an electrification study of its North Campus. Electrification work supported by NYSERDA has also assisted with the installation of a number of EV chargers on UB's campus.

[10] Net energy-positive represents a building that produces more energy than it consumes on an annual basis.

[11] SUNY Albany has the next largest array at 1.9 MW. See: Solar Liberty. 2022. University at Albany Announces Completion of Largest Rooftop Solar Array in State University of New York System. https://solarliberty.com/university-at-albany-announces-completion-of-largest-rooftop-solar-array-in-state-university-of-new-york-system/. May.

[12] This total includes roughly 5.3 million kWh/yr from non-NYSERDA assisted projects.

largest solar projects in the State in terms of capacity, along with being parts of one of the largest on-campus solar initiatives in the Country.[13, 14]

In addition to energy and environmental benefits, the accessibility of the arrays provide learning opportunities for UB students, faculty, and the community. This benefit is discussed further in the **Education/Awareness Benefits** Section below.

TABLE 2. SYSTEM SIZE (MW) AND ANNUAL KWH PRODUCED FOR NYSERDA-ASSISTED UB SOLAR PROJECTS

Solar Project	System Size (MW)[1]	Annual kWh Produced[2]
Arrays		
Solar Stroll	6.5	8,297,796
Bizer Creek	1.8	2,193,485
Creekside	0.6	732,000
Rooftop Solar		
Helm	0.4	462,000
Beane	0.4	487,000
Center for Arts	0.4	452,000
Baird Hall	0.1	89,000
Total Impacts[3]	**10.1**	**12,713,281**

1. System Size (MW) are reported as Final DC Capacities (MW).
2. Solar Stroll, Bizer Creek, and Creekside annual kWh produced are calculated as the average across the 25-year expected project lifespan.
3. Totals may not sum due to rounding.

3.1.2 Clean Energy Generation and Avoided Energy Use

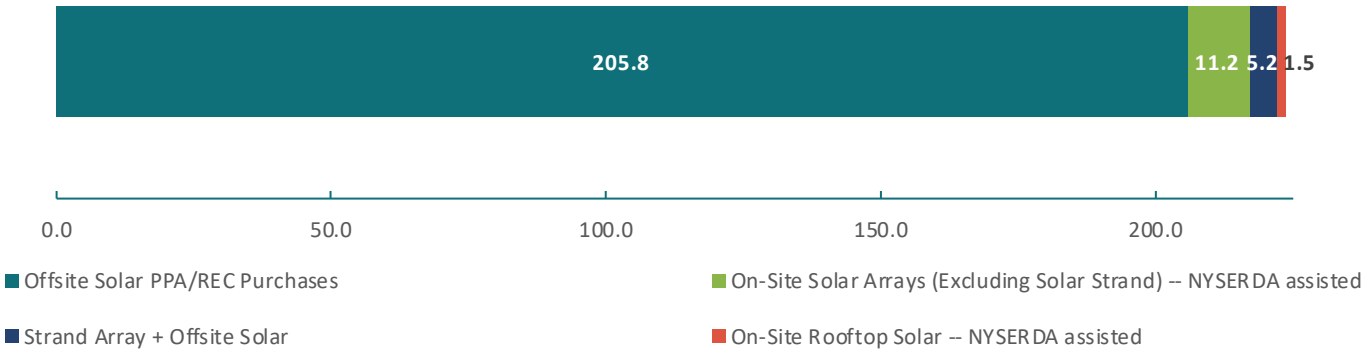
The ETL and Clean Green Campuses initiative-assisted solar arrays and rooftop solar projects listed in **Table 2** above account for roughly 56 percent of UB's total solar generation. This accounts for over five percent of UB's 223.7 MWh annual average consumption over the past three years (**Figure 1**). UB's other on-campus arrays, and additional offsite panels account for the remainder of UB's solar

[13] Based on data from NYSERDA and Open NY, these will be the 118th and 474th largest projects in New York State by capacity, out of more than 180,000 total (across all sectors and types of projects). See: New York State. 2022. Statewide Solar Projects: Beginning 2000. https://data.ny.gov/Energy-Environment/Statewide-Solar-Projects-Beginning-2000/wgsj-jt5f. Accessed: Nov.

