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Energy Security and Resilience in South Asia

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South Asia is a region covering almost a quarter of the world's population, including some of the most densely populated nations such as Bangladesh and India.[1] In terms of energy supply, the countries in the region are endowed with coal reserves, renewable energy, and hydropower resources. While they also have oil and natural gas reserves, the demand for these resources exceeds the indigenous supply. Regional countries are thus heavily dependent on imports for energy security.

Electricity production in South Asia has increased rapidly, quintupling from 340 terawatt hours (TWh) in 1990 to 1,500 TWh in 2015.[2] However, around 20% of the region's total population is still without electricity access, and around 35% is without clean cooking access. And even when generated supply might exceed demand, the region continues to witness electricity shortages due to improper load management and dispatch systems.[3] Energy security and reliability will hold utmost importance for regional governments in the coming years as electrification expands to rural areas and energy demand grows in in the cities. Beyond the energy security and demand issues faced by the countries in South Asia, the region is highly vulnerable to extreme weather such as hurricanes, flooding, and heatwaves.

With these challenges in mind, this essay begins by outlining South Asia's climate vulnerability. It then examines efforts in the Indo-Pacific to fortify transmission and distribution, renewable energy, and hydropower infrastructure to be resilient to extreme climate and weather threats. Finally, the essay considers policy options (including the need for private investment and collaboration) for South Asian countries to utilize some of these best practices to proactively incorporate resilience into their development.

The Need for a Resilient Energy Sector

South Asia is one of the regions most vulnerable to climate change as estimated by the Global Climate Risk Index (CRI). India and Sri Lanka ranked fifth and sixth, respectively, in the list of nations most affected by extreme weather in 2018.[4] According to the long-term CRI, Pakistan, Bangladesh, and Nepal rank fifth, seventh, and ninth, respectively, in the list of nations most affected by extreme weather from 1999 to 2018. Further, the World Bank reported that in the last decade climate-related disasters caused the region damages worth $149.27 billion, and it predicts that climate change could push around 62 million South Asians below extreme poverty levels by 2030.[5]

Regional water supplies could be threatened by the rapid retreat of thousands of glaciers in the Hindu-Kush Himalayas (spanning countries from Afghanistan to Myanmar). In addition, extreme weather events such as heatwaves from rising temperatures will increase the cooling demand, putting further pressure on current energy supply options and heightening the need for flexible grid infrastructure. India, China, and Indonesia are forecast to contribute around half of the global energy demand for space cooling by 2050.[6] Such trends have an adverse impact on the entire energy value chain, causing business interruptions from fluctuations in demand and supply, physical damage to energy infrastructure, and construction delays, among other effects.

The region is already moving toward the diversification of energy supply options by increasing deployment of renewable energy, expanding use of hydropower resources, and further strengthening the electricity transmission and distribution networks. In addition to these efforts, adaptation and mitigation strategies for tackling extreme weather events could help achieve the twin objectives of energy security and reliability.

There is thus an urgent need for the region to collectively assess the risks and prioritize technology and financial solutions for building resilient energy systems. To successfully do so, it can be beneficial to learn and collaborate with other regions or countries that are vulnerable to extreme weather events, have experienced damage to power sector infrastructure, and have designed policy, regulatory, and technological solutions to build a resilient energy system. Case studies of best practices by more developed countries for strengthening power and renewable energy infrastructure and crafting policy measures for resilient energy systems could help South Asian countries increase their energy security.

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Power Transmission and Distribution

Electrical systems and infrastructure are mostly vulnerable to flooding from hurricanes and cyclones. Damage to components of electrical networks, such as substations, is often irreversible, and in some cases entire substations must be replaced. Measures to increase the resilience of these systems to severe storms usually include raising the level of the substation, moving the system underground, and rerouting power lines away from high-risk areas. Building underground lines can be expensive and could create new vulnerabilities, such as salt accumulation in soils, that cause corrosion problems in cables and increase transmission losses.

Learning from Superstorm Sandy, ConEdison has invested around $1 billion in capital initiatives to build smarter and stronger overhead and underground energy delivery systems.[7] The company's Storm Hardening and Resiliency Plan (2013–16) included a wide range of measures, such as redesigning underground networks, reinforcing critical tunnels, flood-proofing vulnerable facilities, upgrading overhead systems, burying select overhead lines, protecting the gas distribution equipment from flooding, hardening internal communication infrastructure, and investing more in smart-grid technologies. Beyond this resiliency plan, ConEdison convened the Storm Hardening and Resiliency Collaborative with interested parties such as city agency officials and nonprofit and academic stakeholders to better understand system vulnerabilities, prioritize investments, and future-proof infrastructure.

