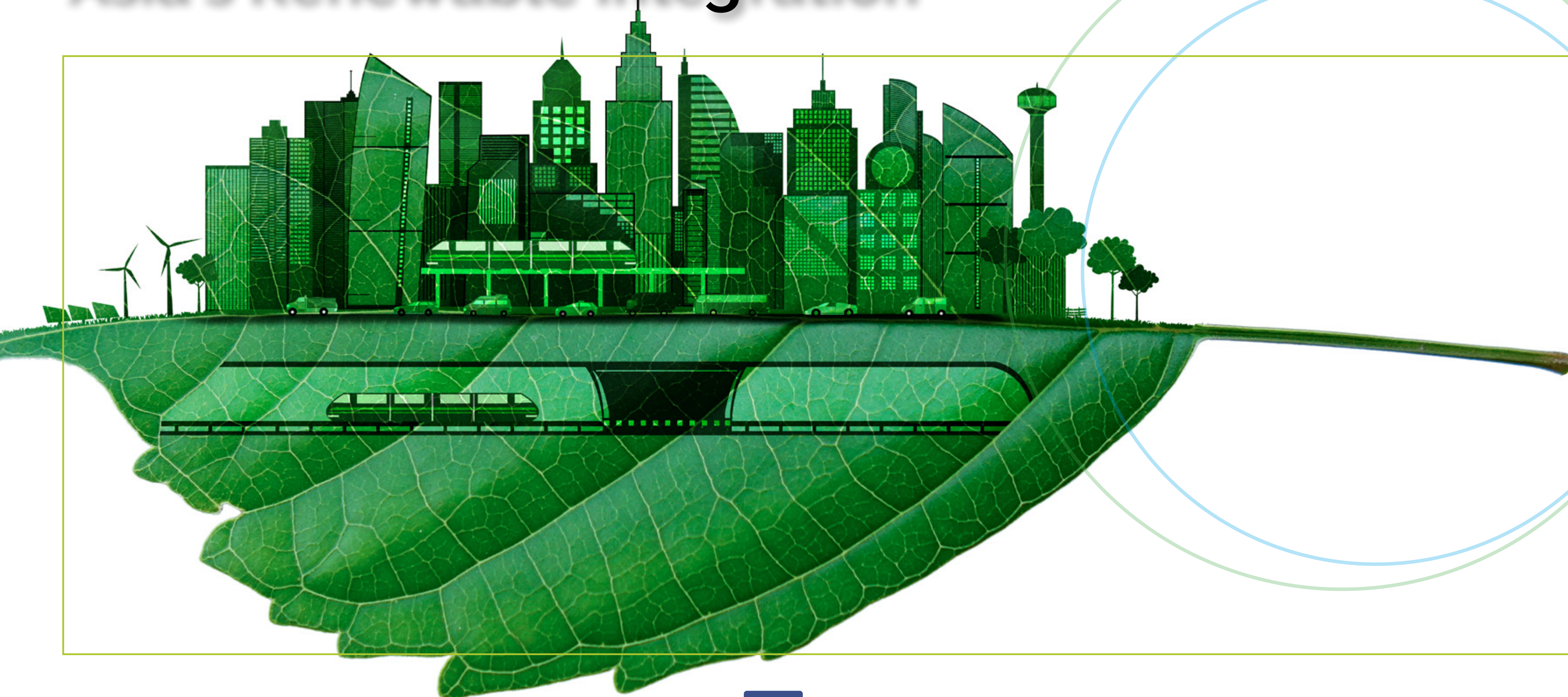
Expanding Transmission to Accelerate Asia’s Renewable Integration



BLACK & VEATCH

The United Nations Intergovernmental Panel on Climate Change (IPCC) has reported changes in every region across the global climate system. It warns of increasing temperatures and more extreme weather events from more frequent and intense heat waves to increases in heavy rainfall and flooding across Asia.

