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Queensland powers up to make solar energy ready for networks

The Australian university is on track to offset its energy needs from its own solar farms, which are also research platforms that help solve the challenges of incorporating solar into existing electricity grids

The need for renewable energy has never been more urgent. Global energy demand increases every year, and access to cheap energy is a key factor in pulling more and more people from poverty. However, finding a sustainable solution that does not impact the environment is also essential.

Tantalisingly, the use of photovoltaic solar panels to turn sunlight into electricity is now a mature technology option – but feeding solar power into existing electricity networks is not straightforward, and sometimes looms as a serious hurdle.

As nations and communities turn to solar at an accelerating rate, a daunting problem is keeping researchers awake at night: how can we integrate a highly variable energy source into power grids that must maintain stable and reliable electricity?

Solar panel output can change markedly through the course of a day as weather and cloud cover changes. Existing electricity networks are not designed for this variability, or for hundreds of thousands of distributed solar PV generations at customer premises. Consequently, due to bi-directional power flows, voltage fluctuations can cause serious equipment malfunction or cause power systems to operate outside an accepted voltage range.

Artist impression of the soon-to-be-constructed 64MW Warwick Solar Farm near Brisbane, Australia, which will ultimately make The University of Queensland energy neutral

It's a global challenge, and one that is a priority for researchers at The University of Queensland (UQ) in Australia, which has invested in unique research infrastructure to solve this PV integration problem.

The university operates several distributed rooftop solar plants at its St Lucia campus, and a centralised, medium-sized solar plant at its Gatton campus, which has three different technologies and a battery system. These plants are embedded within a multidisciplinary R&D program, which brings together expertise in electrical engineering, big data and machine learning, as well as energy economics.

Professor Tapan Saha, head of UQ's Power and Energy Systems Group, leads the integration program. He explains that the UQ's solar plants produce continuous streams of high-resolution data, meaning that information from across an entire power plant is collected every minute at St Lucia and every second at Gatton.

"This data allows us to quantify the variability associated with solar power generation and its impact on the grid," he says.

"From this we can model voltage stability impacts on an electricity grid, identify ways to improve voltage management, and engineer solutions that will facilitate increased distributed solar power, and solar power reliability, in the energy mix."

Double benefit

Concurrently with this research, UQ's current and future solar plants are on track to help offset the university's annual AUD$22 million electricity bill. Once finalised, this will equate to an annual saving of around 150,000 tonnes of green gas emissions and will make UQ the first university in the world to generate more energy than it consumes.

The St Lucia and Gatton plant set-ups are so unique that universities, government agencies and companies around the world use their data. This has prompted several research collaborations with electricity utilities and universities around the world to develop advanced voltage management technologies.

> **"Energy generated at the Warwick site will ultimately make UQ energy neutral, a feat that will allow the University to eventually recoup its financial investment in solar energy generation and research"**

"The University encourages engagement with researchers and industry nationally and internationally," says Andrew Wilson, UQ's Manager of Energy and Sustainability.

"That engagement extends to students because the facilities are also a prime site for teaching."

Construction of the University's solar power capability began in 2010 and has three components.

The first is a 2.4 megawatt (MW) system installed across 25 rooftops on UQ's St Lucia campus, in Queensland's capital city, Brisbane. This installation includes live data displays to promote campus awareness and engagement with the initiative, and will soon also include Tesla Powerpack battery storage.

The second is the Gatton Solar Research Facility (GSRF), a 3.3 MW plant that also includes battery storage and is located at UQ's agricultural campus at Gatton, 100 kilometres west of Brisbane. This site has been operating since 2015, and was one of Australia's largest solar farms when it was commissioned.

The GSRF includes a mix of fixed panel arrays alongside systems that can track the sun by rotating 180 degrees (called a single axis tracking array) and 340 degrees (dual axis tracking array). The GSRF has become integral to a large body of international research on the network challenges posed by solar energy.

"Our combination of fixed and rotating arrays is unique and means we can quantify the additional power available when solar panels can align to capture optimal sunlight," Professor Saha says.

He says the research and prospective outcomes are also kept tethered to the realities of energy economics.

"Besides broadening our datasets, an economist on our team uses the Gatton Solar Research Facility to understand the economic costs and benefits associated with, for example, fixed versus rotating arrays at commercial scales."

Lessons learnt at Gatton were used to help design the third and largest component – an AUD$125 million investment in a 64 MW solar farm at Warwick, 160 kilometres south-west of Brisbane. Data obtained from this new plant will help place UQ at the forefront of research to understand the variability of energy yield, generation prediction, demand response capability and real-time market risk in large-scale solar PV plants.

Construction of the Warwick solar farm will begin in February 2019 using single axis tracking array technology. Comparisons between single and dual axis tracking at the Gatton facility have already demonstrated that this configuration provides the optimal balance between energy capture efficiency, capital costs, maintenance requirements and operational resilience.

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It's not surprising there is 'electricity in the air'.

"Energy is an exciting space to be working in," says Andrew Wilson.

"Based on our financial modelling, solar power is the cheaper energy option for UQ both today and over the long term. Cost reductions in recent years have made these technologies increasingly attractive as they also help UQ to achieve sustainability goals."

It's this potential on a global scale that makes solving the solar generation/network stability issue so crucial and why UQ has placed such a major research initiative into this space.

Professor Saha goes a step further and believes, based on some of the big data and machine learning research that is already underway, that resolving the voltage management and other power quality issues at the Gatton solar array with storage capability demonstrates solar power's potential to actually improve network reliability under certain supply-demand scenarios.

Such early findings are already being explored in greater detail and new data from the plant at Warwick will help to develop solar farm management systems that provide operational services to power grids.

"With industry partners, we are trialling new technologies and designing control systems to mitigate for voltage variation, and we are confident this is achievable without the intermediary of batteries," Professor Saha says.

This would be a step-change in renewable energy technology. For Professor Saha it is the future; a future that he and his team are striving to bring to reality as soon as possible.

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