

RESILIENT POWER PROJECT CASE STUDY

Vieques Microgrid Network

Community Resilience for a Remote Island in Puerto Rico

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RESILIENT POWER PROJECT CASE STUDIES

This case study is one in a series by Clean Energy Group (www.cleangroup.org) produced as part of The Resilient Power Project (www.resilient-power.org), which aims to accelerate the equitable deployment of clean, affordable, and resilient power technologies in historically marginalized and underserved communities nationwide. This case study series highlights installations of solar combined with battery storage (solar+storage) to demonstrate their economic, community resiliency, and health benefits.

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Cover image: Solar panels on a residential rooftop in Vieques, Puerto Rico. Photo courtesy of Community Through Colors.

Vieques Microgrid Network

Community Resilience for a Remote Island in Puerto Rico

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LEARN MORE

A profile of the Vieques Microgrid Network is available on Clean Energy Group's website at:
www.cleanegroup.org/initiatives/technical-assistance-fund/featured-installations/vieques-microgrid-network

Webinar - Resilient Power in Puerto Rico: Innovative Applications for Solar+Storage to Serve Vulnerable Populations (March 2020). Slides and recording: www.cleanegroup.org/webinar/resilient-power-in-puerto-rico-innovative-applications-for-solar-storage-to-serve-vulnerable-populations

Webinar - Energía resistente en Puerto Rico: Cómo el Solar+Almacenamiento está re moldeando el panorama energético (December 2019). Slides and recording: www.cleanegroup.org/webinar/energia-resistente-en-puerto-rico-como-el-solaralmacenamiento-esta-re-moldeando-el-panorama-energetico

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SOLAR+STORAGE ON THE ISLAND OF VIEQUES

A rural island community leveraged solar and energy storage to build energy security and combat high energy burdens.

THE CHALLENGE: An Aging, Unreliable Grid Left Island Residents Without Power for Over a Year

In September 2017, Category 5 storm Hurricane Maria knocked out all power across Puerto Rico. It took a year to restore electric service to all the municipalities of the main island. Vieques, an island of about 8,000 people located eight miles east of the Puerto Rican mainland, remained without electricity for 18 months, the second-longest blackout in world history.^{1,2} It took a year and a half for the Puerto Rico Electric Power Authority (PREPA) to repair the underwater transmission cable that connects Vieques to the mainland power grid.^{3,4} Eventually the little island was reconnected, but service remained unreliable and expensive.

Energy Insecurity. Vieques receives power via a decades old 38-kilovolt underwater transmission cable repaired most recently in 2019 after damage caused by Hurricane Maria. The cable, despite its deteriorating condition, is unlikely to be replaced



Exposed power lines along the coast of Vieques.
Credit: Community Through Colors

¹ “Quick Facts: Vieques Municipio, Puerto Rico,” U.S. Census Bureau, <https://www.census.gov/quickfacts/viequesmunicipiopuertorico> (accessed January 2, 2025).

² Trevor Houser and Peter Marsters, “The World’s Second Largest Blackout,” Rhodium Group, April 12, 2018, <https://rhg.com/research/puerto-rico-hurricane-maria-worlds-second-largest-blackout/>.

³ Alexander C. Kaufman, “On Puerto Rico’s ‘Forgotten Island,’ Tesla’s Busted Solar Panels Tell a Cautionary Tale,” Huffington Post, May 17, 2019, www.huffpost.com/entry/elon-musk-tesla-puerto-rico-renewable-energy_n_5ca51e99e4b082d775dfec35.

⁴ Maria Gallucci, “Rebuilding Puerto Rico’s Power Grid: The Inside Story,” IEEE Spectrum, March 12, 2018, <https://spectrum.ieee.org/rebuilding-puerto-ricos-power-grid-the-inside-story>.

before 2029.⁵ Instead, LUMA – the island’s transmission and distribution entity – is focusing on repairs to identify “potential failure points” within Vieques, such as substation maintenance, the most recent of which were completed in fall 2024.⁶ However, without a reliably functioning cable connecting Vieques to the mainland grid, Vieques remains highly susceptible to island-wide power failures.

