



As Singapore continues to strike a balance between providing reliable supply and cost to consumers, it is modernising its grid and exploring opportunities that can be pursued in renewables, data analytics, control and consumer empowerment. This is key to addressing climate change.

BT FILE PHOTO

Powering Singapore for the future

Advances in digital technologies will usher in the use of smart meters within a Smart Grid, communications networks and data management systems. **BY SUBODH MHAISALKAR AND AMIT PATHARE**

CLIMATE change – a key topic during the Singapore International Energy Week – is the existential threat today. The drumbeats are getting louder, and the world is beginning to listen. On the other hand, with improving living standards, growth in global energy demand is seen as inevitable. These seemingly contradictory priorities of growth and reducing environmental impact are prompting governments and corporations to consider the challenges and opportunities presented by green growth where economic expansion is decoupled from energy usage.

A large proportion of the global strategy for reduction in emissions intensity will rely on electrification and deployment of renewable energy. The world's primary energy supply continues to rely on fossil fuels like coal, gas and oil. Renewables contribute only around a quarter of the energy mix, even though their share is growing. Driven by falling costs of solar cells and wind energy (88 per cent and 54 per cent reduction respectively from 2010 to 2019), investments in renewables capacity continue to outstrip those in new capacity of fossil fuel-based power generation. Battery costs have similarly fallen 86 per cent from 2010 to 2019, making electric vehicles progressively cheaper and easier to provide back-up for solar cells for when the sun doesn't shine.

Energy demand delivered by electricity (for example, transportation, cooking, cooling) will double from 19 per cent in 2017 to 40 per cent in 2050. This shift to renewables and electrification will require a fresh look at the power sector.

The current "power grid", designed in the late 19th century, is uni-directional where energy flows from central power plants to the customers. In Singapore, power-generation companies produce electricity which is transported to customers via the power grid owned and operated by SP Group. Integrating renewables and catering for large variable loads (such as charging of electric cars and buses) have created the need for the advent of the "Smart Grid".

THE SMART GRID

Recent years have seen numerous advances in digital technologies. These advances include smart meters, communications networks and data management systems that enable two-way communication between utilities and customers. Better monitoring and control have enhanced both energy efficiency and reliability.

The Smart Grid is thus an electricity network that enables integration of renewables and uses smart technologies to better serve consumers.

SP Group's Smart Grid Index 2019 compares 75 utilities from 35 countries. US and European utilities were ranked higher than many Asian utilities. This could be attributed to the US/European utilities' continued focus on green energy adoption. Singapore was ranked 33rd (score of 66 per cent), while utilities from the Asean countries were ranked between the 50s and 60s with scores in the range of 45-50 per cent. Asia-Pacific utilities have also made significant improvements in Distributed Energy Resources, security and customer empowerment and satisfaction. US/European utilities fare better in areas including monitoring and control, data analytics, renewables integration, green energy, security as well as consumer empowerment.

By one indicator – the System Average Interruption Duration Index which measures the average duration of interruption in power supply, indicated in minutes per customer – Singapore is the undisputed world leader. The Republic's grid performance, measured in terms of both the frequency and duration of grid outages, is far better than that of even the other cities in the top 10 – including Tokyo, Frankfurt, London, Taipei and Hong Kong.

Singapore's high performance may be explained by our urban, high-density networks, continuous investments in advanced technological solutions, and the use of underground cables instead of overhead lines that are vulnerable to natural disasters. Singapore's approach towards Smart Grids prioritises sustainable growth, energy security and affordability. The grid charges in Singapore for the average consumer are among the lowest in the world. Some consumers may be willing to pay more for fewer outages, but it is neither feasible to charge different prices according to the quality of electricity supply nor socially possible to impose high charges on everyone.

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THE SMART GRID OF TOMORROW

Levelling up, the Smart Grid of tomorrow is envisioned to be a technology leap that will usher in the Internet of Energy, with the capability to manage millions of con-

nected devices at all levels of the grid.

Replacing today's analog power-line transformers with power electronics will allow bi-directional energy flows, enable intelligent and remote network management, and usher in the era of a fully digital power grid.

The grid will also require an added buffer of storage and demand sinks and an array of power devices that will allow it to absorb massive swings in supply and demand and cater for intermittency of renewables.

These hardware improvements will be optimised by a range of software solutions driven by stochastic algorithms that integrate supply and demand movements. We can think of it in terms of a new Artificial Intelligence "brain" for the grid that can:

- absorb and structure the vast amounts of data being continually generated by a multitude of devices;
- deploy platforms and protocols for these devices to "communicate" with each other; and
- adapt, learn and evolve in order to keep improving grid efficiency without compromising on security.

Transactive platforms could potentially use blockchain technology with embedded encryption for power transactions enabled by ultra-fast 5G telecommunications networks.

As Singapore's challenges are markedly different from America's and Europe's, we require a different approach. Feed-in-tariffs, microgrids, natural disasters and transmission over hundreds of kilometres are not top challenges to the Singapore power grid. Instead, Singapore has to deploy and integrate renewables into its power system.

Although the architectures of future grids are still emerging, Singapore's priorities include clean energy generation, energy efficiency and grid resilience. Initiatives to support these include power generation from natural gas and potentially hydrogen in the future, deployment of solar cells coupled with energy storage, building and industrial energy efficiency, and electrification of transport.

The time for incremental efforts is gone. A groundbreaking shift in clean energy deployment, underpinned by the right supporting infrastructure for scale-up of these solutions, is the way. In keeping with the Smart Nation vision, the Smart Grid offers an unparalleled opportunity to leverage the full potential of electrification that enhances security, reliability and affordability. This is key to addressing climate change and delivering sustainable development for Singapore.

■ The writers are from the Energy Research Institute (ERI), Nanyang Technological University (NTU) of Singapore. Subodh Mhaisalkar is associate vice-president and professor at the School of Materials Science and Engineering at NTU, and also executive director of the ERI. Amit Pathare is a senior scientist and programme director at ERI.