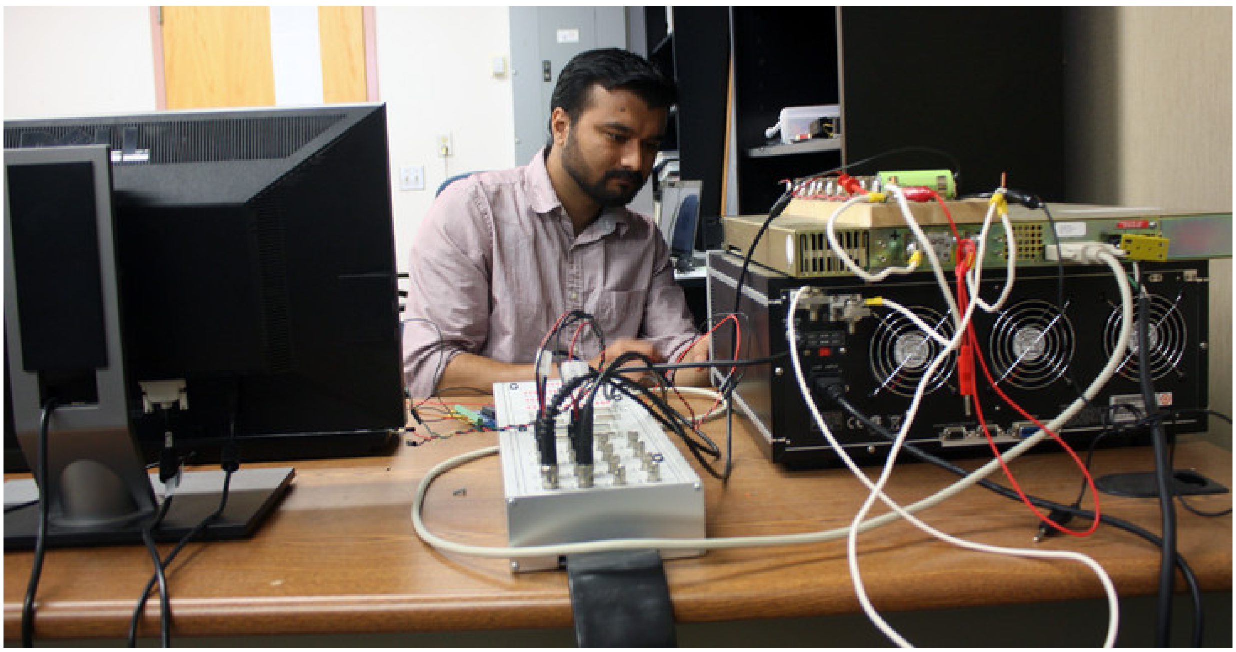
New approach for storing energy could make solar farms less costly

October 11 2016, by Chris Hennessey



Partha Mishra, a Ph.D. candidate in mechanical engineering, uses testing equipment linked to a computer to analyze the state of charge of a battery in a lab in Reber Building at Penn State University Park Campus. Credit: Chris Hennessey

A visit to a commercial solar energy farm anywhere in the world reveals the need for matching the variable electric supply generated by the farm's solar panels to the electricity needs of different clients.

Energy storage provides one solution to this problem: solar panels can collect energy and send it to battery packs for storage until it is needed and drawn off into the power grid. While this arrangement works, the large battery packs are costly, due in part to the power electronics inside each pack.

Power electronics, such as inverters, are needed for the operation of a solar farm, but battery packs often require their own circuits for the charge stored in their many cells. This balancing is necessary for pack efficiency and safety, but the electronics needed for balancing can be quite costly. Much effort has gone into improving and refining battery pack balancing circuits in order to maximize their cost effectiveness, efficiency, reliability, and performance.

Partha Mishra, a Ph.D. candidate in mechanical engineering, and his faculty advisor, Hosam Fathy, co-authored the paper, "Can Photovoltaic Energy Storage Systems Be Self-Balancing?", which has been selected as a finalist for the Best Student Paper Award at the American Society of Mechanical Engineering Dynamic Systems and Controls Conference, October 12 in Minneapolis, Minn.

Their paper offers a new way of thinking about solar energy storage. At the solar power station proposed in the paper written by Mishra and Fathy, small groups of photovoltaic (PV) cells are connected to a small lithium-ion battery. Together, the PV cells and the battery form a hybrid unit. Their paper shows, both theoretically, and in simulation, that when the resulting hybrid units are assembled in series into a hybrid string, there is no need for balancing circuitry anymore.

"Partha is able to achieve a property never attained before in lithium-ion battery packs: an inherent self-balancing capability," Fathy said.

This self-balancing property is a result of the behavior of PV cells: when a battery cell in Mishra and Fathy's hybrid string operates at a lower voltage than another cell in the string, the photovoltaic cells attached to the lower-voltage battery cell pump more electrons into it, increasing its voltage. Differences in voltage between cells in the hybrid string diminish to zero if all the units in the string are homogenous – or identical – in terms of their design, manufacturing, and the solar irradiation levels they experience. Heterogeneities among cells may cause the cells to converge to slightly different final voltages, at slightly different rates, but the system remains self-balancing in the presence of heterogeneity, in the sense that large discrepancies in voltage between different cells still diminish significantly with time.

"The main advantage," of the proposed technology, said Mishra, "is cost reduction."

Balancing a battery pack can be achieved with costly power electronics, but the ability to balance a battery pack without balancing electronics is very appealing from a cost perspective.

Mishra and Fathy's paper points to another advantage: the time needed for balancing a battery pack using traditional balancing circuits often increases with the number of cells in the pack. This places a practical limitation on how large battery packs can get before balancing becomes challenging, and therefore places a practical limitation on battery pack voltages. The self-balancing topology proposed by Fathy and Mishra has a balancing time that is independent of the number of hybrid cells in series, which may allow for longer strings and higher pack voltages.

The new approach to solar energy storage has been examined using both mathematical analyses and simulations, but hardware demonstrations are important for translating this approach into a commercial product. "We are looking forward to doing real-world experiments," said Mishra.

The discovery of this new topology for integrating photovoltaic and battery cells has created a lot of excitement in Fathy's research group.

"To me, the most exciting aspect of this work is that it gives us a new system to study, understand, and explore," said Fathy. "To the best of our knowledge, this integration topology has never been studied before, so there is much to learn regarding its dynamics, behavior, and design."

For his part, Mishra is excited about the potential of his work, but also about presenting to an audience of peers and experts, and benefitting from their feedback.

"I will present the paper twice. Once at a regular session and again at a special session for the Student Paper Competition," he said. "I'm refining my slides and getting ready."

Provided by Pennsylvania State University

Citation: New approach for storing energy could make solar farms less costly (2016, October 11) retrieved 26 April 2024 from https://techxplore.com/news/2016-10-approach-energy-solar-farms-costly.html