Immediate, rapid and large-scale reductions in greenhouse gas emissions are required to limit climate change, says the panel. The pressure to decarbonize Asia's electric industry will mount and continue to see increased investments into and integration of renewable energy; ASEAN as a region, for example, has a target of integrating 23 percent renewable energy by 2025.

This pathway, however, is far from straight forward.

According to Black & Veatch's 2021 Strategic Directions: Electric Industry Asia Report, the introduction of too much intermittent renewable energy and underinvestment in more reliable transmission networks are some of the biggest threats to reliable grid operation and performance across Asian electricity markets. *(Figure 1)*

Introducing greater levels of intermittent renewable energy requires some level of reserves to account for the periods when the renewable resources are unavailable. Further, land use needs and locational favorability of wind and solar often dictate that large-scale renewable energy resources be sited away from electricity consumers leading to congestion on transmission lines and potentially stranded generation assets unless appropriate grid planning is brought to bear.

Simultaneous expansion of Distributed Energy Resources (DERs) can lead to challenges in distribution networks with an increasingly bi-directional grid at the intersection of transmission and distribution systems and an ever-greater number of generation sources to manage. Grid management will be far more complex than ever before; in practical terms, the complexity of large centralized base load facilities is increasing the need for investment and solution development in transmission and distribution systems. This is resulting in the need for greater engineering focus in these sectors over the next several years as the electricity sector decarbonizes.

Figure 1

What are the biggest threats to reliable grid operations and performance in your region? *(Select up to three)*

Source: Black & Veatch

41.9%	Network capacity investment not keeping pace with demand
38.7%	Underinvestment in more reliable transmission networks
32.3%	Introduction of too much intermittent renewable energy
29.0%	Not enough energy storage capacity
29.0%	Natural disasters
25.8%	Aging infrastructure
19.4%	Cybersecurity threats
16.1%	Government policies
12.9%	Lack of adequately trained manpower and appropriate tools
6.5%	Lack of reliable network data and ability to analyze/act
6.5%	Introduction of other distributed energy resources

Invest in Efficient, Resilient and Reliable Systems

The highlighted renewable energy integration challenges create opportunities — and arguably a necessity — to expand and invest in higher quality transmission and distribution systems that improve the efficiency, resiliency and reliability of supply and balance the variability of renewable sources. A reliable grid, keeping pace with the growth of decentralized power, will help

to optimize generation and enhance grid stability.

Transmission expansion strategies include deploying interconnection lines, interconnection substations, and switching facilities in areas with high potential for renewable generation to allow seamless connection to the grid. These facilities, when appropriately deployed can also manage some of the challenges with renewable generation related to lower inertia and lack of dynamic reactive power capability while also facilitating integration with the collector substations which accompany each large-scale renewable development.

With multiple moving parts in a regional energy transition increasing grid management complexities, digitalization of the grid will be necessary to address the rapidly changing landscape of Asia's power industry.

This eBook presents key approaches for different phases of renewable energy projects and proposes transmission expansion strategies that will accelerate renewable integration in Asia.

STEP 1. Planning phase

Robust upfront interconnect planning will mitigate the risk for sub-optimal generation deployment because of inadequate transmission infrastructure. Advanced interconnection planning will also minimize incidences of curtailment where a renewable asset is constrained from generating power due to transmission congestion resulting from peak generation from other neighboring generation sources.

Load flow studies, short circuit studies, transient stability analysis and harmonic studies are some power system studies that will assess and validate the effectiveness of renewable generation assets' ability to integrate into the transmission system.

Once it has been validated that the project integrates sufficiently, and as desired, estimates can then be performed to understand possible additional facilities needed to accommodate the proposed renewable generation resources.

During the planning phase, it is important to consider cost allocation strategies with respect to required facility updates as the impacts from a proposed renewable facility can often have consequences which extend beyond the identified interconnection point. Should the cost allocation strategy be assigned to each project as they progress through an interconnect queue process, development can be stifled due to the inequitable sharing of system upgrades among proposed generation projects.

