Transmission in the Transition

Adapting transmission systems to futureproof the growing expansion of clean energy

Transmission Systems of the future need to rapidly adapt to the new world of sustainable energy. Grids need to expand to accommodate the growing new sources of clean energy and adjust to the variability and intermittency nature of such sources.

With real world solutions available and new technologies now maturing, modern sustainable Transmission Systems have become a key enabler of the Energy Transition.

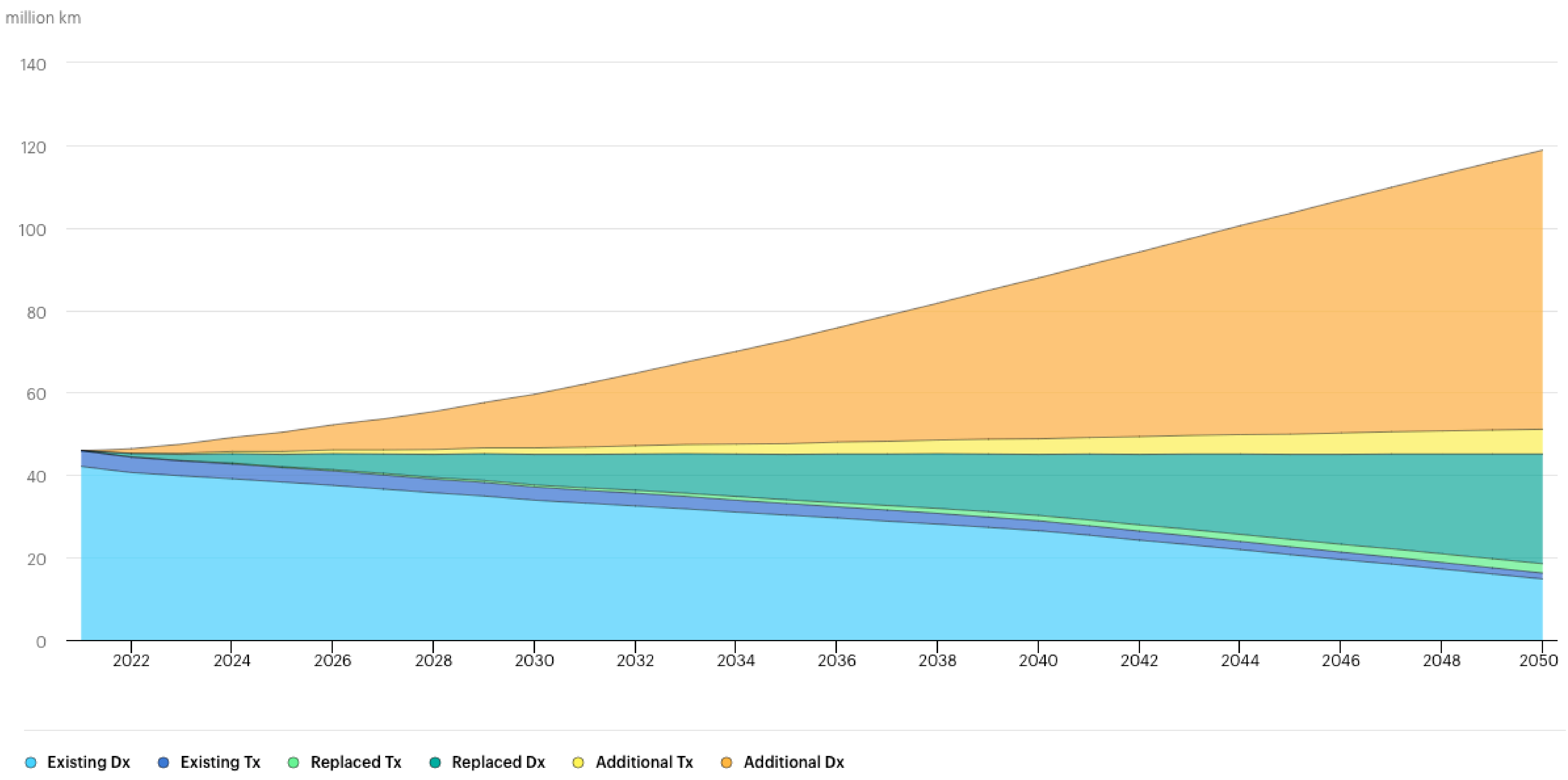
Integrating renewables: why transmission grids are key