In September 2016 the South Australian network, which has a high share of installed wind and solar capacity, became islanded due to damage to the transmission network from severe storms, leading to a reduction in wind power generation. In this "black swan" event, the electricity supply was lost for more than 24 hours in some locations. In light of energy transitions leading to changes in the generation fleet, rapid growth in consumer-owned distributed energy resources, and the increasing frequency of extreme weather events, the Australian Energy Market Commission recommended specific measures for improving the resilience of the electricity network, including the following mechanisms:[8]

- An annual review to identify risks in six key areas, such as voltage and system strength.
- Protected operational tools for additional action, such as constraining the dispatch of generation or limiting inter-connector flows.

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- A provision empowering the commission with the flexibility to determine whether compliance with a rule would place a material risk on the ability to maintain power system security during a period of spot-market suspension and, as needed, to take appropriate steps to inform registered participants and the regulator.

Numerous other examples can be found. For example, the U.S. National Center for Atmospheric Research has assessed the hazards associated with climate change and identified substations at risk in future superstorm scenarios so that analysts have the resources to determine the most effective storm-hardening strategy. Likewise, CLP Power in Hong Kong conducts regular drills to prepare for typhoons and introduced an emergency restoration system for rapid temporary pylon construction.

Renewable Energy Infrastructure and Policy Measures

Climate-induced disasters and extreme events such as hurricanes, cyclones, earthquakes, and floods can also have an impact on solar photovoltaic (PV) and hydropower installations. This section considers cases from the Caribbean, the United States, and Australia for incorporating the best available design, delivery, and operational practices.

Structural robustness and system design (solar PV). The 2017 hurricane season (particularly Hurricanes Irma and Maria) affected numerous countries in the Caribbean and regions in the United States. Over half the Caribbean electric utilities own or operate solar PV as part of their generation mix. While some of these systems could withstand the heavy winds, others suffered major damage or completely failed. The most urgent causes of failure were related to system design, module hardware, and construction methods.

One case study on the impact of storms on solar power carried out by the Rocky Mountain Institute revealed the importance of specifications and collaboration.[9] In addition to the best practices drawn from the surviving solar PV installations, the case study emphasized the importance of building specifications on high-load PV modules, appropriate use of hardware such as clamps and ballast, and other measures to strengthen the specifications of equipment through comprehensive inspections. Effective collaboration requires multiparty considerations about equipment, modules, and racking suppliers.

Advanced distributed technologies (microgrids and distributed energy resources, or DERs). Microgrids and DERs present a huge opportunity for increasing resilience through implementing generation closer to the load, ensuring self-sufficiency in times of grid breakdown, improving grid flexibility, and reducing overall reliance on transmission infrastructure. Microgrids and DERs were initially promoted to address environmental concerns, but they also reduce risks from extreme weather and thus provide a more reliable energy supply to communities.

After Hurricane Maria in 2017, Puerto Rico announced the Electrical Grid Modernization plan of $20 billion (spread across ten years) to build customer-centric, resilient, and sustainable energy systems.[10] This plan sought to harden the grid by repairing and reinforcing substations, while also making it more flexible by integrating solar, battery, and liquefied natural gas (LNG), among other measures to deploy innovative and advanced technologies to improve operation and control. The plan also focused on decentralization of the grid by building eight islandable microgrids, deploying DER technology, and distributing response facilities.[11]

Utilities in the United States and Australia are likewise moving toward the deployment of microgrids and DERs that use more active control of solar power, batteries, and the grid to create efficient power storage and consumption and support consumers during outages on the wider network caused by extreme weather events. The Australian Energy Market Operator (AEMO) has introduced the concept of a DER register to increase the visibility of the large number of new installations of rooftop solar and energy storage resources to better understand the behavior of DERs in general, manage them with grid operations, and avoid electricity outages from severe weather.[12] For example, during a heatwave and bushfire in late 2019, AEMO called on consumers in New South Wales to temporarily reduce their energy usage to support the management of grid operations. Similar efforts were made in Texas during a polar vortex event in 2014. The state's grid operator avoided blackouts and plant failures by calling on large industrial customers to reduce electricity use, while enabling grids to utilize all available power sources.

However, resilience planning must be an ongoing process rather than a one-time effort. Texas witnessed a major winter storm in February 2021 that led to extensive power shortages resulting from a combination of major fuel supply disruptions and weather-linked rising demand. This event highlights the need for increasing system-level investment and frequent examination of power and fuel supply infrastructure in light of new climate issues and changing power system operations.

