KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Realizing the G20's Vision for a Resilient Grid During the Power Sector's Transformation

Turki Al-Aqeel, Shahid Hasan

Instant Insight

August 17, 2020

KS--2020-II24

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

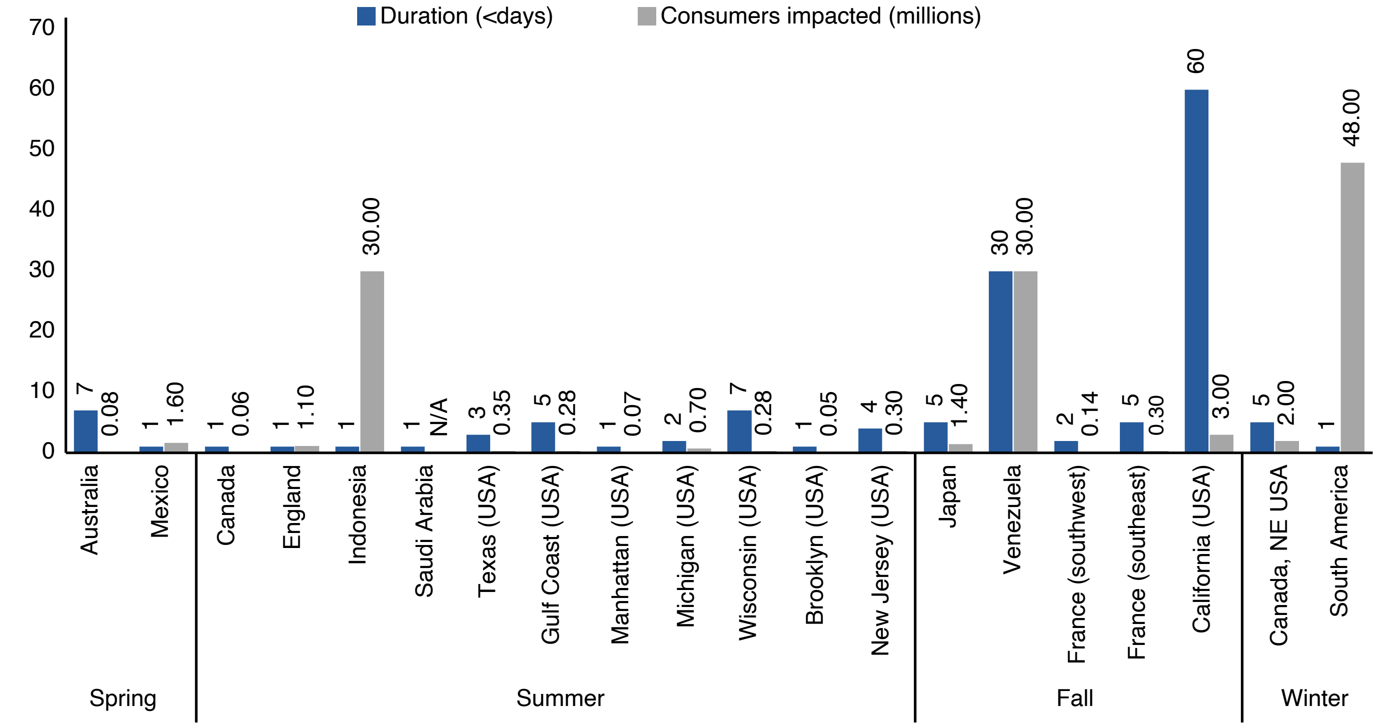
Introduction

In many parts of the world, summer and fall bring unpleasant climate events such as hurricanes, wildfires, floods, tornadoes, or thunderstorms that disturb energy systems, especially power grids. These events impact power demand and disturb the power sector's supply. Electricity production can be affected by disruptions to fuel access and grid infrastructure. In particular, railways and barges are more susceptible to increased interruptions and delays during severe weather events. Renewable energy resources can be affected by changing precipitation patterns and rising temperatures. Likewise, high wind conditions can also knock down overhead transmission lines. Thus, power outages can lead to widespread power blackouts,[1] potentially impacting thousands or millions of people across cities, regions, or countries. In some cases, utilities may be forced to implement intentional power outages to prevent power system components from being negatively affected by wildfires or other natural events.