Many transmission grids worldwide were designed for consistent power output from fossil fuels. These older grids are ill-equipped to provide adequate inertia to manage the variability inherent in renewable sources like wind and solar. Electricity grids not only need to expand and reconfigure to keep up with a changing energy landscape but also need to enable economic development by meeting the global demand growth.

The International Energy Agency estimates that for countries to reach their individual national goals on decarbonisation, over 80 million kilometres of Transmission and Distribution lines would need to be added or replaced by 2040, the equivalent of the entire existing global grid.

EIA's International Energy Outlook projects a 34 percent increase in world energy consumption by 2050 due to global population growth, increased regional manufacturing, and higher living standards (EIA International energy outlook 2023). Many advanced economies will need to contend with aging transmission infrastructure, which requires huge capital commitments to refurbish and upgrade existing infrastructure to extend its life cycle.

Grid length development in emerging market and developing economies in the Announced Pledges Scenario, 2021-2050



IEA (2023), Grid length development in emerging market and developing economies in the Announced Pledges Scenario, 2021-2050, IEA, Paris https://www.iea.org/data-and-statistics/charts/grid-length-development-in-emerging-market-and-developing-economies-in-the-announced-pledges-scenario-2021-2050, Licence: CC BY 4.0

Solutions for grid stability and capacity expansion

India is one country bucking global trends in transmission infrastructure, making significant strides to expand and modernise its grid to accommodate renewable energy. In regions like Madhya Pradesh, India, SMEC played a critical role in expanding the transmission network to integrate 4,000 MW of solar and wind energy into the grid. The project added 1,700 km of new transmission lines providing clean, stable and affordable energy.

New 'Green Energy' corridors are critical in transmitting power from regions rich in solar and wind energy to demand centres across the country. Phase I is nearly complete, and Phase II, targeting an additional 10,750 circuit kilometres of transmission lines, is set to be finished by 2026.

The future of power transmission will require sophisticated operational flexibility across power, voltage, transfer capacity and energy storage:

- **Power:** Solutions that adjust the amount of electricity generated or consumed.
- **Voltage:** Solutions that regulate the voltage level within the grid.
- **Transfer Capacity:** Solutions that increase or decrease the amount of electricity that can be transmitted.
- **Energy:** Solutions that store or release energy.

This integrated systems approach highlights the many levers that can impact the efficacy of renewable energy transmission. Below we explore three key avenues that illustrate how transmission is adapting to the new world of sustainable energy.

1. Improving transmission system stability

Renewable energy variability requires advanced solutions for stabilising power grids. Historically, traditional rotating plants provided inertia, helping to stabilise frequency fluctuations. However, modern grids must rely on new technologies like battery energy storage systems (BESS) to provide this function.

Projects like the 250MW Torrens Island Battery Project in South Australia, demonstrate SMEC's expertise in grid reconfiguration. The Torrens Island battery is one of the largest in the country and one of the first in the world to feature grid-forming inverters, which provide synthetic inertia. Similarly, the Dalby hybrid solar-storage facility in Queensland combines solar energy with BESS to create dispatchable, reliable renewable power. One of Australia's first true hybrid projects, Dalby leverages recent rule changes, allowing shared grid connections.

