# First West African hydro-solar plant deployed in Ghana

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Aerial view of 50-MW solar PV plant, with 200 additional MW under development. Credit: BPA

The first West African hydro-solar plant was deployed in Ghana in January, with technical support from the United States Agency for International Development (USAID) and the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). Once its full capacity is brought online, this hydro-solar plant will put Ghana on track to cut its power sector greenhouse gas emissions by 235,000 tons per

year.

As energy demand increases in Ghana, its government is seeking to diversify the country's energy mix and find innovative ways to integrate variable renewable energy (VRE) into its national grid—particularly wind and solar—to reach its target emissions goals, shift away from fossil fuels, supplement hydro resources during drought periods, and lower energy costs.

To support this effort, in 2017 the USAID-NREL Partnership facilitated discussions with Ghana's Bui Power Authority (BPA) at an NREL-hosted workshop focused on advanced photovoltaic (PV) plant capabilities, solar and wind grid integration, and best practices on integrating small-scale and utility-scale VRE into Ghana's grid. Following the workshop, BPA invited the NREL team to provide additional technical assistance to support BPA with adding power from solar PV to an existing 400-megawatt (MW) hydroelectric dam to cut greenhouse gases, augment the hydro power, and provide energy diversity.

Building on those discussions, USAID's Power Africa West Africa Energy Program (WAEP) and NREL collaborated with BPA to operationalize the first 50 MW of PV within the existing Bui Generating Station hydroelectric dam site in 2021, with plans to grow PV capacity to 250 MW. Scheduled for completion by late 2022, the plant will also contain a 20-MW-hour battery energy storage system and controls, which the NREL team suggested so the plant can meet existing grid codes for renewable energy resources, manage the variability of solar, and increase the country's power sector reliability.

This new capacity will provide enough energy to power an estimated 200,000 households and allow BPA to gain valuable experience in developing more solar energy projects.

"The global challenge of climate change, as well as the need to secure energy supply, makes the development of the hydro-solar plant very important for Ghana and West Africa," said Peter Acheampong, deputy director of renewables at BPA who closely collaborated with the NREL-WAEP team.

## Building the PV installation

Since 2017, the NREL-WAEP team has hosted workshops, provided technical analysis, reviewed grid impact and stability studies for the plant, modeled power flow for transient events, and evaluated plant designs to ensure compliance with Ghana's new grid codes for VRE. They also offered guidance on utility-scale PV and worked closely alongside stakeholder and industry groups in Ghana to review best practices with operationalizing this large-scale VRE plant. In addition to working with BPA and the Volta River Authority (VRA, another Ghana power authority), the NREL-WAEP team collaborated with sector agencies, including distribution utilities, transmission utilities, and independent power producers, in conducting analytical studies and impact assessments beyond the Bui solar project.

The addition of PV to the hydro plant allows BPA to balance the variable output of solar by simultaneously increasing or decreasing hydro power output in real-time to maintain a steady power supply to meet demand, including the addition of new controls and capabilities to effectively manage output. NREL worked closely with BPA's renewable energy manager to provide in-depth analysis of the impacts of such hybrid hydro-PV operation, and the institutional, operational, and hardware changes required to ensure the proposed system can operate in a hybrid manner while maintaining system stability and reliability. In parallel, NREL worked with Ghana Grid Company Limited, the system operator and transmission asset owner, to better understand the potential operational impacts of interconnecting BPA's hybrid system.

"We are equipping them with all the tools and lessons we learned in the United States about VRE integration, and, in some cases, helping them to avoid some of the challenges we had with the latest technology and standards. Having this type of partnership is an effective way to streamline the process of integrating advanced technologies," said David Corbus, the Wind Grid Integration Lead at NREL and a member of the NREL-WAEP team supporting the Ghana solar project.

This project represents a major advancement in West Africa's efforts to integrate larger shares of renewables into its regional energy mix. As Ghana President Nana Akufo-Addo stated in a speech read on his behalf, "This further shows my government's commitment to deliver on the promise to increase the renewable energy component in our energy mix to 10 percent by 2030."

The first 50 MW of the plant generates energy onto the national grid during the day, with 1 MW of the installed system consisting of floating solar PV. Overall, the hydro-solar hybrid installation allows Ghana to harness its immense solar resources, combat low water levels during the dry season, and provide grid operators more flexibility to run the hydropower plant at night.

## Exploring rooftop solar

In parallel to the large-scale utility PV installation, the NREL-WAEP team is also supporting deployment of decentralized PV in Ghana, enabling consumers to tap into the savings of rooftop solar. The team is providing electric distribution companies with the tools needed to understand and plan for distributed PV, recognize the financial impact for utilities and consumers under different scenarios, and rapidly assess the benefits and challenges of capacity-hosting analysis and new customer solar installations.

"We worked with the Electricity Company of Ghana and the Northern Electricity Distribution Company, where we transferred open-source software to them and gave them training, capacity building, and workshops with utility engineers where we assessed plans and looked at studies for integrated distributed PV," Corbus said about the team's contributions to Ghana's behind-the-meter PV planning.

Part of the training involved completing utility revenue impact analysis and tool development training, which assesses how PV affects build models, cash flow, and revenue. The team also works with the Public Utility Regulatory Commission and the Energy Commission of Ghana to clarify results, respond to questions and challenges for distributed PV planning, and translate analysis outcomes into policy.

## The road ahead

The Bui Hydro-Solar Hybrid project is a historical leap toward a more sustainable future for Ghana and West Africa, paving the way for more renewable energy technologies across the continent, serving as a model for future hybrid plants, and demonstrating how interagency collaboration can accelerate program results and enable future partnerships.

"Through a societal push towards sustainable clean energy, it is my hope that a total of 60% or more power supplied to the national grid is from renewable energy sources. Although it may be on a higher side as Ghana is a developing country and we might be constrained to some uncontrollable factors, with the right mentality, we can push to make this dream or hope a reality," said Acheampong.

But there is a long road ahead: more than half of Sub-Saharan Africa still lacks access to electricity. The NREL-WAEP team is continuing its work to bring clean, accessible, and affordable energy to the region,

overcoming cross-cultural and geographic barriers to solve mutual deployment goals and provide innovative and reliable energy solutions.

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