In 2019, there were some 20 significant blackouts worldwide (Figure 1). Several climate-related conditions were to blame for 70% of the outages, and nearly 50% resulted in widespread blackouts that cascaded across large areas. Eighty percent of the significant blackouts that occurred in 2019 did so during summer and fall. Figure 2 shows the 20 major global blackout events of 2019, classified based on the season in which they occurred, their leading causes, and their impact (whether the blackout impacted a local grid or spread to impact the grid[s] of neighboring areas/jurisdictions).

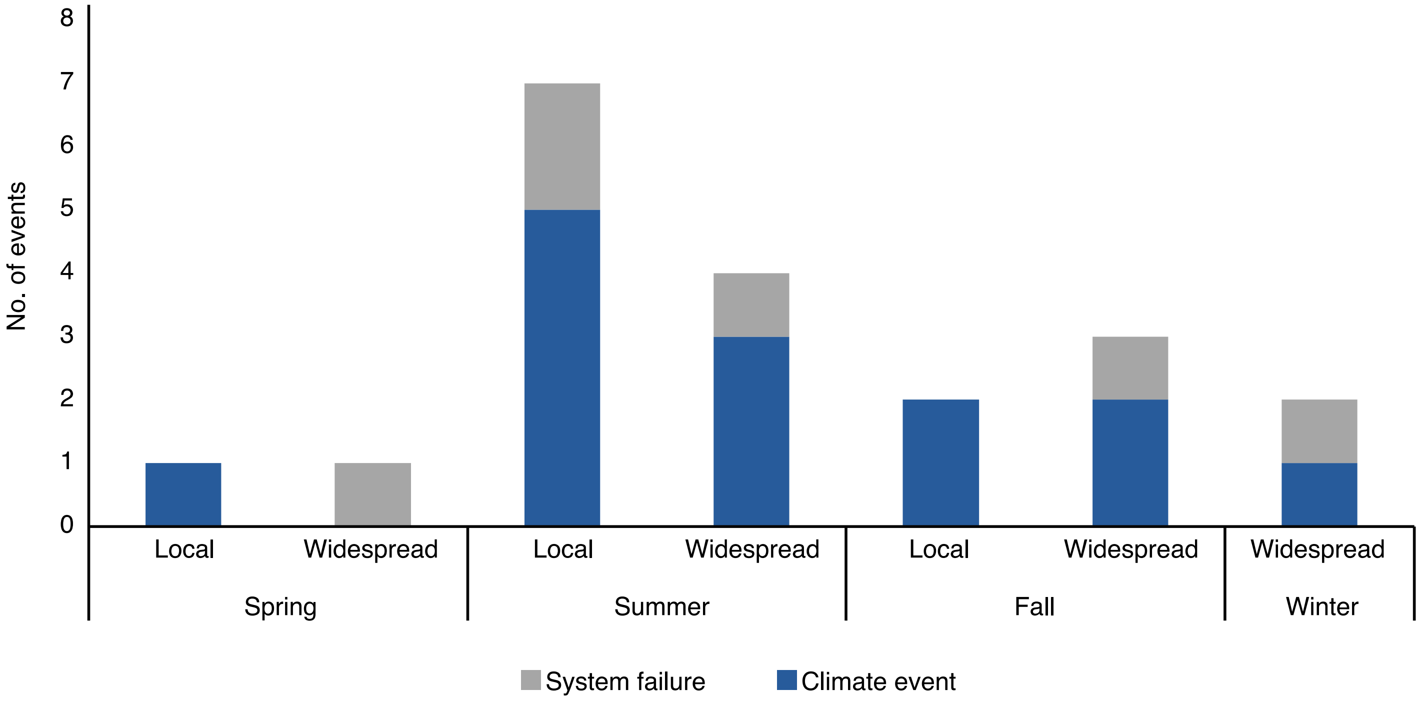
This instant insight suggests ways of enabling power system flexibility[2] to enhance grid reliability and resilience during severe climate events. The discussion is in line with the G20's recommendations for ensuring stable, reliable, and flexible electricity supplies, and developing resilient grid infrastructure. Enhanced flexibility will help to support the power system as it undergoes transformative changes.

