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Report ID #: 2022-1206-0936 Resource Collection: Black Sky / Long Duration Power Outage

This is a collection of resources related to black sky long term power outage. Newly shared items are denoted with NEW

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A black sky long term power outage is an extended duration outage lasting weeks to months and spans a wide geographical area, potentially covering several states or even multiple countries.

The risk posed by a catastrophic power outage, however, is not simply a bigger, stronger storm. It is something that could paralyze entire regions, with grave implications for the nation's economic and social well-being. Unlike severe weather disasters, a catastrophic power outage may occur with little or no notice and result from myriad types of scenarios: for example, a sophisticated cyber-physical attack resulting in severe physical infrastructure damage; attacks timed to follow and exacerbate a major natural disaster; a large-scale wildfire, earthquake, or geomagnetic event; or a series of attacks or events over a short period of time that compound to create significant physical damage to our nation's infrastructure. An event of this severity may also be an act of war, requiring a simultaneous military response that further draws upon limited resources. The President's National Infrastructure Advisory Council found that our existing plans, response resources, and coordination strategies would be outmatched by an event of this severity. Significant action is needed to prepare for a catastrophic power outage that could last for weeks or months. (Source: <u>Surviving a Catastrophic Power Outage: How to</u> Strengthen the Capabilities of the Nation, 2018)

General Black Sky Reports & Workshop Summaries

Summaries of some EIS Council Earth Ex exercises are in the exercise section

NEW - EPRR Task A, Black Sky Playbook use Cases

National Association of Regulatory Utility Commissioners (NARUC) | June 2021 https://pubs.naruc.org/pub/657AA84B-1866-DAAC-99FB-534273953471

EPRR Task A, Technical Outline Of a Black Sky Playbook: Literature Review

National Association of Regulatory Utility Commissioners (NARUC) / March 2021 https://pubs.naruc.org/pub/967F2CF6-155D-0A36-31A8-777B369E2E26

NEW - Left in the Dark: Power Outages in an Interconnected World

FEMA PrepTalk | February 2020

In her PrepTalk, Kate Konschnik dives into the fundamentals of how electricity is generated in the U.S. She explains how our aging electrical infrastructure increases the chances of catastrophic failures and offers considerations for emergency managers to prepare their communities for extended power outages.

https://www.fema.gov/blog/preptalks-kate-konschnik-left-dark-power-outages-interconnected-world

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General Black Sky Reports & Workshop Summaries (continued)

NEW - Frontiers in the Economics of Widespread, Long-Duration Power Interruptions: Proceedings from an Expert Workshop

Lawrence Berkeley National Laboratory | January 2019

The workshop was organized around six key themes in the economics of widespread, long-duration interruptions. These topics included definitions of resilience and reliability; regional economic modeling approaches; uncertainty quantification; data challenges and opportunities; contingent valuation survey techniques; and reduced-form analytical tools for assessing the impacts of power interruptions of this scale.

https://eta-publications.lbl.gov/sites/default/files/long_duration_interruptions_workshop_proceedings.pdf

Surviving a Catastrophic Power Outage: How to Strengthen the Capabilities of the Nation

President's National Infrastructure Advisory Council (NIAC) | December 2018

NIAC was tasked to examine the nation's ability to respond to and recover from a catastrophic power outage of a magnitude beyond modern experience, exceeding prior events in severity, scale, duration, and consequence. NIAC found that existing national plans, response resources, and coordination strategies would be outmatched by a catastrophic power outage.

https://www.cisa.gov/sites/default/files/publications/NIAC%20Catastrophic%20Power%20Outage%20Study_FINAL.pdf

"Black Sky" Infrastructure and Societal Resilience Workshop

EIS Council, University of Cambridge - Centre for the Study of Existential Risk, and International Centre for Infrastructure Futures | January 2017

Summary of the 2017 workshop which included the following focus areas: Emerging Black Sky Hazards; Coordination Challenges and Implications; Infrastructure Interdependence and Resilience; Resilience, Systems, Risk and Perception; Resilience Learning and Perspectives; Infrastructure Decision-making, Stakeholder Engagement and Disaster Recovery https://www.cser.ac.uk/media/uploads/files/Black-Sky-Workshop-at-the-Royal-Society-Jan.-20171.pdf

Power Outage Impacts

Also see the CRA's EMP / Space Weather Threats Resource Collection Brief for additional impact studies.