It is also important in the planning stage to look beyond the known transmission constraint solution tools such as line and remote substation upgrades. As an example, we are seeing global interest in storage as a solution to eliminate transmission constraints. Having a storage solution — such as lithium-ion battery energy storage systems (BESS) — that can absorb power and dispatch power on demand alleviates transmission constraints and has an added benefit of being able to time shift generation availability to resolve constraints inherent in the generation resource.

Thinking of interconnecting assets in totality may enhance project optimization. Increasingly a renewable generation project developer may have the option to build transmission assets beyond those required to deliver plant output at the prevailing transmission system voltage. When options exist to build or expand the interconnect substation along with any generation plant tie lines, there can be benefits to a generation owner in cost reductions as it relates to design, construction and schedule.

Other factors that will need to be considered during the planning stage, include technology, voltage and configuration. Details include the number of circuits required, collector substation configuration along with any reactive power compensation needs, such as capacitor bank, shunt reactors or dynamic reactive power.

Planning will need to reflect the potential power that is likely to be evacuated from the interconnection asset in the future. Space availability is another consideration when deciding between Air Insulated Substations (AIS) or space-saving Gas Insulated Substations (GIS).

Understanding grid compatibility requirements is critical as interconnection assets, like substations, may need to comply with the specifications and regulations of the transmission owners. Similar equipment requirements of the transmission owners can impact the procurement process; developers who do not think beyond the collector substation can be saddled with a completed renewable energy

facility with delayed connection to customers and revenue due to lack of compatibility with the transmission owner's system. Compatibility issues can extend into protection, control and automation schemes which may seem trivial to review or consider at the project outset.

Relevant to many Southeast Asia renewable development locations, inter-island connectivity may also need consideration and advanced planning in partnership with regulators or local utilities that may require accountability for unique dynamics which are encountered with inter-island connection limitations.

Revamping existing grid infrastructure

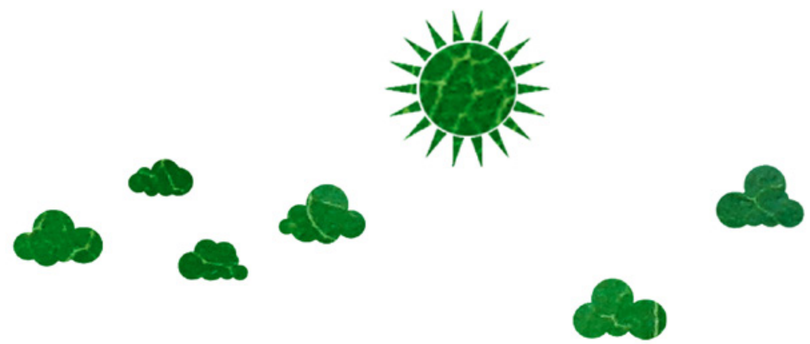
In cases where transmission congestion is present in a system, expanding bulk power transfer may be required to allow for the movement of power from areas with locational favorability to renewable generation, such as areas with strong solar or wind potential. When examining new bulk power transfer capability, it is important to consider land acquisition costs, required Right of Way (ROW) and aesthetics of transmission towers due to the increasing concerns from communities with transmission expansion.

In these situations, advanced technologies can be considered such as composite core conductors or advanced tower designs. An example of an advanced tower design technology includes Breakthrough Overhead Line Design® (BOLD), which can maximize power transfer on existing ROWs by replacing old transmission lines with smaller-footprint, higher-capacity BOLD lines. BOLD technology is ideal for long distance and intercountry connections where High-Voltage AC interconnections are viable.

STEP 2. Design phase

With the volume of land required for large-scale renewable projects, alongside increased distances to connect transmission lines to major urban centers, land and environmental issues require detailed consideration when planning and designing the systemwide integration of renewable energy resources.