[14] University at Buffalo. 2022e. UB advances commitment to clean energy as on-site solar arrays fire up. https://www.buffalo.edu/sustainability/news/latest-news.host.html/content/shared/www/sustainability/articles/news-articles/UB-Advances-Clean-Energy-Commitment-Solar-Arrays.detail.html. Dec.

electricity.[15] These other arrays bring the total solar capacity owned by UB to approximately 18 MWh of annual generation, nearly ten percent of UB's total electric consumption. In addition, the University purchases renewable energy credits (RECs) to offset the remainder of its electrical demand and is planning to replace its RECs entirely with purchases from additional solar power purchase agreements (PPAs) as conditions allow.

FIGURE 1. UB ELECTRIC GENERATION SOURCES (MWH)



3.1.3 Avoided Fuel Consumption

Through UB's CAP and 10 in 10 strategy, the University is targeting reductions a number of ways to achieve net-zero emissions by 2030. The most substantial effort currently underway to reduce fuel consumption is through electrification of the University's South Campus. This work to electrify the Campus's central heating system was made possible in part by a $550,000 FlexTech grant from NYSERDA to partially fund an electrification study. Interviewees identified NYSERDA as the only entity providing funding for these types of technical feasibility studies and emphasized that NYSERDA funding serves as a critical building block in enabling UB to achieves its ambitious electrification objectives.

The University has similar plans to electrify the North campus, with the ultimate goal of completely eliminating all of the University's heating fossil fuel use. Efforts directed by the CAP and electrification studies have and will lead to further emissions reductions in other areas at UB, including the transportation sector, where UB is working to electrify its vehicle fleet and provide more carpooling opportunities, and in dining services where the University is focused on reducing food waste and energy used in preparing food for the campus. As these initiatives advance, UB predicts that significant emission reductions will follow.

[15] For more on the Solar Strand, see: https://www.buffalo.edu/home/feature_story/solar-strand.html. For more on offsite solar see: https://solarliberty.com/blog/ub-begins-construction-on-ground-mounted-solar-panels/.

3.2 Environmental

3.2.1 GHG/Criteria Emissions Reductions and Associated Health Benefits

Information provided by UB and the solar developer was analyzed to calculate the GHG and criteria emissions avoided through the NYSERDA-assisted on-site solar projects using NYSERDA's emission factors and EPA's AVoided Emissions and geneRation Tool (AVERT).[16] AVERT uses solar installation and non-solar electricity generation data to estimate pollutant emissions avoided (PM2.5, NOx, SOx, NH4, VOCs). Based on AVERT, the projects will result in a statewide reductions of 5,952 tons of CO_2e annually, along with 7,160 pounds of NO_x, 1,500 pounds of $PM_{2.5}$ and 1,580 pounds of SO_2 avoided (**Table 3**).

TABLE 3. ANNUAL CRITERIA EMISSIONS AVOIDED FROM SOLAR INSTALLATIONS

State[1]	CO_2e[1,2]	SO_2 (lb)	NO_x (lb)	$PM_{2.5}$ (lb)	VOCs (lb)	NH_3 (lb)
New York	-5,952	-1,580	-7,160	-1,500	-690	-690
New Jersey	-	-10	-70	-270	-100	-250

1. CO_2e is estimated based on NYSERDA's 2022 annual average of Long-run Marginal Emission Factors for Upstate NY.[17] All other avoided criteria emissions are estimated using EPA's AVERT tool, which also reports avoided emissions in New Jersey when entering a New York state based project. AVERT does not give the option to select or view impacts to other contiguous states.
2. The CO_2e column reports the GHG impact of reductions in CO_2, CH_4, and N_2O. NO_x reports the annual quantity of emissions avoided estimated from the AVERT tool. Therefore, both values can be reported separately without double counting.

