

Powering the Future

The Critical Role of Transmission,
Storage and Grid Integration

Real impact,
made together.

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Beyond Generation:

Building the Energy Grids of Tomorrow

The global energy landscape is undergoing its most profound transformation since the advent of electricity. As renewable energy sources rapidly displace fossil fuels, the spotlight is shifting from how we generate power to how we move, store and manage it. The reality is clear: there is no energy transition without transmission, and there is no grid stability without storage.



Hybrid Energy Storage (AI generated image)



The Grid Challenge:

From Bottleneck to Enabler

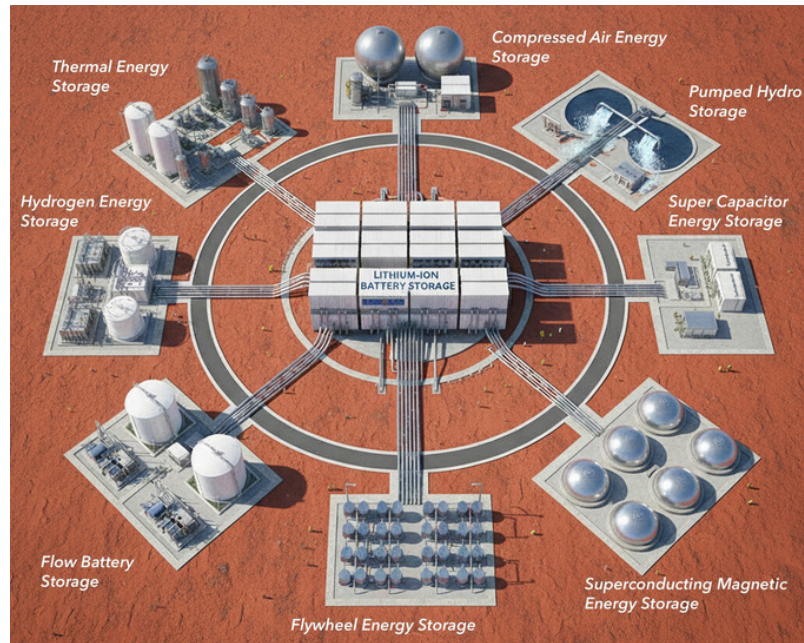
Many of the world's transmission grids were designed for an era of consistent, predictable power output from fossil fuels. These ageing systems are ill-equipped to manage the variability inherent in renewable sources like wind and solar. The challenge is twofold: grids must not only expand to accommodate new clean energy sources but also adapt to their intermittent nature.

The scale of the task is staggering. The International Energy Agency estimates that over 80 million kilometres of transmission and distribution lines would need to be added or replaced by 2040 for countries to meet their decarbonisation goals – equivalent to the entire existing global grid. Meanwhile, the US Energy Information Administration projects a 34 per cent increase in world energy consumption by 2050, driven by population growth, expanding manufacturing and rising living standards.

This is not merely an infrastructure challenge; it is an economic imperative. Grids that cannot keep pace with the energy transition risk becoming bottlenecks that constrain growth and delay decarbonisation.

The Storage Revolution: Balancing Supply and Demand

The intermittency of renewables – solar panels that generate only when the sun shines, wind turbines that turn only when the wind blows – creates a fundamental timing mismatch between generation and consumption. Energy storage has emerged as the critical bridge, but no single storage technology offers a complete solution.



Energy Storage Solutions

This is where Hybrid Energy Storage Systems (HESS) come into their own. By combining complementary technologies, HESS optimises performance in ways that individual systems cannot achieve:

Lithium-ion batteries with supercapacitors

buffer high-power transients,
extending battery life and improving
responsiveness

Lithium-ion with hydrogen storage

combines fast response with long-
duration energy capacity

Lithium-ion with pumped hydro

integrates bulk energy storage
with rapid operational flexibility

Lithium-ion with vanadium redox flow batteries

merges power density with long
cycle life and intrinsic safety

In Indonesia, at the Balambano hydroelectric project, lithium-ion batteries are replacing diesel generators for black-start capabilities, delivering significant emissions reductions. And in partnership with VFlowTech, we are advancing underground hybrid systems that combine lithium-ion with vanadium redox flow batteries, maximising land-use efficiency in urban environments.

Grid Stability:

New Solutions for a New Era

Modern grids require sophisticated operational flexibility across four key dimensions: power, voltage, transfer capacity and energy storage.

Traditionally, rotating fossil-fuel plants provided system inertia, helping to stabilise frequency fluctuations. As these plants retire, new technologies must fill the gap. Battery energy storage systems with grid-forming inverters – such as the 250MW Torrens Island Battery Project in South Australia – now provide synthetic inertia, marking a world-first in battery technology. Similarly, synchronous condensers mimic the effect of fossil-fuel turbines by spinning freely and supplying reactive power, maintaining grid stability without emissions.



To address grid stability challenges in Ghana, our teams have engineered a Static Synchronous Compensator (STATCOM) solution and implemented Supervisory Control and Data Acquisition (SCADA) systems together with Advanced Distribution Management Systems, improving both grid resilience and operational efficiency.

Optimising Existing Capacity

Expanding capacity by adding new transmission lines is not always feasible due to land constraints and the complexity of land acquisition. Innovative solutions are therefore essential:

- **Grid power generation curtailment** helps balance supply and demand without immediate infrastructure upgrades.
- **High Temperature Low Sag (HTLS) conductors** increase the thermal capacity of power lines while reusing existing structures.
- **Advanced monitoring and control systems** enhance transmission capacity and reliability through real-time scenario planning and network simulation.

In Tanzania, our Distribution Masterplan Study demonstrates how long-term planning can address increased energy access to rural communities, demand forecasting and the integration of distributed energy sources.



Madhya Pradesh Green Energy Corridor

Regional Integration:

The Future of Energy Trade

As renewable installations are often far from demand centres, long-distance transmission infrastructure is essential. Extra High Voltage (EHV) and High Voltage Direct Current (HVDC) transmission lines facilitate electricity trade across borders, much like major road and rail networks enable trade of goods.

Ambitious projects such as Sun Cable's Australia-Asia PowerLink, which aims to transmit renewable energy from Australia to Singapore via HVDC submarine cable, illustrate the potential for long-distance, cross-border renewable energy transmission. Similarly, the planned ASEAN power grid promises to integrate the national power systems of its ten member countries, accelerating regional decarbonisation.

Conclusion

As the global energy transition unfolds, the expansion of utility-scale renewable energy will depend on dynamic, agile transmission networks. Grid systems must maintain a constant balance between supply and demand, with stable voltage levels and network frequency control.

Bill Gates captured it succinctly: 'Climate change is the hardest problem humanity has ever faced, but I believe we have the human ingenuity to solve it. And if you care about climate change, you should care about transmission.'

At Surbana Jurong and SMEC, our Global Energy business is developing solutions for rapid decarbonisation. Through systems thinking, we are implementing effective solutions to provide affordable, reliable and clean energy for all. By integrating hybrid energy storage technologies and advancing transmission grid development, we are turning the challenge of renewable intermittency into an opportunity for a more resilient energy future.

There is no transition without transmission and energy storage.



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