Hydropower. Hydropower plants are especially vulnerable to earthquakes and floods. During an earthquake, the base of the dam, lift joins, spillways, and intake towers are most vulnerable. Floods can likewise cause considerable damages if the water overtops the dam. For example, flooding caused a hydropower plant failure at the Oroville dam in California in 2017. After several years of drought, sudden changes in the rainfall patterns during a series of storms forced the operations team to open the dam spillway. The findings of an independent forensic team that studied the incident indicate a long-term systemic failure of the California Department of Water Resources and recommended regulatory and general industry practices to recognize and address inherent spillway design and construction weaknesses, poor bedrock quality, and deteriorated service spillway chute conditions.[13] To improve resiliency, the report also recommended

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periodic in-depth reviews of the original design and construction, as well as updating industry best practices and adopting risk-assessment processes used in other industries worldwide.

Recommendations for South Asia

Countries in South Asia are in the process of strengthening their transmission and distribution systems to cater to expanding electrification, growing energy demand, and higher shares of renewable energy, distributed energy resources, and microgrids, among other new technologies. The lessons from the cases examined in the preceding sections could facilitate the adoption of aspects of resilient energy systems, such as climate-proof infrastructure, better building design practices, a flexible regulatory framework, and an integrated resource plan that supports more innovation and renewable energy.

Further, with the increasing integration of renewable energy and other advanced technologies, investment in grids needs to increase to make power systems more resilient and reliable. The cost to "build back better" and incorporate the resiliency efforts will require investments by both governments and utilities, as was demonstrated by the resilience plans developed in Puerto Rico following Hurricane Maria and in New York by ConEdison following Superstorm Sandy to build stronger and smarter energy systems.

Another important lesson is that the government alone cannot cover the costs of ensuring secure and reliable energy systems. This is particularly relevant for countries in South Asia, where many state-owned utilities are known to be financially stressed. Therefore, attracting private investment in the energy sector is crucial. The Connecticut Green Bank is an exemplary model for leveraging private investment in clean energy projects.[14] Every public dollar invested by banks in clean energy projects drove $6 of private investment.[15] Since 2011, with only a $35 million capitalization, the Connecticut Green Bank has leveraged nearly $800 million in private capital to generate more than a billion dollars of investment in small-scale clean energy and transportation systems. While many of the green banks have raised private capital for clean energy and energy efficiency projects, New Jersey Energy Resilience Bank has emulated the Connecticut Green Bank model to finance the development and enhancement of DER technologies at critical facilities affected by extreme weather events.

However, private-sector investment is constrained by insufficient data and limited sharing of best practices. This reduces the ability of both the energy and finance sectors to properly price the escalating investment risk presented by extreme weather. Under such conditions, it becomes particularly useful for countries experiencing similar issues to learn from and collaborate with each other on building resilient energy systems.

For South Asia, tapping into opportunities to cooperate within the region could reap benefits, considering the unique similarities in economic and geographic characteristics among regional countries. While investment required to plan for reliable and resilient smart energy systems may add costs to business as usual if taken up at the national level, regional cooperation, including by leveraging existing institutions such as the South Asian Association for Regional Cooperation (SAARC), could unlock new investment and financing in the energy sector. At the regional level, for example, building up insurance-based solutions for energy resilience, which currently have only minimal penetration in South Asia, is one important potential area for cooperation. Further, subsidy programs to ensure affordable energy supplies for communities could be expanded to cover the contingent funds for critical power sector assets that need safeguarding from extreme weather events. Regional cooperation on cross-border power trade in South Asia also provides tremendous scope for effectively utilizing the existing energy resources and generation assets in order to improve energy security for countries currently experiencing electricity shortages and support supply infrastructure during extreme weather.

South Asia could seize the opportunity to collaborate under the larger Coalition for Disaster Resilient Infrastructure that was launched by Prime Minister Narendra Modi at the 2019 UN Climate Summit.[16] The coalition is a multi-stakeholder global partnership of national governments (including many Indo-Pacific countries), UN agencies, multilateral development banks, and the private sector. It offers opportunities for nations that are still in the early stages of infrastructure development to learn from other countries about best practices for regulations, financial incentives, and governance for building resilient energy systems.

Policymakers should prioritize resilience as a core element of their energy and climate plans to prepare for long-term scenarios highlighting the possible implications of extreme weather events. Recommended measures to secure the electricity supply include supporting structural improvements to power networks, creating incentives for utilities to facilitate timely investments in resilient electricity systems and for system operators to enhance visibility and controllability with advanced weather forecasting, and promoting smart-grid technologies and the application of islanding schemes.

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Endnotes

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