

Continuous Improvement

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Critical Infrastructure Interdependencies The Journey to Security, Resiliency and Reliability

"Life doesn't make any sense without interdependence. We need each other, and the sooner we learn that the better for all of us." – Erik Erikson

The focus of this article is on Subsector Interdependence, which was identified in the recent NERC ERO Reliability Report as one of four areas of risk priorities.¹ As the report states, "[s]ubsector interdependence continues to increase and has reached an inflection point with the natural gas subsector."

As defined in the Modelling Interdependencies between the Electricity and Information Infrastructures² whitepaper, an interdependency is "a bidirectional relationship between two infrastructures through which the state of each infrastructure influences or is correlated to the state of the other."

This article provides additional information and resources on Critical Infrastructure Interdependencies, as well as some suggestions on how to lower the risk of these interdependencies. Awareness and mitigation contribute to continuously improving electric system security, resiliency and reliability.

The 2003 Blackout

Before we start discussing natural gas and electric interdependencies, it is important to learn from the past. Analysis of the 2003 blackout determined that there was a lack of understanding of the interdependencies with other infrastructures supporting the electric grid. The planning studies did not take into consideration these interdependencies. The blackout report highlights the complex work involved in operating and planning a system, and all the studies that must be performed for proper planning and operations. The blackout report states "the findings of the ESWG (Electric System Working Group) and SWG (Security Working Group) suggest that if multiple contingencies occur in a single area, they are likely to be interdependent rather than random, and

should have been anticipated in planning studies."³ Planning studies should take into account all the critical infrastructure interdependencies with the electric grid, and how those contingencies effect the reliable operation of the grid.

Electric and Gas Interdependencies

Electric power is essential, and interdependencies with other industries can have a significant impact on reliability. In recent years, the energy mix of fuel for generating electricity has evolved to have more dependency on natural gas. The electric power sector uses natural gas to generate electricity and produce useful thermal output. In 2020, the electric power sector accounted for about 38% of total U.S. natural gas consumption, and natural gas was the source of about 33% of the U.S. electric power sector's primary energy consumption.⁴ The challenge with reducing this interdependency is that the electric transmission system and natural gas pipelines appear linear in isolation but become much more complex when interdependencies are introduced. This is due the number of "system of systems", where each infrastructure's subsystems create the complexity (for example the introduction of more solar, wind, and other factors in the electric sector). The bi-directional nature of interdependencies, specifically electric grid reliance on natural gas, creates a complex relationship that depends on working together as a system rather than working in isolation.⁵

To help with this interdependency, an organization should effectively identify its external interdependencies by examining all its assets and services to determine: 1) a list of its assets that are controlled or affected by outside

¹ [NERC | RISC ERO Reliability Risk Priorities Report | July 2021](#)

² [Modelling Interdependencies between the Electricity and Information Infrastructures](#)

³ [Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations](#)

⁴ [Natural gas explained - Use of natural gas](#)

⁵ Rinaldi, S.M. & Peerenboom, James & Kelly, T.K.. (2002). Identifying, understanding, and analyzing critical infrastructure interdependencies. Control Systems, IEEE. 21. 11 - 25. 10.1109/37.969131.

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entities and 2) a list of its services that are directly or indirectly affected by outside entities. These lists should also identify the outside entity that controls or affects each asset or service, a point of contact, and any contracts, or agreements in place with the outside entity. In addition, the organization should be aware of the reliability and resilience requirements of the external entity. This includes implementing a clear process in place for identifying external interdependencies.

There are several critical infrastructure interdependencies in the electric, transportation, natural gas, water, and communications/IT industries. Figure 1 illustrates the bi-directional relationships electricity has with other infrastructures.

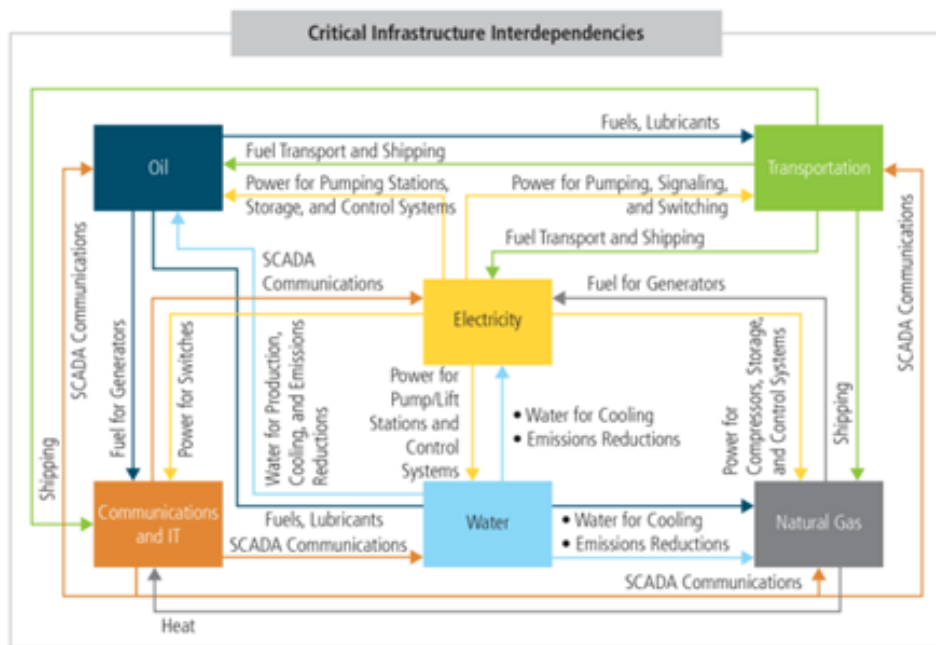


Figure 1: Critical Infrastructure Interdependencies⁶

⁶ [Transforming the Nation's Electricity System: The Second Installment of the Quadrennial Energy Review](#)

⁷ [Grid reliability and the role of natural gas](#)

⁸ [NERC Guideline Natural Gas and Electrical Operational Coordination Considerations](#)

Natural Gas Storage Interdependency and Mitigation

One specific interdependency between electric power and natural gas is storage capability. While coal, for example, can be stored onsite, natural gas relies on pipelines for fuel delivery. "Pipeline constraints can cause dispatch difficulty and, in some cases, even outages in systems heavily reliant on natural gas," says Francis O'Sullivan, from MITEI (MIT Energy Initiative) and a main author of the MIT Energy Initiative (MITEI) analysis report. "Natural gas is a just-in-time fuel, exacerbating the challenges between it and the electricity sector. But there are steps that can be taken to add in resiliency and reduce the risks that power will not be available when it is needed most."⁷ One suggestion is to specify incentives for multiple fuel capabilities with different supply chains to reduce single points of failure. Also, ensuring the two infrastructures are coordinating and communicating these challenges helps with planning and mitigation as well.

Conclusion

Interdependencies are increasing and it is becoming particularly important for our industry to work to mitigate them. More recommendations on the Electric-Natural Gas interdependency are found in "NERC Guideline Natural Gas and Electrical Operational Coordination Considerations."⁸ In addition to the RISC report, this guideline is a must-read and includes additional recommendations and suggestions.

Please contact the manager of Entity Engagement, Michelle Cross with any questions on this subject and to learn more about our maturity model assessment tool that can help you assess several risks, including your external interdependencies. You can also visit our [website](#) and request an assist visit to discuss your interest in a self-assessment.

Thanks for reading!