In 2025, residents of Vieques experienced daily brownouts and frequent service interruptions, often independent of poor weather conditions. This trend is expected to continue.⁷ LUMA records indicate that, as outages become more prevalent at power plants due to failing or damaged equipment, only about 50 percent of total generation supply is expected to be available during the hottest months in Puerto Rico.⁸ The condition of Puerto Rico’s power grid has worsened significantly over the past few years, with the number of outages caused by generation shortfalls tripling since 2024.^{7,9}

In February 2025, a fire caused an extended outage within one unit of Puerto Rico’s largest power plant in Aguirre. Due to the energy shortages following that fire, the U.S. Department of Energy (DOE) issued two emergency orders about the state of Puerto Rico’s electrical grid and directed PREPA to take measures to mitigate current and future risk.¹⁰ LUMA issued a statement recommending “that Puerto Rico stakeholders unite to pursue accelerating new resource additions, particularly energy storage assets [...] that can contribute during peak electricity demands.”¹¹

Reliable electricity should not be a luxury, and yet, the residents of Vieques have not had reliable access to power for years. Authorities continue to anticipate widespread grid outages, leaving little hope that conditions will improve soon.

⁵ “PREPA 10-Year Infrastructure Plan,” FEMA, LUMA, Puerto Rico Electric Power Authority, June 2021, www.congress.gov/117/meeting/house/115197/documents/HHRG-117-II00-20221117-SD017.pdf (accessed October 10, 2025).

⁶ “LUMA Performs Far-Reaching Work to Make Vieques Electrically Resilient,” LUMA, October 30, 2024, <https://lumapr.com/news/luma-performs-far-reaching-work-to-make-vieques-electrically-resilient/>.

⁷ Calculations from early 2025 estimated that if Prudent Utility Practices were applied to the current conditions, LUMA would load shed below 400 megawatt reserves and either disconnect at least some customers during most hours every day or increase risks to system stability.

⁸ “New Resource Adequacy Report: Lack of Reliable Power Supply from Generators will Pose Ongoing Threat to Service Reliability in 2025,” LUMA, October 31, 2024, <https://lumapr.com/news/new-resource-adequacy-report-lack-of-reliable-power-supply-from-generators-will-pose-ongoing-threat-to-service-reliability-in-2025/?lang=en>.

⁹ “LUMA Monthly Generation Performance Report,” LUMA, https://lumapr.com/wp-content/uploads/2025/01/2024.12_Generation-Performance-Report.pdf (accessed October 10, 2025).

¹⁰ “Federal Power Act Section 202(c) Puerto Rico Electric Power Authority (PREPA),” U.S. Department of Energy, May 16, 2025, www.energy.gov/ceser/federal-power-act-section-202c-puerto-rico-electric-power-authority-prepa.

¹¹ “Motion to Submit Interim Update for Summer 2025 of LUMA’s Fiscal Year 2025 Resource Adequacy Study,” LUMA, March 24, 2025, <https://energia.pr.gov/wp-content/uploads/sites/7/2025/03/20250324-MI20220002-Motion-to-Submit-Interim-Update-for-Summer-2025.pdf>.

Energy Burden. The price of electricity can be prohibitively expensive for Vieques residents. Per the 2020 Census, the median annual income on the island is approximately \$15,000, with 52.6 percent of the population falling below the poverty line. The cost of energy in Vieques is exceedingly high at between \$0.20 to \$0.30 per kilowatt-hour, which is double the average cost in the contiguous United States. The US Census states the national average energy burden for low-income households is 8.6 percent of income, which is three times higher than the average for non-low-income households. The energy burden for households in Vieques is at least 10 percent.¹² Some Vieques residents have been forced to forgo electricity altogether due to the high cost, the remote location of their home, or both. In the extreme heat of the summer, the inability to power even a few small fans can worsen the impacts of heat stroke or other pre-existing medical conditions.

THE SOLUTION: Distributed Solar+Storage Systems at Critical Facilities and for Medically Vulnerable Households

Community Through Colors (CTC) is a nonprofit organization founded in 2016 to spread hope and awareness between communities through art and volunteerism. Following those principles, CTC expanded its mission after Hurricane Maria to bring disaster relief and preparedness to remote, isolated, and underserved coastal communities.

In 2019, CTC received a Technical Assistance Fund (TAF) award from the national nonprofit Clean Energy Group (CEG) to explore how solar paired with energy storage (solar+storage) could be implemented in the town of Esperanza, located on the south side of the island of Vieques.

