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# Virginia Coal Power Generation
# Network Modeling Executive Summary

Electric power generation and the associated vulnerabilities of the various power networks are of significant importance to operations analysts, government officials and the public at large. The United States currently receives 44.9% of its annual power needs from burning coal, the single largest electric power source. As a result, the defense of coal transportation and power networks is of significant importance. This analysis focused on coal power generation in the state of Virginia and revealed the power network to be relatively resilient to disruption, in the sense that minimum power is provided. However, there are significant cost increases that must be accounted for in order to keep the network operational.

The network was set up and modeled as Minimum Cost/Maximum Flow Network problem, wherein the goal of the operator was to push as much coal through the network as was needed to meet power demands. The network design allowed for coal to enter the state of Virginia through state mines, imports from other states or imports received via ships at the port of Hampton Roads. Further, the network was assumed to be vulnerable to disruption in the form of interdiction at any arc on the network. For the purposes of this analysis, if an arc was attacked, it was removed from the network. The network also assumed that coal could be moved along the rail network making as many intermediate stops as needed before reaching its destination.

Analysis of the network revealed that the coal supply and transportation system were sufficient to meet required energy demands. Interdictions of up to eight arcs results in minimal cost increase and were not deemed to be of significant impact. On the other hand, the loss of more than eleven arcs results in significant cost increases. It is at this point that the interdictions begin to cut off coal sourced from Virginia state mines. As a result, the system is forced to import all of its required coal. This had the effect of driving up costs significantly. Nevertheless, the network was able to receive the required amount of coal needed to support power generation. Figure 1 shows how costs of operating the network changes with the number of attacks on the network.

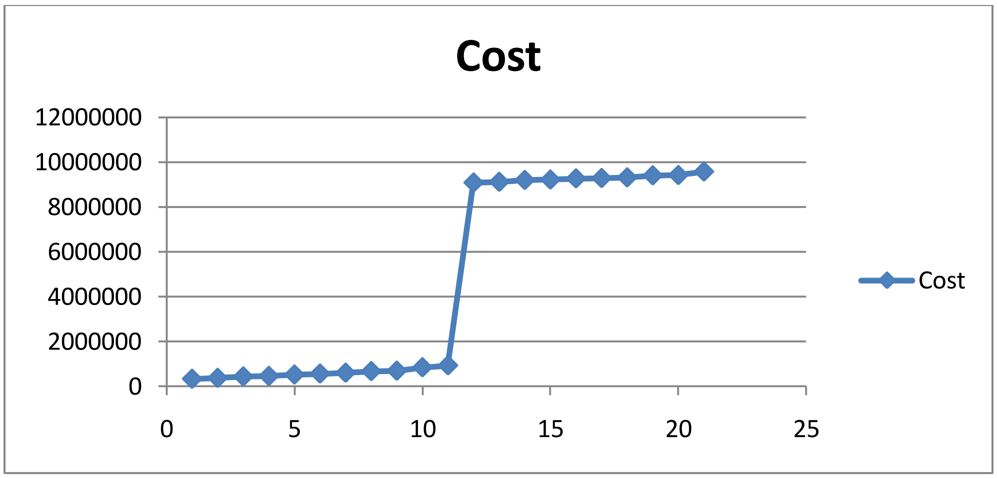


**Figure 1. Cost of network operation given increased number of attacks.**

The results make intuitive sense given the geography of Virginia as well as the fact that a large amount of power is generated in plants that are in close proximity to Hampton Roads. While it is more expensive to import coal, there are significantly reduced transportation costs when the coal only needs to be moved from its port of arrival to a power plant in the same geographic area. As a result, a natural target when interdicting the network would be the larger power plants in the Hampton Roads area. This suggests placing a priority on defending those arcs above others in the network.

When reviewing the results of this model and follow-on analysis, it becomes apparent the main constraint in operating and defending this network actually comes from outside of the model. The cost of providing coal based electricity to consumers will determine the viability of the network over an increasing number of attacks. While it is unlikely the network will ever be completely disrupted and unable to meet demand, it is quite possible that enough arcs could be removed from the network to cause coal power to rise in price to the point that continuing to support this method of power generation becomes untenable for the consumer.