Using the changes in criteria air pollutant outputs ($PM_{2.5}$, SO_2, NO_X, NH_3, VOCs), from AVERT, EPA's COBRA Tool (CO-Benefits Risk Assessment) was then used to estimate the benefits and avoided health impacts of emissions reductions.[18] The health benefits were estimated stemming from the NYSERDA-assisted projects; the Solar Stroll, Creekside and Bizer Creek ground-mounted installations, along with UB's four rooftop solar installations (Helm, Beane, Center for Arts, and Baird Hall). **Table 4** presents a summary of the resulting health benefits for all contiguous U.S states and New York state based on EPA's COBRA Tool. As shown, these projects are estimated to provide $377,133 to $849,550 annually in health benefits to the contiguous U.S. states and $222,010 to $499,805 annually to New York residents. These health benefits include reduced mortality, nonfatal heart attacks, restricted activity days, and lost workdays.

[16] US EPA. 2022a. AVoided Emissions and geneRation Tool (AVERT). https://www.epa.gov/avert. Accessed: Nov.

[17] NYSERDA. 2022. Projected Emission Factors for New York State Grid Electricity - Data Annex. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf. Accessed: Jan 2023

[18] US EPA. 2022b. CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). https://www.epa.gov/cobra. Accessed: Nov.

TABLE 4. SUMMARY OF HEALTH BENEFITS FOR THE CONTIGUOUS U.S. STATES AND NEW YORK FROM UB'S SOLAR INSTALLATIONS

Health Endpoint[1]	Change in Incidence[2] (cases, annual) Low / High		Monetary Value[3,4] (dollars, annual) Low / High	
	All Contiguous U.S. states[6]	New York	All Contiguous U.S. states	New York
Mortality	0.034 / 0.077	0.020 / 0.045	$370,144 / $837,416	$217,661 / $492,377
Nonfatal Heart Attacks	0.004 / 0.036	0.002 / 0.022	$620 / $5,766	$371 / $3,450
Infant Mortality	0.000	0.000	$1,863	$1,141
Hospital Admits, All Respiratory	0.009	0.005	$311	$186
Hospital Admits, Cardiovascular (except heart attacks)	0.009	0.005	$455	$274
Acute Bronchitis	0.051	0.032	$31	$20
Upper Respiratory Symptoms	0.915	0.582	$39	$25
Lower Respiratory Symptoms	0.643	0.409	$17	$11
Emergency Room Visits, Asthma	0.021	0.011	$12	$6
Asthma Exacerbation	0.942	0.595	$70	$44
Minor Restricted Activity Days	29.323	18.641	$2,571	$1,634
Work Loss Days	4.989	3.181	$999	$665
Total Health Effects			**$377,133 / $849,550**	**$222,010 / $499,805**

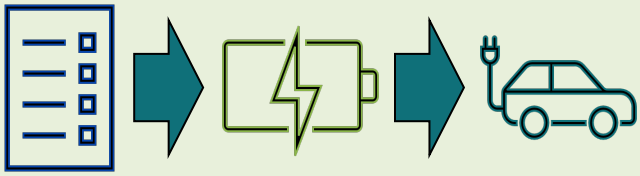
Health Endpoint[1]	Change in Incidence[2] (cases, annual) Low / High		Monetary Value[3,4] (dollars, annual) Low / High	
	All Contiguous U.S. states[6]	New York	All Contiguous U.S. states	New York

1. As a result of avoided emissions across state boundaries, there are additional benefits to the contiguous U.S. states that are not represented in this table related to improved air quality not just in New York state, but also monetary value in Alabama, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, and Wisconsin.
2. Positive numbers indicate annual reductions in the number of cases and the associated costs avoided.
3. Incidence refers to the number of new cases of a health endpoint over one year. The change in incidence is not necessarily a whole number because COBRA calculates statistical risk reductions which are then aggregated over the population.
4. COBRA calculates the monetary value of each health endpoint based on data on the healthcare costs of the health endpoint and research into the willingness to pay to avoid the health endpoint.[19]
5. The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA.
6. COBRA presents results for all contiguous U.S. states because changes in air quality can impact health endpoints in multiple locations due to the transportation of emissions across state and county lines.