Synchronous condensers are another solution to provide inertia and voltage regulation. They mimic the effect of fossil fuel turbines by spinning freely and supplying reactive power, helping to maintain grid stability. Recently, as part of Ghana's Power Compact, SMEC managed the installation of Static Synchronous Compensators (STATCOM) which perform a

Torrens Island BESS

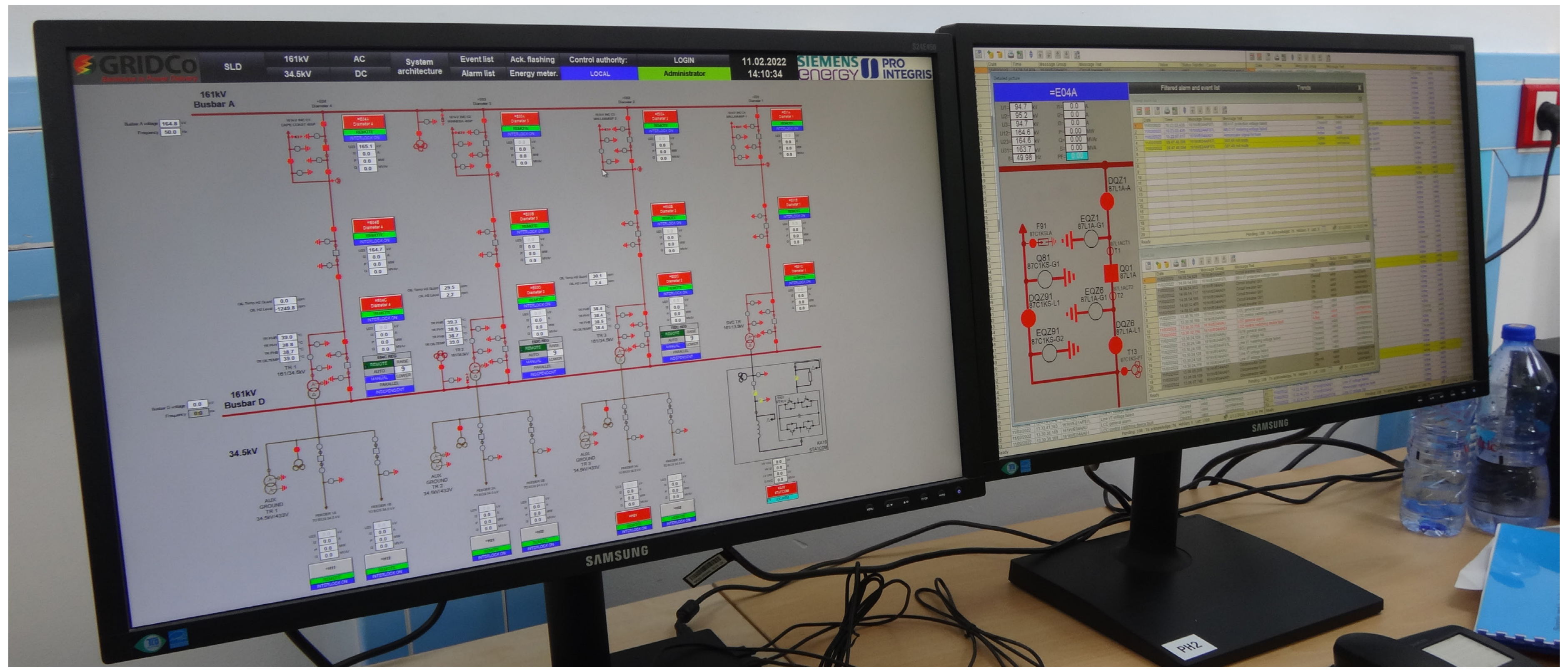
2. Optimising existing capacity

Power grids in many countries are reaching their limits for adding new renewable energy sources, based on traditional planning and operating standards. Adding new transmission line capacity is not always an option due to availability of land and the complexity of the land acquisition process.