Clean Energy Group's Technical Assistance Fund. The first steps to exploring solar+storage for a facility can be resource intensive, requiring organizations to commit time and money to evaluate costs and benefits. Through the TAF, Clean Energy Group seeks to reduce these early-stage project development barriers by funding solar+storage feasibility assessments for community-serving facilities. The techno-economic assessments evaluate the system's potential design, including its cost, economic and resilience benefits, and emissions reduction potential. After receiving a solar+storage assessment, community facilities are better equipped to move to the next steps of project development.

¹² "Low-Income Energy Affordability Data (LEAD) Tool," U.S. Department of Energy, www.energy.gov/scep/slsc/lead-tool (accessed October 10, 2025).

CTC was able to develop a solar+storage feasibility assessment in-house with support from Clean Energy Group. CTC initially set out to study 25 low-income and medically vulnerable households in one neighborhood in Esperanza. As a result of this initial study, CTC was able to identify and ultimately install solar+storage at six single family households, prioritizing residents who rely on electricity for medical equipment such as CPAP machines and nebulizers, or who take medication that requires refrigeration. All of the households that installed solar+storage are low-income, have a high energy burden, and/or are not currently connected to the grid due to their location or prohibitive electricity costs.



A residential battery is installed in a household in Vieques.

Credit: Community Through Colors

With increasing consumer electricity demand and rapidly deteriorating grid service quality, CTC recognized the need for a more impactful and accessible solution. Rather than going door-to-door to assess each household's capacity and need for resilient, affordable power, CTC explored the possibility of installing solar+storage at community centers across the island of Vieques, thus aggregating power for critical services and the restoration of baseline operations to the island when outages occur. With solar+storage powering the community centers, people could depend on nearby community spaces for support during grid outages, rather than solely powering a limited number of private households.

As of 2025, CTC has supported the development and operation of more than 15 resilient solar+storage systems across the island, including:

- An ***emergency management trailer***, which can be deployed to support critical functions across the island during power outages and emergencies.¹³
- An ***emergency communications tower***, which enables emergency response teams to more effectively communicate throughout the island without relying on cellphone towers and an unreliable grid.
- The only ***fire station*** on the island of Vieques.
- The island's ***hurricane shelter***, located at an elementary school.

¹³ Read more about this project on Clean Energy Group's website: www.cleaneigroup.org/initiatives/technical-assistance-fund/featured-installations/vieques-emergency-management-trailer.

- Multiple **resilience hubs** housed at community facilities, including a children's outreach and programming center and a cancer treatment center. During grid outages, resilience hubs in Vieques continue to power the facility's lights, refrigerators, freezers, and fans, and invite community members to recharge their cellphones.
- A **municipal administration building** in Esperanza.
- A local **radio station**, which can keep residents across Vieques informed through long-term outages.
- A **dialysis clinic**, so it can continue to treat patients during power outages.
- A **senior care center**, which serves as a fresh food bank during outages, uses solar+storage to provide power to the refrigerated food storage area.
- The **Community Kitchen**, which serves over one hundred individuals and families who face medical, financial, or systemic vulnerabilities.
- Cold storage facilities at **two farms**, increasing immediate availability of food after severe weather events and preventing food spoilage.



Rooftop solar in Vieques. Credit: Community Through Colors

20 percent of the building's electrical loads, which means only designated critical loads receive power during outages.

Resilience. The primary goal of the Vieques Microgrid Network is to provide backup power to critical community facilities during grid outages. The solar+storage systems have successfully provided uninterrupted power during daily brownouts and multiple brief power outages. The systems also remained online with minimal intervention during and after the widespread power outages caused by Hurricane Fiona in 2022. Solar+storage has supported Vieques residents through outages by providing safe and cool spaces to access communications, medical relief, food, shelter, and water.