3.3 Economic

3.3.1 Public/Private Investment

UB has received approximately $2 million from NYSERDA to support its energy efficiency and sustainability goals over the past two decades. The $1 million that NYSERDA contributed to the GRoW Clean Energy Center and advancing onsite solar represents UB's largest NYSERDA grant over the last five years. **Table 5** shows a full list of the recent funding NYSERDA has provided to UB, including the funding amount, and the NYSERDA program that provided the support. NYSERDA's financial support also allowed UB to collaborate with other funding partners and leverage additional support for these projects. For example, National Grid also partnered with UB to provide additional funding for EV charging infrastructure alongside NYSERDA.



UB's climate action plan targeted electrification and transportation goals. This led to further electrification studies, which resulted in the installation of EV charging stations on campus. NYSERDA provided funding for each of these efforts.

[19] Willingness to pay is a metric frequently used in economics that represents the maximum amount a consumer will pay for a good, service, or, in this case, to avoid a specific outcome.

TABLE 5. NYSERDA FUNDING FOR UB CAP PROJECTS

UB Project	NYSERDA Program	Funding[1]
On-site solar, GRoW CEC	REV Campus Challenge/ ETL	$1,000,000
South and North Campus Electrification Studies	FlexTech	$550,000
Climate Action Plan	REV Campus Challenge	$125,000
On-campus EV chargers	Charge Ready NY	$100,000
Additional clean energy upgrades	Various rebate programs	Unknown

1. Approximate numbers

3.3.2 Jobs

To estimate the job creation benefits from the NYSERDA-assisted solar installations at UB, the National Renewable Energy Laboratory's Jobs and Economic Development Impact (JEDI) Photovoltaic Model was used.[20] Using the solar capacities for the three arrays and four rooftop projects, the model estimated job creation during construction and subsequent operating years. **Table 6** and **Table 7** present the number of jobs created from the solar projects. Altogether these projects created an estimated 125 jobs during construction and 2.6 full-time equivalents (FTEs) annually over the lifetime of each project for operation and maintenance work.

In addition to the jobs created by the solar installations, UB's commitment to reach its climate neutrality goal through ongoing and future investments in clean energy projects (including campus-wide electrification) will create a substantial number of additional jobs and spending in the region. While the actual impacts that these future projects will have on jobs in the region is uncertain, UB's clean energy investments going forward will be substantially more than the total investments to date in the solar projects.

TABLE 6. SUMMARY OF JOB CREATION FROM ROOFTOP, BIZER CREEK, CREEKSIDE AND THE SOLAR STROLL SOLAR ARRAYS DURING CONSTRUCTION AND INSTALLATION

During Construction and Installation	Rooftop Solar Jobs[1]	Bizer Creek, Creekside, and the Solar Stroll Jobs	Total
Construction and Installation Labor	2.6	17.8	20.4
Construction and Installation Related Services	3.6	25.3	28.9

[20] NREL. 2022. JEDI: Jobs & Economic Development Impact Models. https://www.nrel.gov/analysis/jedi/. Accessed: November.

During Construction and Installation	Rooftop Solar Jobs[1]	Bizer Creek, Creekside, and the Solar Stroll Jobs	Total
Module and Supply Chain Impacts			
Manufacturing	0.0	0.0	0.0
Trade (Wholesale and Retail)	1.2	8.5	9.7
Finance, Insurance and Real Estate	0.0	0.0	0.0
Professional Services	0.8	5.7	6.5
Other Services	1.4	9.6	11
Other Sectors	2.7	19.0	21.7
Induced Impacts[2]	3.4	23.7	27.1
Total Impacts	**15.7**	**109.7**	**125.4**

1. Jobs refer to full-time equivalent employment for one year (1 FTE = 2,080 hours).
2. Induced impacts reflect the spending from workers and are driven by reinvestment and spending of earnings by direct and indirect beneficiaries.