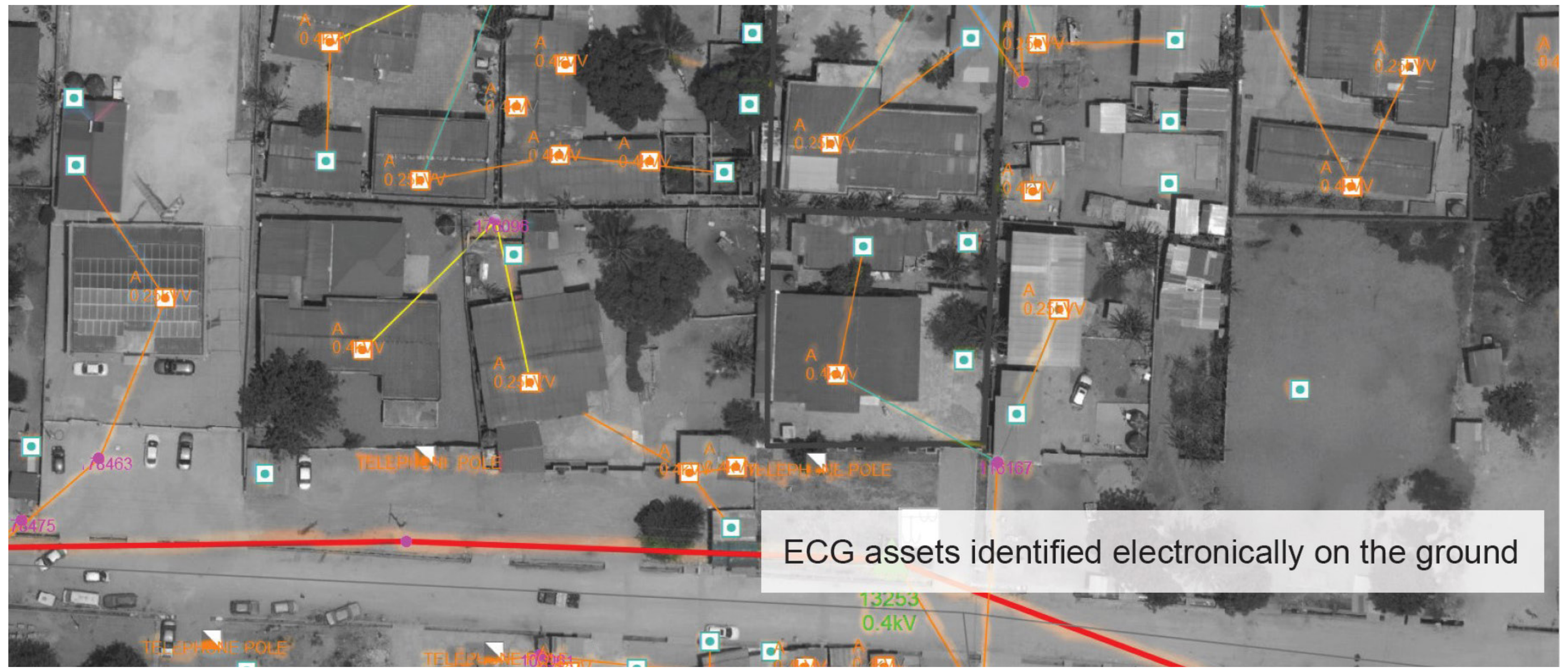
One solution is to use Grid Power Generation Curtailment. This can help optimise existing grid capacity by allowing the system to balance energy supply and demand without the need for immediate infrastructure upgrades. Replacing overhead line conductors with High Temperature Low Sag (HTLS) conductors is another option to increase the thermal capacity of a power line while reusing the existing power line structures. In such cases strengthening and refurbishing of the existing tower or pole foundations may be required to extend the life of the plant. Determining the condition of an existing foundation through non-intrusive inspection methods can mitigate risks and eliminate the need for outages during planning and design stages.

Planning for future energy demands is as important as modernising existing infrastructure. Tanzania's recent Distribution Masterplan Study demonstrates how SMEC contributes to long-term planning, addressing increased energy access to rural communities and the associated grid growth, demand forecasting, and the integration of distributed energy sources. This kind of forward-thinking approach ensures that future grids can meet the needs of renewable energy-driven power systems.