Most of the solar+storage installed as part of the Vieques Microgrid Network can provide backup power for between 12 and 72 hours during an outage depending on the system's size and the critical loads it supports. For example, a smaller solar+storage system may only be able to support

Reliability. With an unreliable electrical grid in Vieques, solar+storage allows for continuity of emergency services through brownouts or blackouts. Community facilities that have resilient solar+storage capacities can continue their daily operations while also supporting residents who depend on electricity for medical purposes, financial transactions, communications, and more. Community centers that provide food can confidently store higher quantities of emergency food supplies during hurricane season with the knowledge that their refrigerators and freezers will preserve fresh meats, fruits, and vegetables with significantly lower risk of spoilage and electrical appliance damage. With increased access to online learning platforms, students may be able to continue their studies during blackouts without interruption. Access to reliable electricity is the first step towards ensuring healthy communities, financial independence, and an equitable workforce.

Community Engagement. CTC engaged and consulted community members, businesses, and government officials regarding the desire for and feasibility of a microgrid in Vieques prior to design, planning, and installation. In addition to verbal community support, fifteen households and four local business owners provided signed letters of support. The mayor of Vieques approved several projects, including installations at the municipal building and dialysis clinic. Throughout the initial stages of the project, program participants provided landowner consent and documentation of utility bills, signed off-taker agreements, and participated in site assessments. The project team ensured participants were informed of system requirements and adapted each system to individual needs.

Parallel to CTC's work designing and developing solar+storage systems, the organization has also created solar+storage educational opportunities across Vieques. With support from the National Renewable Energy Laboratory and DOE, CTC hosted a community workshop at the Vieques public library to teach residents about solar and battery storage technologies, and they distributed a solar manual created by local partner Energia desde Cero. Feedback from workshop participants was positive, particularly from those with limited technical knowledge, and the event sparked more community interest in developing solar+storage in Vieques. CTC also worked with a local radio station to broadcast solar+storage resources on air to its audience.



*Installing rooftop solar in Vieques, Puerto Rico.
Credit: Community Through Colors*

Workforce Development. Rural and remote communities across the US and Puerto Rico often have limited access to experienced solar+storage technicians. Few installers will travel to the island of Vieques, and even fewer will provide ongoing operations and maintenance support for solar+storage. CTC recognized early on the importance of providing workforce development programming so that solar+storage on the island could be locally built and maintained. In 2018, CTC developed a hands-on training curriculum for off-grid installers of residential buildings, large-scale commercial sites, and smaller temporary or mobile projects. CTC partnered with Footprint Project, a nonprofit specializing in mobile solar+storage, to conduct a three-day solar+storage installation workshop, which included installing a solar system. For the solar+storage systems CTC supported in Vieques, CTC team members underwent training to be able to manage system operation and maintenance. By supporting workforce development programs, CTC is ensuring residents of Vieques not only benefit from locally sourced resilient power, but also from the jobs these solar+storage projects bring.

Project Overview

Year Commissioned: 2017-2025, with additional projects in development

Services Provided: Renewables integration, reduced demand charges, backup power, workforce development

Infrastructure Supported: Over fifteen buildings, including: an emergency communications tower, community resiliency hubs, farms, a dialysis clinic, schools, a fire department, an elderly care center, a community radio station, and single-family residences of community members that rely on electricity for medical equipment.

Solar: 225 kW total

Storage: 355 kWh total, lithium-ion chemistry

Duration of Backup Power: Between 12 and 72 hours for most of the systems

Location: Vieques, Puerto Rico

PROJECT FINANCIALS

The Vieques Microgrid Network was made possible through fundraising campaigns, grant support, and donations of new or used solar panels, battery storage systems, and related equipment. System size was sometimes determined by available materials and did not always represent optimal sizing. On average, the battery systems were rated at half the capacity of the associated solar array, providing limited backup power. As a result, several of the systems will receive upgrades in the future to better serve their needs. The Vieques Microgrid Network is maintained by CTC. Some solar+storage systems within the network are owned by the host facility and others are owned by CTC.

The Vieques Microgrid Network is designed to optimize resilience, but many systems also provide financial benefits. The batteries charge and discharge throughout the day to adapt to fluctuating demand rates. Solar+storage has reduced or eliminated the facility's electricity bills, allowing staff to focus the organization's limited funding on providing essential services. Residents that installed solar+storage on their homes can save the equivalent of 10 percent of their annual income, which families can use to pay for food or medications that would increase their quality of life. Facilities with refrigerators and freezers have experienced lower rates of food spoilage and less frequent damage to appliances, saving hundreds of dollars during power outages. By installing solar+storage and pursuing energy efficiency measures, the community facilities have seen their electricity bill reduced by up to 84 to 100 percent in some cases.