Case Studies of the Economic Impacts of Power Interruptions and Damage to Electricity System Infrastructure from Extreme Events

Lawrence Berkeley National Laboratory | November 2020

Although a number of studies have examined the physical and engineering impacts of extreme weather and other precipitating events on the bulk power system, decision makers evaluating investments in preventive strategies need information on the costs of past power interruptions and the benefits of preventing them in the future. This paper contributes to addressing this need by offering six case studies that detail the economics, at the level of the utility service territory, of power interruptions caused by extreme weather and lasting from a few days to several weeks. https://eta-publications.lbl.gov/sites/default/files/impacts_case_studies_final_30nov2020.pdf

Sensitivity of Infrastructure Sectors to the Disruption of Commercial Electric Power

Sandia National Laboratories | October 2019

This analysis, conducted in 2017, focuses on describing the function of each of the other infrastructure sectors and subsectors, with an eye towards those elements of these sectors that depend on primary electric power service through the commercial electric power grid.

https://www.osti.gov/servlets/purl/1817325

Life without Electricity: Storm-Induced Blackouts and Implications for EMP Attack

Dr. Peter Vincent Pry - Report to the US Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack | July 2017

This paper looks at the societal impacts of storm-induced blackouts of the electric power grid including. Events reviewed include Hurricane Andrew (1992), Western heat Wave (1996), The Great Ice Storm (1998), Hurricane Floyd (1999), Washington DC Ice Storm (1999), and Hurricane Lili (2002).

http://www.firstempcommission.org/uploads/1/1/9/5/119571849/life_without_electricity - final_april2018.pdf

Power Outage Impacts (continued)

Cascading Effects and Escalations I Wide Area Power Failures - A Summary for Emergency Planners London Resilience | 2017

This report provide a synthetic overview of the cascading effects caused by wide-area power failures, and to define the recurrent impacts and sources of escalation. It provides a reference for the training and the situational awareness of decision makers and emergency operators.

https://www.ucl.ac.uk/risk-disaster-reduction/sites/risk-disaster-reduction/files/report_power_failures.pdf

Blackouts: a Sociology of Electrical Power Failure

University of Auckland and University of Lincoln | 2013

This article looks at what happens when the power goes off. It scrutinizes the causes and consequences of accidental electrical power cuts.

https://core.ac.uk/download/pdf/19531796.pdf

Exercises & Scenarios

EARTH EX Annual EIS Council's Virtual Black Sky Exercise

EarthEx is a virtual black sky exercise using EIS Council's online exercise platform. The exercise features multiple "lanes," providing detailed guidance for organizations in many different sectors. https://eiscouncil.org/earth-ex/

Summary of EARTH EX® III 2019: Lessons learned from a global resilience exercise

The Resilience Shift & EIS Council | November 2019 https://www.resilienceshift.org/wp-content/uploads/2019/12/Earth-EX_Lessons-Learned_FINAL.pdf

EARTH EX® - London and Glasgow. Building resilience for global scale complex catastrophes

Earth Ex, The Resilience Shift, and EIS Council | March 2019 https://www.resilienceshift.org/wp-content/uploads/2019/10/Earth-EX-report_FINAL_Pages.pdf

Helios Solar Storm Scenario

University of Cambridge - Centre for Risk Studies | November 2016

This report provides a catastrophe scenario for a US-wide power system collapse that is caused by an extreme space weather event affecting Earth: the Helios Solar Storm scenario. This scenario is a stress test for managers and policy-makers. Stress tests are important for understanding risk exposure across a spectrum of extreme systemic shocks. https://www.jbs.cam.ac.uk/wp-content/uploads/2020/08/aig-helios-solar-storm-16-june.pdf

Plans

Electric Power Disruption Toolkit for Local Government

Cal OES | January 2020

Cal OES has developed this toolkit to identify possible actions that local governments can take to protect public health and safety during electric power disruptions regardless of the cause. It also provides preparedness, response, recovery, and mitigation actions relevant to electric power disruptions.

https://www.caloes.ca.gov/wp-content/uploads/Preparedness/Documents/Electric-Power-Disruption-Toolkit-January-2020-FINAL.pdf

Note - this toolkit focuses more on shorter-term power outages and PSPS events.

Power Outage Incident Annex to the Response and Recovery Federal Interagency Operational Plans: Managing the Cascading Impacts from a Long-Term Power Outage

FEMA | June 2017

The primary audience for this annex is federal departments and agencies with a role in emergency management. However, local, state, tribal, territorial, and insular area officials, as well as private sector and nongovernmental partners with roles and responsibilities for responding to and/or recovering from long-term power outages will also benefit from the material in this annex.

https://www.fema.gov/sites/default/files/2020-07/fema_incident-annex_power-outage.pdf

Black Start

What is Blackstart? "Black start is the ability of generation to restart parts of the power system to recover from a blackout. This entails isolated power stations being started individually and gradually reconnected to one another to form an interconnected system again. It is used when the grid experiences a blackout and must be restarted from scratch." (Source: National Renewable Energy Laboratory, Grid Modernization Black Start)

NEW - Electric Grid Blackstart: Trends, Challenges, and Opportunities

Pacific Northwest National Lab | April 2022

This report documents the study of the expected future state of the grid that will have an impact on blackstart restoration readiness and recommends actions that can be taken to increase grid resiliency, improve system modeling, perform more extensive studies, enhance training activities, and perform industry outreach to enhance power system blackstart capabilities.