For example, climate change is significantly threatening the resilience of Asia's power systems. Flooding, forest fires and storm damage all pose major risks and call for increasingly hardened design. Smart grid improvements too — to improve the responsiveness of the system during outages — are paramount as well as other factors from vegetation management to considering underground transmission options where affordable and appropriate.



Design Expertise and Skillsets Needed to Modernize Asia's Transmission

Core skillsets required in the detailed design teams deploying projects, include:

- Substation professionals familiar with outdoor design standards. Indoor design expertise is also essential when a project includes Gas-Insulated Substation (GIS) technology.
- Physical design, and protection and control capabilities for underground cable design
  - Renewable energy projects require a significant amount of cable to collect the power and deliver it to a step-up transformer for integration into the transmission system. A team with cable design experience can deliver savings by optimizing designs that lower the number and/or size of conductors needed in a collection system.
- Deep design modularization experience to deliver cost and schedule certainty
  - Renewable energy facilities typically have a standard feeder arrangement to collect power from each string of inverters or wind turbines. That offers opportunities to modularize the design and leverage pre-fabrication and pre-assembly off-site — increasingly critical as we continue to face impact of COVID-19 in the region. Controlled construction in a factory environment allows for pre-checkout before showing up at site and limiting the on-site integration time for a collector substation.

Transmission's Role in Asia's Decarbonization

Better planned and designed transmission systems are key to success in Asia's decarbonization journey. Addressing voltage and frequency variability and grid code requirements effectively across the grid will reduce system losses, conserve energy and manage peak demand. With greater levels of intermittent and variable resources connecting to the grid, power quality is key to reliability and effective grid management.

Six technologies to accelerate Asia's renewable energy integration include:

1. High-voltage direct current (HVDC) technology provides an efficient means for moving bulk power over long distances, critical in optimizing transmission from remote solar or wind facilities to urban or industrial demand centers when an HVAC solution is not optimal due to higher line losses. HVDC is also critical to the integration of regional grids where asynchronous operation dictates HVDC interconnects.

2. Advanced system control devices, such as **Flexible Alternating Current Transmission Systems (FACTS),** will enable better control of power flow from congested parts of the grid to less congested portions. FACTS devices such as static compensators (STATCOMs) are also critical to furnish the dynamic reactive power needs with integration of large blocks of renewable injections. This is especially true with the onshore interconnect facilities associated with offshore wind projects.

3. Transmission technologies with greater situational awareness of local weather conditions, such as **Dynamic Line Ratings,** will provide near real-time updates on the available capacity of critical bulk power pathways. Dynamic Line Rating technology can also furnish additional energy transfer capability on deployed assets which may resolve transmission congestion without investment in new construction.

4. **Virtual power plants** can scale electric production across hundreds of DERs and provide increased flexibility and resilience for grid operators. Virtual power plants can aggregate multiple distribution connected microgrids that could be deployed by commercial and residential users to create a more manageable larger 'plant' to cope with daily and seasonal variations in both generation and load.

5. Adopting **digitalization strategies** that address core challenges of grid stabilization, peak load management, system flexibility and reliability in a holistic manner will be critical to balance changing consumer expectations, unpredictable load patterns, and increasing use of DERs.

6. **Energy storage** whether through BESS or a different technology which is more suited for long-term energy storage, such as hydrogen, flow batteries and pumped hydroelectric, will be increasingly important to alleviate challenges with intermittency of renewable generation systems. Storage can also play a role in the delivery of synthetic grid inertia which is increasingly important with the retirement of large power generation plants which offer the spinning mass needed to stabilize the power system during large system changes, such as loss of load and lines.

STEP 3. Construction phase

Construction success happens before ground is broken. Having robust execution plans at the earliest stages of the project is critical to project delivery certainty. With testing and commissioning adequately addressed in the plans, project delays can be minimized.