Modern control and monitoring systems can also enhance transmission capacity and reliability. SMEC's power compact team in Ghana led the implementation of Supervisory Control and Data Acquisition (SCADA) systems and Advanced Distribution Management Systems which help to ensure grid resilience and operational efficiency. Scenario planning and network simulatio



Advanced Distribution Management, Ghana Power Compact.



Electricity Company of Ghana GIS spatial database

3. Explore regional grid integration

Electricity trade across country and regional borders is facilitated though interconnected transmission systems. The concept is comparable to a major regional road or rail network facilitating trade of goods across borders. Due to the vast distances and capacities required, Extra High Voltage (EHV) or High Voltage Direct Current (HVDC) transmission lines are deployed.

As renewable energy installations are often far from demand centres, long-distance transmission infrastructure is essential. With the growth of renewable energy generation plants in remote locations where wind and solar resources are abundant it is expected that multi terminal HVDC systems will also become more common place.

One ambitious proposal being considered is Sun Cable's Australia-Asia PowerLink, which aims to transmit renewable energy from Australia to Singapore via a high-voltage direct current (HVDC) submarine cable. This groundbreaking project illustrates the potential for long-distance, cross-border renewable energy transmission, a critical step toward decarbonising global energy systems.

Another example is the planned ASEAN power grid which is hoped will integrate the national power systems of its 10-member countries and facilitate the region's decarbonisation efforts.

Ghana's Power Compact

Conclusion

Bill Gates remarked "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."

As the global Energy Transition unfolds and the demand for clean energy increases it has become clear that the expansion of utility scale renewable energy will rely on dynamic and agile network of transmission grids. Grid systems need to maintain a constant balance between supply and demand with stable voltage levels and network frequency control.

As more renewable energy sources get added to grid networks, additional system inertia support will be required to absorb the impact of varying demand patterns. Through systems thinking we can implement effective systems to provide affordable, reliable, and clean energy for all.

SMEC and SJ has positioned our Global Energy business to develop and advance solutions that will assist with rapid decarbonization and the reversal of devastating global warming trends. To this end our efforts in advancing Transmission Grid system development remain key - as the adage goes, there is no Transition without Transmission.

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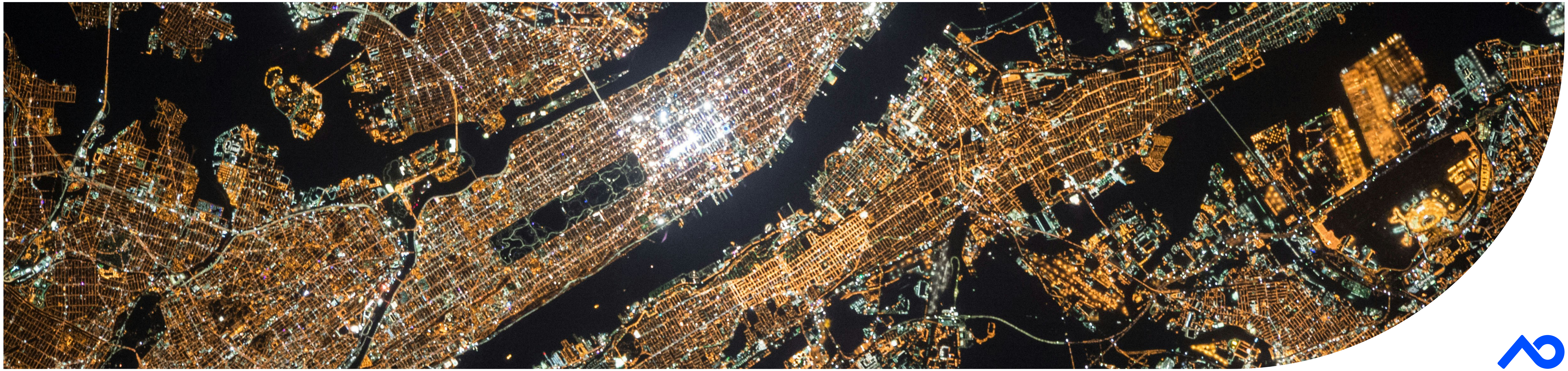
– Bill Gates



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