TABLE 7. SUMMARY OF JOB CREATION FROM ROOFTOP, BIZER CREEK, AND THE SOLAR STROLL SOLAR ARRAYS DURING OPERATING YEARS

During Operating Years	Rooftop Solar Annual Jobs[1]	Bizer Creek, Creekside, and the Solar Stroll Annual Jobs	Total
PV Project Labor Only	0.3	1.6	1.9
Local Revenue and Supply Chain Impacts	0.1	0.3	0.4
Induced Impacts	0.0	0.2	0.2
Total Impacts	**0.4**	**2.2**	**2.6**

Jobs refer to full-time equivalent employment for one year (1FTE = 2,080 hours).

3.3.3 Regional Economic Benefits

To estimate the regional economic impacts, JEDI was used to calculate total impacts across the NYSERDA-assisted solar projects. **Table 8** and **Table 9** present the impacts during construction and over the lifetime of each project, respectively. The projects added roughly $15.1 million to the local

economy during the construction phase; including $5.3 million in the construction and installation sectors and $9.8 million across other sectors including (but not limited to) trade, finance, professional and other services. The value added represents the difference between total gross output and the cost of intermediate inputs. In other words, it is the dollar value of the net additional economic activity related to a project. This measure is analogous to the measurement of gross state product (GSP) at the State level.[21] Once completed, the projects will provide an estimated $215,000 annually to the regional economy over the lifetime of the projects.

TABLE 8. SUMMARY OF ECONOMIC BENEFITS FROM ROOFTOP, BIZER CREEK, CREEKSIDE, AND THE SOLAR STROLL SOLAR INSTALLATIONS DURING CONSTRUCTION AND INSTALLATION ($2021)

During construction and installation	Earnings[1] ($1,000s)		Output[2] ($1,000s)		Value Added[3] ($1,000s)l	
	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll
Construction and Installation Labor	$166	$1,155	$166	$1,155	$166	$1,155
Construction and Installation Related Services	$319	$2,228	$681	$4,752	$495	$3,457
Subtotal	**$485**	**$3,383**	**$846**	**$5,906**	**$661**	**$4,612**
Manufacturing	$0	$0	$0.0	$0	$0	$0
Trade (Wholesale and Retail)	$105	$734	$353	$2,462	$217	$1,515
Finance, Insurance and Real Estate	$0	$0	$0	$0	$0	$0
Professional Services	$60	$416	$175	$1,224	$115	$800
Other Services	$196	$1,368	$524	$3,653	$341	$2,380
Other Sectors	$71	$496	$206	$1,439	$124	$867
Induced Impacts	$211	$1,473	$691	$4,820	$437	$3,050

[21] Output is a simple measure reported by JEDI of the total value of all goods produced. Value added reported by JEDI is a subset of Output and serves as a measure of wealth created by project (or an economy). Value added (net additional economic activity) is a more useful measure to report because it nets out double counting of activity that occurs across sectors in the reporting of output measures.

During construction and installation	Earnings[1] ($1,000s)		Output[2] ($1,000s)		Value Added[3] ($1,000s)I	
	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll
Total Impacts	**$1,128**	**$7,870**	**$2,795**	**$19,503**	**$1,895**	**$13,224**

1. Earnings refers to wage and salary compensation paid to workers and benefits.
2. JEDI reports Output as economic activity or the value of production in the state or local economy.[22] It is total value of industry production (e.g., construction), including value added and the supply chain value. This value accounts for each dollar moving through various aspects of the supply chain, resulting in some double counting.
3. Value added reported by JEDI is the difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers (wages and salaries and benefits), proprietary income, other property type income (payments from interest, rents, royalties, dividends, and profits), indirect business taxes (excise and sales taxes paid by individuals to businesses, and taxes on production and imports less subsidies).[23]