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-32773.pdf

Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans - Recommended Study Blackstart Resource Availability

NERC | May 2018

This report provides details of the joint study team's assessment and makes recommendations for industry-wide consideration regarding practices, procedures and methodologies aimed at improving system restoration overall, and blackstart capability planning and testing in particular.

https://www.ferc.gov/sites/default/files/2020-05/bsr-report.pdf

Hydropower Plants as Black Start Resources

Oak Ridge National Laboratory | May 2019

This report identifies the advantages of using hydroelectric power for black start and compares hydropower with other types of power plants for providing this valuable service to ensure the resiliency of the power grid. <u>https://www.energy.gov/sites/prod/files/2019/05/f62/Hydro-Black-Start_May2019.pdf</u>

Blackstart Resource Availability Study

FERC, NERC, and Regional Entities | May 2018

This report provides details of the joint study team's assessment and makes recommendations for industry-wide consideration regarding practices, procedures and methodologies aimed at improving system restoration overall, and blackstart capability planning and testing in particular.

https://www.ferc.gov/sites/default/files/2020-04/bsr-report.pdf

Nuclear Power: Black Sky Liability or Black Sky Asset?

International Journal of Nuclear Security | 2016

This paper poses the question, "Can nuclear power plants be transformed from Black Sky Liabilities to Black Sky Assets, and if so, how?" An integrated framework for addressing this question is proposed. https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1047&context=ijns

California Midterm Reliability Analysis

California Energy Commission 1 September 2021 This reports includes discussion of some of California's black start capabilities. <u>https://www.energy.ca.gov/sites/default/files/2021-09/CEC-200-2021-009.pdf</u>

Emergency Generators & Backup Power

Note - if the generator or transfer switch relies on electronics, those electronics might be affected in the event the power outage is caused by an EMP or geomagnetic disturbance.

Vehicle-to-Building (V2B) for Resilient Backup Power Workshop Presentations

California Energy Commission | January 2021

This workshop discusses market, technology, and regulatory needs and barriers to deploying bi-directional plug-in electric vehicles (PEVs) and chargers that are capable of powering critical loads in commercial buildings and homes during electric grid outages such as public safety power shutoffs.

https://www.energy.ca.gov/event/workshop/2021-01/staff-workshop-vehicle-building-v2b-resilient-backup-power

Emergency Generators & Backup Power (continued)

Case Study: Generator Failure During Power Outage following Hurricane Isaias Underscores Heightened Risk to **Patients in Single Generator Facilities**

Power for Patients | January 2021

This article provides a timeline of events and lists lessons learned and promising practices based on a hurricane-related power outage at a skilled nursing facility.

https://www.poweredforpatients.org/wp-content/uploads/2021/01/P4P-Little-Sisters-of-the-Poor-Generator-Failure-Case-Study.pdf

Reliability of emergency and standby diesel generators: Impact on energy resiliency solutions

National Renewable Energy Laboratory | April 2020

Emergency diesel generators are the most common form of backup power for critical loads when the grid fails and are most often deployed as stand-alone generators (<2000 kW) tied to individual buildings. Understanding the finite reliability of emergency diesel generators during continuous operation is crucial for energy planners, managers, and end-users. A new analysis of two large non-public emergency diesel generator operational data sets shows that commonly used reliability metrics are inadequate to predict the performance during a grid outage. https://www.osti.gov/pages/servlets/purl/1659849

Emergency Diesel Generator Reliability and Installation Energy Security (Technical Report)

National Renewable Energy Laboratory | April 2020

This report provides an analytic approach to quantitively assess the impact of an emergency diesel generators reliability on both stand-alone building tied systems and microgrids.

https://www.nrel.gov/docs/fy20osti/76553.pdf

A Comparison of Fuel Choice for Backup Generators

National Renewable Energy Laboratory | March 2019

This report discusses the costs and benefits of backup generator configurations. It analyzes the relative costs and benefits -in terms of economics and reliability-of natural gas versus diesel as fuels for backup systems. It also compares the relative merits of grid-connected backup systems that enable financial benefits when the grid is functioning, versus backup-only systems that only generate energy for critical services when the primary grid is down. https://www.nrel.gov/docs/fy19osti/72509.pdf

CRA Resource Collections

- Active Shooter
- Black Sky Long Term Power Outage •
- Bomb Threats & IEDs •
- Climate Change
- Cybersecurity
- Drought
- Earthquake •
- Electic and Natural Gas Infrastructure
- **Emergency Communications**
- EMP and Space Weather Threats
- Extreme Heat .
- Extremism & Terrorism
- Foresight
- Hybrid Threats ٠
- Insider Threats ٠

- Mass Evacuations
- Nuclear and Radiological Incidents
- Physical Security
- Recovery: Economic & Long Term
- Satellite Communications
- Social / Civil Unrest & Riots
- Supply Chains
- Suspicious Packages
- Tsunamis
- Undersea Cables
- Unmanned Aircraft Systems (UAS)
- Vehicle Attacks
- Volcanoes
- Wildfires

The California Resiliency Alliance's Resource Collection Briefs are designed to serve as a type of reference library for resources around a specific topic.