Some facilities required a roof repair before solar could be installed. These photos show the roof of a senior center in Vieques before and after repairs. Credit: Community Through Colors

CHALLENGES TO DEVELOPMENT AND LESSONS LEARNED

In developing solar+storage projects across Vieques, CTC experienced and overcame several barriers unique to projects developed outside the contiguous United States.

Inflated Costs and Fewer Choices. The various materials and components needed to install solar and battery storage had to be shipped from the mainland US to Puerto Rico and then to the island of Vieques. The increased distance, time, and logistics increased the total installation cost for the project.

CTC also needed to consider how batteries would perform in Puerto Rico's warm and humid tropical climate. Heat can drain a battery's resources quicker than energy modeling typically indicates. To address this issue, CTC experimented with batteries from several manufacturers before selecting a model that best addressed environmental limitations. Both the availability and cost to ship materials had to be evaluated in the context of potentially lower-than-expected system performance, an added challenge that constrained the choices project developers could make.

Financing Barriers. The techno-economic feasibility assessment funded by Clean Energy Group's Technical Assistance Fund showed that several potential project sites had very favorable projected returns on investment (ROIs). In other locations, this assessment might have helped to secure financing, but multiple investors and investment groups stated that they would not assume the risk associated with pursuing projects in Puerto Rico. Even those who committed to projects with CTC, quickly backed out after assessing the additional costs and potential risks associated with maintaining solar+storage in a hurricane-prone area.

Furthermore, although DOE offered several funding opportunities for community solar developers within the US, projects in Puerto Rico were ineligible because Puerto Rico has not established official regulations for "wheeling," or the transmission of electricity from one system to another through the electric power grid.

Without these funding streams, CTC has relied on donations of equipment and money, sometimes relying on donations from CTC's own staff to bridge financial gaps. CTC was recognized for its innovative and impactful work, including receiving DOE's Community Energy Innovation Prize and being recognized as a finalist for the DOE's American-Made Sunny Awards for Community Solar.^{14,15} Prize money from these awards reimbursed work already completed. CTC is continually looking for additional finance options to support and expand their work.

¹⁴ "Puerto Rico Energy Recovery and Resilience Newsletter," U.S. Department of Energy, January 2025, www.energy.gov/gdo/articles/puerto-rico-energy-recovery-and-resilience-newsletter-january-2025 (accessed on October 10, 2025).

¹⁵ "The 2022 Sunny Awards for Community Solar," U.S. Department of Energy, www.energy.gov/communitysolar/2022-sunny-awards-community-solar (accessed on October 10, 2025).

Limited Operations and Maintenance Support.

The island of Vieques is located eight miles east of the Puerto Rican mainland. The Vieques Microgrid Network was installed, in part, by companies based on the mainland. In theory, these companies would also be responsible for overseeing the productivity of the system and providing maintenance support as needed. However, in practice, CTC found that maintenance crews would not or could not travel to the island. Instead, CTC became the de facto lead on both system operation and maintenance, often requiring additional training for CTC team members.

Innovation on the Island. Pairing solar with battery storage was relatively novel for community-led projects in the contiguous United States when Hurricane Maria hit in 2017. The resulting devastation that Hurricane Maria brought to Puerto Rico catalyzed a movement to deploy solar and battery storage on the island. CTC, which had been established in 2016, shifted its focus and began coordinating the deployment and repair of solar+storage in Vieques. To build the network of community-led solar+storage microgrids, CTC had to establish its own playbook reflective of the barriers unique to Puerto Rico. In the future, once Puerto Rico establishes official regulations for wheeling, CTC hopes to accelerate the deployment of large community solar systems that can serve entire neighborhoods, continuing in its tradition of piloting innovative solutions to serve community needs.

Energy Efficiency and Consumer Education. After installation, CTC found that some of their systems were underperforming and incapable of providing resilient power for the length of time that was originally anticipated. Upon further investigation, CTC discovered that this was often due to one of two scenarios: either the buildings were operating with old, inefficient appliances whose inefficiencies were not originally considered, or consumers had added additional appliances after installation and were overburdening the system. To address these issues, CTC began providing energy efficiency audits and workshops about optimizing solar+storage to program participants. CTC reviewed energy smart choices such as consolidating food into one storage unit, ensuring the storage system is charged before a storm, and reducing the number of loads that the solar+storage hosts choose to power during grid outages.