TABLE 9. SUMMARY OF ECONOMIC BENEFITS FROM ROOFTOP, BIZER CREEK, CREEKSIDE, AND THE SOLAR STROLL SOLAR INSTALLATIONS DURING OPERATING YEARS ($2021)

During Operating Years	Earnings[1] $ ($1,000s		Output[2] $ ($1,000s)		Value Added[3] $ ($1,000s)	
	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll
PV Project Labor Only	$14	$99	$14	$99	$14	$99
Local Revenue and Supply Chain Impacts	$4	$28	$14	$98	$9	$61
Induced Impacts	$2	$14	$7	$45	$4.	$29
Total Impacts	**$20**	**$141**	**$35**	**$242**	**$27**	**$188**

[22] JEDI Photovoltaics Model rel. PB05.20.21

[23] JEDI Photovoltaics Model rel. PB05.20.21

During Operating Years	Earnings[1] $ ($1,000s		Output[2] $ ($1,000s)		Value Added[3] $ ($1,000s)	
	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll	Rooftop Solar	Bizer Creek, Creekside and the Solar Stroll

1. Earnings refers to wage and salary compensation paid to workers and benefits.
2. Output reported by JEDI refers to economic activity or the value of production in the state or local economy.[24] It is total value of industry production (e.g., construction), including value added and the supply chain value. This value accounts for each dollar moving through various aspects of the supply chain, resulting in some double counting.[25]
3. Value added reported by JEDI is the difference between total gross output and the cost of intermediate inputs. It is comprised of payments made to workers (wages and salaries and benefits), proprietary income, other property type income (payments from interest, rents, royalties, dividends, and profits), indirect business taxes (excise and sales taxes paid by individuals to businesses, and taxes on production and imports less subsidies).[26]

3.3.4 Cost-savings/ Effectiveness

UB's initial plan submitted to the REV Campus Challenge included a proposal to partner with other local universities and municipalities to reduce costs by jointly entering into large-scale solar projects. Unfortunately, legal, procurement and other regulatory challenges created barriers that prevented most of the parties from advancing. Specifically, regulatory barriers prohibited parties from offering a single RFP. However, UB and Erie County were able to separately advance individual RFPs and reach secure a PPA to purchase solar power for a rate of about seven cents/kWh, which is roughly on par with each entity's current electricity rate.

3.4 Education/Awareness Benefits

3.4.1 Increased Education Opportunities Created by the GRoW Clean Energy Center

While UB considers the educational opportunities that the CAP and the solar project provide to students as a substantial benefit, the GRoW Clean Energy Center was cited as the most tangible opportunity for learning about energy efficiency and sustainability. The GRoW Home was initially an entry in DOE's 2015 Solar Decathlon, where it placed second overall in the national competition. The structure was built to LEED and Passive House certification standards. It was first assembled in Western New York, disassembled for travel, and then reassembled in California, the location of the competition. The design and construction of the structure was a collaborative effort between more than 400 students and faculty across 10 different departments at UB. While many other participating universities were forced to leave or discard their entries following the competition, NYSERDA

[24] JEDI Photovoltaics Model rel. PB05.20.21

[25] California Air Resources Board. 2022. The Innovation Benefits of Climate Action under AB 32.

[26] JEDI Photovoltaics Model rel. PB05.20.21

provided funding to UB to transport the GRoW home back to New York, where it is installed on the University's North Campus.[27]

The GRoW Clean Energy Center serves as a campus meeting site for a variety of events. The Center's now permanent site next to the 750 kW Solar Strand highlights the University's commitment to climate action and its ability to successfully generate renewable energy. The GRoW Clean Energy Center can accommodate up to 40 people, in its net energy-positive space and has hosted classes and other events for the wider community.[28,29] Its specific uses include:

- Gathering and orientation space for K-12 clean energy tours which include visits to the UB Solar Strand.
- Host for exhibits and learning opportunities related to renewable energy and the structure's original design.
- Meeting space for Western New York clean energy and sustainability organizations.
- Space for small class seminars and student sustainability club activities.
- Showcase for the extensive sustainability work being conducted across the University.