Figure 1. Major blackouts of 2019 (by country).



Source: Extracted from publicly available information.

Figure 2. Distribution of major power blackouts by season, 2019.



Source: Extracted from publicly available information.

The G20's goal of a resilient power grid

While several power outages occurred across the world in 2019, 19 out of the significant 20 outages occurred in G20 countries. In G20 countries transitioning toward low-carbon, sustainable energy resources, governments and system planners have become concerned about the ability of the markets and existing regulatory frameworks to provide a reliable and resilient supply of electricity to the emerging grids. The electric power grids of G20 countries are faced with changing demand patterns, and rising shares of intermittent renewable energy, which make power system supply and demand flexibility crucial. Reliable[3] and resilient[4] power grids are pivotal to the success of energy transitions in G20 countries, and thus require both technological and market-based interventions for their augmentation. Furthermore, they are essential enablers of energy access and the cornerstones of energy market stability.

At the 2019 G20 Japan Summit, G20 energy ministers recognized the importance of achieving stable, flexible, clean, affordable, and resilient power systems for a low-emissions future by improving electricity markets and supporting the conditions for investment. They also stressed the importance of diversifying energy sources, suppliers, and routes; facilitating open, flexible, transparent, competitive, stable, and reliable markets; and increasing energy efficiency. The G20 energy ministers also emphasized the importance of technologies that can help integrate variable renewable energy into the power system, including energy storage, smart grids,[5] electric vehicles, flexible power plants, and demand-side management. Integrating a large share of renewables necessitates enhancing the sustainability of power grids and ensuring they can provide an uninterrupted supply of energy to meet demand (G20 2019a, 2019b). Renewable policies should align with other policies, such as those for storage and smart grids, and are essential in further enhancing the flexibility and resilience of grid architecture.[6]

The need for a new paradigm

Power system planners use reliability and resilience measures to assess the readiness of grids to sustain power outages. The term “reliability” implies ensuring continuous and uninterrupted power supplies to consumers at minimum cost (IEEE 1976), whereas “resilience” refers to the ability of the grid to withstand and recover from technical or natural incidents. Current reliability measures are important indicators for the reliability of grid performance. However, their scope generally excludes severe climate-related events, and thus, they are insufficient to measure the need to maintain system inertia[7] at a reasonable level (Glover, Sarma, and Overbye 2011). While grid resilience is focused on maintaining resource adequacy, enhancing the supply to grid fringes, and strengthening local flexibility, extreme power grid outages are mainly caused by suboptimal resource allocation and a lack of system inertia, not by resource availability (Taft 2018; Balash et al. 2018).

The lack of sufficient system inertia is also the reason for some of the blackouts that occurred during 2019, which might be attributable to the shift toward decentralized generation. The proliferation of decentralized generation could compromise the significant system inertia usually provided by centralized power plants (Pierpont et al. 2017). As power grids embrace the emerging trends that are shaping new grid architecture, including the spread of distributed energy resources, renewables, and electrification, sufficient grid flexibility is an essential requirement.

The rising need for flexibility comes mainly from the growing share of renewables, along with the changing demand profile (increasing air conditioner use, electric vehicle deployment, industrial electrification, and expanding grid fringe capacity). To facilitate the deployment of large-scale renewables, all grid sectors, i.e., generation, transmission, and distribution, must enhance the flexibility of conventional generation, grid interconnectivity, storage technologies, and demand-side management.

As power sectors transition from centralized generation toward distributed, intermittent, low-carbon, and inverter-based generation, the G20 must foster collaboration on power system flexibility. The rapid transition in the electricity sector requires a holistic system approach that balances policy objectives, system operations, and investment costs. Below are some of the key power grid reliability and resilience policy considerations:

1. Grids need to integrate many different solutions to address both short-term (i.e., operational flexibility to meet sub-hourly, hourly and daily fluctuations) and long-term (i.e., planning for desirable resource and technology mixes) flexibility requirements. Furthermore, both centralized and decentralized options for flexibility provisions should be considered.