*Maintenance at a Vieques senior center.
Credit: Community Through Colors*

NEXT STEPS: Establishing a Local Energy Cooperative

In June 2023, Clean Energy Group awarded a Resilient Power Leadership Initiative (RPLI) grant to CTC to support the creation of the Vieques Energy Cooperative. The RPLI program provides community-led organizations with a capacity-building grant to establish or expand their energy equity and resilient solar+storage programming.

An energy cooperative is a member-owned, nonprofit entity that provides energy services to its members. Unlike investor-owned utilities, cooperatives reinvest revenue into infrastructure or return it to members in the form of bill credits. Establishing an energy cooperative in Vieques was a natural next step towards equitably developing clean and resilient energy resources, but finance was a barrier to establishing the Cooperative. In Puerto Rico, an energy cooperative must pay a monthly fee of \$500, regardless of revenue or activity. This poses a problem for the development of community-led, community-owned energy companies in Puerto Rico that need upfront capital, often from investors, to begin to function as an energy cooperative. To secure capital from investors, the company needs to prove its legitimacy by registering as an energy cooperative. This leaves new energy cooperatives vulnerable to perpetual fees without any guarantee that the cooperative will ever provide any services. For these reasons, CTC delayed applying for official certification until January 2025. In March 2025, CTC received approval to establish the Vieques Energy Cooperative as an official entity.

Officially established in March of 2025, the Vieques Energy Cooperative will serve as a legal entity capable of addressing local energy issues and systematic barriers. It was designed to not only increase Vieques' energy resilience but also to improve the community's quality of life and access to opportunity through green jobs, community ownership of energy resources, and lower electric bills. The Cooperative is managed by a board consisting entirely of Vieques stakeholders who provide a critical service in ensuring the entity serves the needs of the community.

In addition to using the RPLI grant to support the Cooperative's initial legal fees, CTC leveraged this funding to identify additional federal funding opportunities, provide workshops on energy efficiency and usage, plan for potential new energy systems, and explore the cooperative's maintenance structure.

The Vieques Energy Cooperative was founded in part to manage the ongoing operations, maintenance, and repair needs of the solar+storage systems, reducing confusion and additional fees for the hosts of the site. Due to the piecemeal way the systems needed to be funded through donations, the systems are either owned entirely by the host or by CTC. Eventually, the Vieques Energy Cooperative will control the performance and oversee the maintenance of all the solar+storage systems in what will become an innovative model of community ownership.

CTC is currently pursuing the next steps to build the Cooperative's capacity and realize the community's goals. As part of these plans, the Cooperative has planned community events and workshops to build awareness about solar+storage, its benefits, and the current and future role of the Cooperative.

As the Vieques Energy Cooperative continues to grow, it seeks to provide three solar+storage ownership models for residents and businesses: the existing donation model (where donated funding or equipment precipitate project installation), a full-purchase option (which is currently not financially feasible for many Puerto Rican households or businesses), or a rent-to-own model through the Cooperative. In the proposed rent-to-own option, residents will pay the electric cooperative for their energy use, as they do with the current utility. Each payment would contribute to the upfront capital costs of the solar+storage system. Once the cost of the system is paid off, the residents will fully own their stake in the energy and assets of the community microgrid. They will no longer need to pay for the electricity generated by the system. This model encourages and creates pathways to pursue community ownership of energy resources. Residents who own their own energy-generating resources will have a sustainable way to reduce their monthly expenses and create opportunities to build wealth through asset ownership.

CTC would like to expand participation options for residents and businesses that are not well-suited to host solar and/or battery storage. Individuals and organizations that have installed solar+storage can act as hosts and sell excess power generation to other businesses whose rooftops are not ideal for hosting a solar array, thus increasing participation in the program and providing additional revenue to site hosts. CTC believes that the revenue generated will directly reduce income disparities across racial and cultural lines. CTC is engaged with other nonprofits, for-profit entities, and institutions of higher education to make this goal a reality.



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