3.4.2 Increased Education on UB's Carbon Footprint and Climate Change Activities

The presence of the GRoW Clean Energy Center on UB's campus and the educational opportunities it provides help encourage students to pursue clean energy careers who otherwise may not have due to lack of personal first-hand experience with clean technology. Separately, the Department of Environment and Sustainability was established within UB's College of Arts and Sciences in 2019, further highlighting UB's recent and ongoing focus on sustainability. Since that time, 289 students have graduated with degrees in Environmental Science and 28 students have minored in Environmental Science.[30] Because of the diverse socioeconomic backgrounds of UB students, opportunities to learn about clean technologies and sustainability are available to students with a wide range of different backgrounds. Roughly one-third (34 percent) of UB students can be considered low-income (and receive Federal Pell Grant Aid).[31] Additionally, the University is rated "very high" for racial diversity by CollegeSimply, with a student body that includes more than 50 percent minority or people of color students.[32]

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[27] For more information on the GRoW Home see: Bohm, M. 2018a. Energy technology and lifestyle: A case study of the University at Buffalo 2015 Solar Decathlon home. Renewable Energy 123. Jan.; and Bohm, M. 2018b. Thermal Performance of Novel Natural Ventilation Apertures in a High-Performance Single-Family House. International Building Physics Conference. Jun.

[28] Net energy-positive buildings refer to those that produce more energy than they consume.

[29] UBNow. UB's GRoW Home is all grown up. 2018. https://www.buffalo.edu/ubnow/stories/2018/10/grow-home-south-campus.html. Accessed: Nov.

[30] Hsu, C. 2019. UB launches Department of Environment and Sustainability. UBMD. https://www.ubmd.com/about-ubmd/news.host.html/content/shared/university/news/news-center-releases/2019/10/019.detail.html. Oct.

[31] CollegeSimply. 2022. UB Geographics & Diversity. https://www.collegesimply.com/colleges/new-york/university-at-buffalo/students/. Accessed: Nov.

[32] CollegeSimply. 2022.

3.4.2 Awards/Recognition

Vice President Kamala Harris visited UB in September 2022 and toured the Solar Strand and GRoW Home. As part of the Vice President's address, she stressed the need for students to lead the nation forward in combatting climate change and highlighted the work occurring at UB and in the greater Buffalo area as "very exciting and…a model for our country."[33]

Vice President Harris' visit highlighted UB as a leader in promoting sustainability in higher education institutions. These achievements are further shown through UB's rankings in the Times Higher Education Impact Rankings, which assess universities against the United Nations' Sustainable Development Goals. **Table 10** presents UB's recent Impact Rankings.[34] Since these international ranking began in 2019, UB has been ranked among the top two for overall climate action across US schooevery year, including receiving the number 1 ranking in both 2020 and 2021. In addition to the Times' rankings, UB ranked 5th in the EPA's Green Power Partnership Top 30 College & University ratings based on the University's use of 225 million kWh of annual green power usage (solar and wind energy).[35, 36]

TABLE 10. UB'S TIMES HIGHER EDUCATION RECENT IMPACT RANKINGS

Sustainable Development Goal	2019 US Ranking	2020 US Ranking	2021 US Ranking	2022 U.S. Ranking
Climate action[1]	2	1	1	2
Affordable and clean energy[2]	N/A[4]	--	1	4
Sustainable cities and communities[3]	11	11	11	7

1. Measures universities' research on climate change and their use of energy; and their preparations for dealing with the consequences of climate change.
2. Measures universities' research related to energy, their energy use and policies, and their commitment to promoting energy efficiency in the wider community.
3. Measures universities' research on sustainability, their role as custodians of arts and heritage and their internal approaches to sustainability.
4. Affordable and clean energy rankings began in 2020.

[33] Nealon, C. 2022. Harris calls UB 'model' for sustainability work. UBNow. https://www.buffalo.edu/ubnow/stories/2022/09/harris-wrapup.html. Sep.