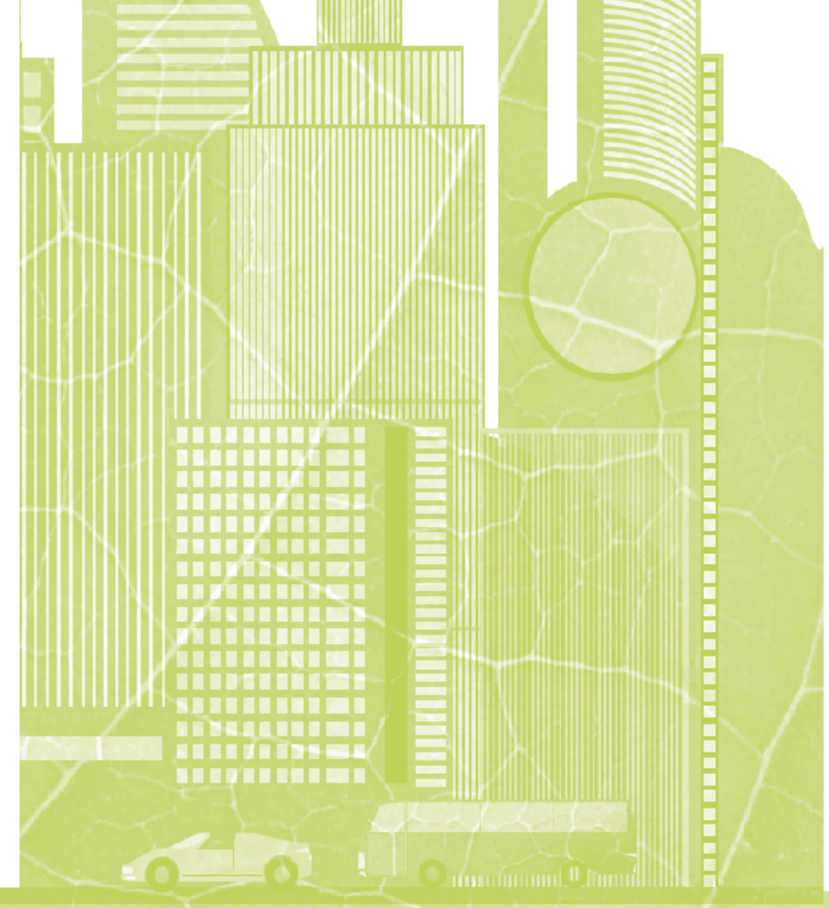
Other key considerations during construction are material management, having the right specialty resources on the team to complete the design and construction, having the right professionals available to support the project ensuring that communication occurs across all team members allowing for prompt resolution of challenges.

It is also important to formulate comprehensive plans to test the integration of the renewable plant with the transmission system to ensure grid code compliance. It is not uncommon for projects to meet energization and generation targets well in advance of achieving commercial operation due to inadequate plans with respect to grid code compliance.

Conclusion

As Asia's electric industry faces increasing pressure to decarbonize and integrate more renewable energy, investment in transmission and distribution systems will enable a more resilient and reliable energy transition. The operational complexities of grids are shifting from large power plants sited near the point of power consumption to more remote renewable plants and DERs. These dynamics require re-evaluation of transmission and distribution systems, requiring more advanced and interconnected planning and design across the system as a whole.

With more than 50 years across all forms of traditional and renewable generation and transmission in Asia, Black & Veatch is ready to deliver the solutions which stakeholders will rely upon. We look forward to working with the industry to support a deeper appreciation of the benefits of our approach to planning, execution and solution delivery.



Financial insights: Digitalization improves project bankability

Digitizing power assets will, over time, make it easier for investors to assess the returns and risk allocation of power projects through better access to information. Information also is a key enabler to data analytics across complex grids which provides insights to transmission operators to visualize risks, such as grid stabilization, peak load management, resiliency and reliability across many inter-dependent factors. Digitizing power systems will support investments in decarbonized grids and enable a more efficient and flexible grid operation. This will, in turn, reduce the cost to owners, investors, operators and ultimately consumers.

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