Applying the framework: A case study

South Australia Blackout, 2016

The South Australia blackout made headlines across the world, leaving many without power.

On Wednesday 28 September 2016, tornadoes with wind speeds up to 260 km/h occurred in South Australia. Two tornadoes damaged three major transmission lines, wind farms ceased power generation and the Heywood interconnector was disconnected. South Australia could not operate in 'islanded mode' - the system managed by Australian Energy Market Operator collapsed within one second and the entire state of South Australia - 1.7m people - lost power. Twenty four hours later, power was restored to 90% of households, yet 70,000 people were still without electricity. 50 hours after the blackout the grid was back to normal.

Using the Energy Resilience Framework, we have mapped out the events, existing practices and regulations, post-disruption investigations as well as recommendations in accordance with the official "Black System South Australia" report. In addition to the three dimensions and 11 goals of the Energy Resilience Framework, a new axis is introduced for chronologically describing what happened, exploring pre-disruption, during disruption and post-disruption, which sheds more light on how to tackle resilience.

AEMO - Australian Energy Market Operator

NEM - National Electricity Market

AERNA - Australian Renewable Energy Agency

NER - National Electricity Rules

TNSP - Transmission Network Service Provider

DNSP - Distribution Network Service Provider

COAG - Council of Australian Governments

ESCOSA - Essential Services Commission of South Australia

DIMENSION	GOAL	PRE-DISRUPTION	DURING DISRUPTION	POST-DISRUPTION
LEADERSHIP AND STRATEGY	*Strategic Vision*	• AEMO's System Security Market Frameworks Review » Exploring new options to procure inertia • AEMO's Future Power System Security programme		• AEMO, with the SA System Restart Working Group, to review the system restart process • These learnings will then be shared with the Restart Working Groups in the other NEM regions, Western Australia, and the Northern Territory
	Effective Regulation	• Reviewing and updating technical standards for registered generators • Multi-timescale regulatory initiatives » Short-term focus areas » Medium-term focus areas • AER's regulation to maintain some minimum level of system strength, but it is unclear how this minimum level is specified.	• Robust energy market structure, in terms of having procedures for Electricity Market Suspension and Energy spot prices, were controlled in accordance with a pre-published "suspension pricing schedule"	• Multiple rule change proposals for standards.
	Integrated Governance	• Collaboration among AEMO, AER and AEMC. (proactive coordination within the energy sector) • COAG Independent Review into the Reliability and Security of the NEM, and ESCOSA to review technical licence conditions for generation in SA (proactive coordination interdependent infrastructure sectors)	Collaboration and coordination among different organisations: • AEMO • TNSPs • DNSPs • Generators	• Continue all the collaboration as outlined pre-disruption
ECONOMY AND SOCIETY	*Empowered and Engaged Customers*	Further research is needed on the customers' preparedness regarding possible interruption of electricity supply	Further research is needed on how the customers responded to the interruption of electricity supply and what they were able to do to minimise impact	Further research is needed on how the customers adapts or makes their own arrangement to be more prepared for this type of event
	Sustainable Financial Systems	• Existing procedure is available for Electricity Market Suspension • Energy spot prices were determined in accordance with a pre-published "suspension pricing schedule" • Negative settlements residue management • Further research is needed on where energy infrastructure investment stands in the financial market and insurance mechanisms have been offered to businesses and generation companies	Further research is needed on whether any financial market responded to the event or any participants in any financial market (e.g. stock exchange) were affected by the black system	AEMO to review market processes and systems, in collaboration with Registered Participants, to identify improvements and any associated NER or procedure changes necessary to implement those improvements
	Whole System Thinking across Supply Chain			The technical challenges of the changing generation mix must be managed with the support of efficient and effective regulatory and market mechanisms, to ensure the most cost-effective measures are used in the long-term interest of consumers
	Effective Disaster Response and Recovery	AEMO has clear restoration strategy in place, which sets out the roles and responsibilities of the different organisations involved, and details of AEMO's restoration strategy used to restore the power system and load in Southern Australia	Wind farms failed to provide effective disaster response and recovery in the presence of the storm and tornadoes: » In addition to 456 MW of sustained reduction in wind generation, 42 MW of transient reduction was experienced due to natural fault ride-through response of remaining wind farms which do not immediately recover active power to pre-event level • Lack of situational awareness in terms of detecting abnormal flows on the electricity network that might have prevented the system separation Electricity network interconnection was not able to sustain the system after the reduction in wind generation, leading to system separation	Proceeding without a clear understanding of the status of the network and what is available could result in safety risks to the public and industry personnel, and damage to the power system and generating units Once the status of the power system is assessed, preparation for system restoration may commence This includes making equipment safe prior to any restoration activities, through liaison with TNSPs, DNSPs, and generators
INFRASTRUCTURE AND ECOSYSTEMS	*Effective Infrastructure Management*	• AEMO was unaware of protection settings for some wind turbines • TNSPs design standards and maintenance of their assets	• Unable to reclassify the loss of multiple circuits under high wind conditions • Unable to reclassify multiple generating unit contingencies	Data related issues: • AEMO to develop, in consultation with Registered Participants, a more structured process to source and capture data after a major event in a timely manner and better co-ordinate data requests made to them • AEMO to investigate, with Registered Participants, the possibility of introducing a process to synchronise all high speed recorders to a common time standard • Establishing arrangements to get access to improved data on DER
	Adaptive and Integrated Planning	• Dramatic change in generation mix, i.e. high renewable and low conventional generation • UFLS scheme is in place to provide demand-side management to the system • Exploring new options for procuring non-energy services	Load shedding or generation response was not planned with a response time fast enough to prevent system separation	• AEMO to develop detailed procedures on the differences required in power system operations during periods of market suspension and identify if any NER changes are required to improve the process • AEMO to investigate the possibility of implementing a better approach for ensuring the minimum stable load of generating units is taken into account in the dispatch process • Increased modelling requirements • Power system modelling and simulation studies
	Understanding Infrastructure Criticality	• Classification/assessment of credible power system contingencies based on weather conditions • Lack of situation awareness in the control room • Staff not trained to properly interpret weather information		
	Sustainable Solutions	Pre-event the wind generation is 883MW, close to 50% of the generation mix at the time.	All on-line wind farms successfully rode through faults, until a pre-set limit which allows a maximum number of successful ride-through events was reached or exceeded.	AEMO permitted the impacted Generators to implement the proposed new settings on-site, enabling successful ride-through for a larger number of successive faults.