[34] Times Higher Education. 2022. Impact Rankings 2022. https://www.timeshighereducation.com/impactrankings#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/undefined. Accessed: Nov.

[35] Hill, D. 2022. Recent rankings point to UB's standing as a leader in sustainability. UB News Center. https://www.buffalo.edu/news/releases/2022/05/003.html. May.

[36] US EPA. 2022c. Green Power Partnership Top 30 College & University. https://www.epa.gov/greenpower/green-power-partnership-top-30-college-university. Accessed: Nov.

3.5 Replication

3.5.1 Leading by Example: RFP Design Consistency/Planning Replication

The framework and best practices that UB developed in planning its solar installation RFP overcame several administrative and legal challenges. As a result, UB's recent experience with solar projects can serve as a successful example to other SUNY institutions looking to complete comparable projects and facing similar challenges. Specifically, the lessons learned by UB in navigating the inconsistencies between State regulatory laws and realities within the New York clean energy marketplace was a key barrier (e.g., UB's classification as a state agency means that it is under different requirements than organizations like NYSERDA or NYPA, which often prevents public educational institutions from entering into long-term contracts like PPAs). The solar developer also revealed during the interviews that their work with UB helped broaden their understanding of the issues they will need to address when working with other colleges and universities.

UB faculty and staff regularly share experiences and ideas through formal and informal settings with other academic institutions and public entities across the State. This includes talking with other REV Campus Challenge member organizations, hosting and attending events, and sharing guidance on climate action plans and campus solar projects, similar to the ones UB completed. UB works closely with the New York Council for Sustainability in Higher Education, which University staff have used as a platform for many of these conversations. A UB official reported that NYSERDA's REV Campus challenge is a main reason that schools across New York State have "done a lot" on climate action [compared to other states].

UB shares its clean energy projects through a public dashboard that provides information on UB's CAP and allows the public to view UB's plans and progress. Since April 2020, the Climate Action Page has had 16,000 views. UB staff believe many of the visits are from UB students using these data for course work.

UB's on-campus solar arrays were designed specifically to be highly visible to members of the public when using the walking and bike paths that pass through the arrays. UB ensured that there would be no fencing around the arrays to allow the public to view the technology up close (and to not adversely affect wildlife). A UB staff member reported that they believe the public access to the solar arrays has increased interest in solar projects and demonstrated that solar energy is viable in Western New York's climate.

Finally, as part of UB's partnership with Erie County, through the NYSERDA-assisted ETL solar project, the County installed a 450-kW solar capacity array on a converted brownfield. The array will generate nearly 520,000 kWh annually, and will result in 2,871 metric tons CO2e avoided. This further highlights UB's commitment to advancing sustainability beyond its campus and into the broader community through its partnership, leadership, and empowering of its students.

Conclusion

UB serves as a leader in both its local region and across all higher education institutions for its commitment and actions in sustainability. While UB's CAP and 10 in 10 roadmap represent an aggressive plan to reach net carbon neutrality, the University's commitment to sustainability and its impact go far beyond its own campuses, through partnerships with local organizations, guidance to other institutions, community engagement, and student training including numerous experiential opportunities. The benefits from these activities can be seen through the GHG and criteria emissions avoided, regional health benefits, job creation, and an increasing level of engagement with both students and the wider community.

UB's ability to achieve this success is bolstered by its ongoing partnership with NYSERDA. The assistance that NYSERDA provided has served as a "catalyst" for a number of large-scale projects necessary for helping UB set and achieve its lofty sustainability goals. This includes NYSERDA's contribution of funding for the CAP and electrification studies, which have served as roadmaps for reaching these targets. NYSERDA's ETL and other funding have allowed UB to complete infrastructure projects and build out projects that provide students with experiential learning opportunities such as the GRoW Clean Energy Center. The relationship between UB and NYSERDA can serve as a role model for other institutions and organizations seeking to pursue the aggressive climate action targets that UB is on track to achieve.

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