2. Appropriately valuing flexibility resources/services and offering the right economic incentives for supply- and demand-side flexibility through fair and transparent regulatory frameworks will be crucial for successful transitions. Ensuring technology neutrality in power sector regulation for both the supply side (different types of fuels) and demand side (demand-side management applications) will be key to enhancing grid flexibility. This will help to strike the right balance between traditional and new technologies without prejudice against or a predisposition for one technology, which is critical for maintaining system stability.

3. G20 energy ministers recognize the importance of quality infrastructure investment that promotes sustainable growth and enhances the resilience of energy systems. This can be achieved by implementing a proper market design that allows technologies to send the right price signals to wholesale markets, drive market efficiency and innovation, and promote sustainable investment frameworks. Improving market design using appropriate mechanisms can unlock greater grid flexibility by utilizing the existing generation's capacity differently and maximizing grid flexibility. Innovative regulations can enable distributed energy resource aggregation and allow the exploitation of their flexibility services.

4. The location of the resources providing flexibility to the grid is important. A larger balancing area with a diverse portfolio of energy resources can reduce the grid's flexibility requirements, especially at the national transmission network level. Promoting interconnectivity through integrated transmission and distribution networks and enabling digitalized applications can help synergize local flexibility resources. Regional market integration can achieve higher economic efficiency, better security of supply, and the cost-effective integration of renewable energy, as it allows capacity reserves to be shared over larger areas and provides flexibility when and where it is needed. Interconnectivity also helps reduce total reserve requirements and lowers system costs by balancing regional differences in supply and demand patterns. Achieving well-functioning regional market integration requires defining resource adequacy, creating regional institutions that handle the market and system operations of cross-border trades, and harmonizing national markets and regulations.

Endnotes

[1] A power blackout is a short or long-term disruption of electricity services in a given area or region. The word "blackout" is attributed to massive, cascading power outages.

[2] Grid flexibility is defined as the power system's capability to respond to changes in system frequency variations caused by fast supply-demand imbalances due to power outages.

[3] Reliability is defined as the probability that a device will function without failure over a specified time period or amount of usage.

[4] Resilience is the ability to reduce the magnitude and/or duration of disruptive events.

[5] A smart grid is a grid that uses digital technologies to improve its reliability, security, and efficiency (both economic and energy) from generation, through the delivery system, to consumers (DOE 2009).

[6] Grid architecture is the application of system architecture, network theory, and control theory to the electric power grid. Grid architecture helps us to understand many of the complex interactions that exist in the power grid.

[7] If supply exceeds demand, system frequency will increase. If demand exceeds supply, system frequency will drop. While frequency fluctuations can jeopardize grid stability, system inertia can enhance stability by resisting frequency fluctuations. Inertia is a term used to describe the amount of kinetic energy stored in the rotating masses of all synchronous generators connected to the grid, measured in Megavolt-Amperes (MVAs).

References

Balash, Peter, Ken Kern, John Brewer, Justin Adder, Christopher Nichols, Gavin Pickenpaugh, and Erik Shuster. 2018. *Reliability, Resilience and The Oncoming Wave of Retiring Baseload Units Volume I: The Critical Role of Thermal Units During Extreme Weather Events*. National Energy Technology Laboratory (NETL).

Pierpont, Brendan, David Nelson, Andrew Goggins, and David Posner. 2017. “Flexibility: The path to low-carbon, low-cost electricity grids.” Climate Policy Initiative.

Institute of Electrical and Electronics Engineers (IEEE). 1976. “List of transmission and distribution components for use in outage reporting and reliability calculations.” *IEEE Transactions on Power Apparatus and Systems* 95 (4):1210-1215. doi: 10.1109/T-PAS.1976.32215.

G20. 2019a. “G20 Osaka Leaders” Declaration.

———. 2019b. “Communiqué G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth.”

Glover, J.D., M.S. Sarma, and T. Overbye. 2011. *Power System Analysis and Design*. Cengage Learning.

Taft, J.D. 2018. “Electric Grid Resilience and Reliability for Grid Architecture.” Pacific Northwest National Laboratory.

U.S. Department of Energy (DOE). 2009. “Smart Grid System Report.”

مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

www.kapsarc.org