NTU team studying potential climate impact on nation's renewable energy

Temperatures of more than 35 deg C could cause solar panels to overheat and reduce their efficiency, while moisture from humidity could cause the panels to degrade faster, says Associate Professor Xu Yan from the Nanyang Technological University's Centre for Power Engineering.
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Unpredictable and extreme weather can affect the efficiency of power plants

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Alarmed by signs that the planet is warming up, countries are shifting to renewable energy, but how well green energy can shield societies against a worsening climate is also a growing concern.

Solar panels could malfunction at temperatures of more than 35 deg C, while wind turbines could spin to a halt with typhoon-level gusts.

A local research team is looking into how Singapore's electricity supply and demand could change with the climate, to help determine how it adapts its energy system.

Using data from the third national climate change study, or V3, a team led by Associate Professor Xu Yan from the Nanyang Technological University's Centre for Power Engineering is studying how warmer temperatures and extreme weather events could impact hydropower, solar and wind production in the region, with a focus on Malaysia, Indonesia and Vietnam.

V3, which was released on Jan 5, localises global climate projections from the latest report by the Intergovernmental Panel on Climate Change – the United Nations' top climate science body – so that they are applicable to Singapore and the broader South-east Asia region.

The V3 study examined the varying severity of climate impacts that Singapore and the region could experience – across low-, medium- and high-emission scenarios.

Each scenario presents how well the world is able to mitigate greenhouse gas emissions in the coming years.

Singapore is also greening its energy mix, with some 30 per cent to be imported in the form of renewables from Cambodia, Indonesia and Vietnam by 2035.

Unlike natural gas, relying more heavily on renewables would require the electricity grid to essentially match peak electricity supply – such as on sunny days, which would allow solar panels to work at maximum capacity – with peak demand, when commercial and industrial activities are running at full speed.

And climate change could throw a spanner in the works, with unpredictable and extreme weather impacting the efficiency of these power plants, while peak demand for electricity is expected to rise continually.

Relying on geographical weather data, the NTU researchers hope to create a model that would map temperature, rainfall and extreme weather projections with local and regional renewable energy production, Prof Xu told The Straits Times.

While it is known that South-east Asia is already vulnerable to extreme weather events such as heavy rainfall and tropical cyclones, data from V3 will provide weather predictions for the region in more detail.

"This could help us to determine the most optimal location to build a solar or wind farm. For instance, it could be in an area that is expected to be less vulnerable to climate impacts," said Prof Xu.

Other factors play a part too, such as determining suitable locations for power lines to be laid, and each country's rules and regulations on renewable exports.

For instance, in 2021 and 2022, Malaysia and Indonesia temporarily banned or suspended the export of renewable energy to prioritise their domestic needs.

Ultimately, the goal would be to help the authorities to determine the most cost-effective way for Singapore to reliably import renewables from the region, Prof Xu added.

Findings from the study, which started earlier in 2024, will be periodically presented to the Energy Market Authority (EMA) and the National Environment Agency, he said.

Importing renewables could come at a hefty price.

Battery storage systems may be needed to supplement renewable power plants to deliver the promised electricity capacity, while subsea cables to transmit the electricity are expensive.

These are also susceptible to damage as a result of warming oceans, said Prof Xu.

The study will also look at how Singapore's peak electricity demand could change with the climate, especially with more frequent hotter days and warmer nights – which are an inevitability, according to V3 predictions, he said.

For instance, in May 2023, peak electricity demand increased by 8 per cent, from 7.3 gigawatts to 7.9GW. The temperature in Ang Mo Kio hit 37 deg C on May 13 that year – the hottest on record since 1983.

In addition, the study will investigate how well Singapore's solar panels will continue to function in hotter weather and increased humidity.

More than 1GW-peak of solar panels have been installed in Singapore so far, with plans to raise capacity to 2GW-peak by 2030.

Temperatures of more than 35 deg C could cause solar panels to overheat and reduce their efficiency, while moisture from humidity could cause the panels to degrade faster, said Prof Xu.

While this has not occurred thus far, measures can be taken to avoid overheating.

Mr Melvin Chen, the head of power and renewables consulting for the Asia-Pacific region at Wood MacKenzie, said that in most cases, the developers of the solar projects would have accounted for such performance-related issues in their design and likely would have increased the overall capacity to account for the drop.

This would allow them to meet EMA's requirement of operating at 75 per cent load factor for power imports, which refers to the power efficiency of the plant.

Batteries also play an important role, storing energy during periods when the panels are overperforming and discharging when underperforming, such as on hotter days.

To mitigate overheating, ground-mounted solar panels and floating solar photovoltaic panels have air cooling, unlike the traditional rooftop solar panels, said Dr Kim Jeong Won from the National University of Singapore's Energy Studies Institute.

Using light-coloured and reflective materials can also help to reduce heat absorption, said Dr Kim.

Likewise, wind turbines may shut down at excessively high wind speeds, and severe storms may damage turbine blades, reducing the turbines' efficiency, she noted.

Mr Chen said that offshore wind farms today can withstand adverse wind conditions, but there are still design limitations.

While there are few documented cases of weather-related damage to offshore wind turbines, more of them have been installed in hurricane-prone regions like the US and Taiwan, and so more studies are needed to understand how extreme weather events could impact them.

The impact of climate change-induced droughts on hydropower production, however, is most palpable, as seen in China and Europe in 2022.

Closer to home, droughts in Laos in 2023 raised concerns that hydropower exports to Thailand could be reduced in future, noted Mr Chen.

Dr Yong Ming-Li, a research fellow in Hawaii's East-West Centre, a think-tank that focuses on the United States, Asia and the Pacific, noted that the Lower Mekong Basin, comprising Laos, Thailand, Cambodia and Vietnam, is one of the regions most vulnerable to climate change, and has had a history of drought affecting hydropower production.

For instance, the Lower Sesan 2 Dam in Cambodia, which is built on a critical tributary system of the Mekong River and became operational in 2018, has faced trouble in reaching its full generation capacity due to drought, she added.

Hydropower dams are also contributors to climate change, as the large storage dam reservoirs are a source of methane and carbon dioxide emissions, while cement production to build dams can also be a source of emissions.

"In general, a growing appetite for hydropower from countries like Thailand and Singapore is likely to bolster the Lao government's resolve to become the 'Battery of South-east Asia', and to cement its pathway to doing so through hydropower development," said Dr Yong, whose work focuses on hydropower development in the Mekong River Basin.

For instance, Thailand has been criticised for driving unnecessary demand for Lao hydropower due to its inflated energy demand projections and propensity to over-invest in energy projects.

Hydropower projects have been criticised for the negative impact on surrounding communities.

In the Vietnamese Mekong Delta, for example, the combined effects of hydropower development, sand mining and climate change have led to severe drought in 2016, and threatened the agricultural productivity of Vietnam's rice bowl, while affecting fishermen's livelihoods, noted Dr Yong.

Singapore, as a major importer, could influence greater governance on mitigating the environmental and social impact, such as by mandating more robust environmental impact assessments. But the impact will never be zero, said Mr Chen.

Dr Yong suggested more concerted coordination among countries in the Mekong River Basin to prioritise the ecological health of the river for rural livelihoods, economic development and nature-based solutions to tackle regional climate change.

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