Executive Summary

Electricity Supply Interruptions: Sectoral Interdependencies and the Cost of Energy Not Served for the Scottish Economy

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The electricity sector has a critical role in the well-functioning of the modern economies. In addition, other infrastructure sectors also rely heavily upon the provision of secure electricity supplies. The reliability of electricity supplies is however vulnerable to supply disruptions from major natural disasters, accidents, and malicious attacks. Such events are characterised as low-probably but high-impact events meaning that while they occur rather infrequently they can cause considerable socio-economic costs and consequences.

At the same time, the costs of such events are largely external to the sector and are therefore borne by the consumers and the wider society. This is particularly the case in the liberalised electricity sectors where the actors are driven by strong profit incentives. The task for the policy-makers and regulators is to provide the utilities with suitable economic incentives for investments and spending to improve the security of the electricity system. However, the amounts to be spent on improving the security of the system also need to be in some relation to the potential damages from major supply interruptions. Therefore, there is a need for estimating the economic costs of electricity supply interruptions.

Due to the many and complex physical and cyber interdependencies among the critical infrastructure sectors, major electricity supply interruptions result in shock transmission and cascading effects to other sectors of the economy. In this paper we investigate the economic effects of large electricity supply disruptions while taking such interdependencies among the infrastructure and other sectors of the economy into account.

We apply a dynamic inoperability input–output model (DIIM) to 101 sectors of the Scottish economy in 2009 to explore direct, indirect, and induced effects of supply interruptions. We also include the household sector in the model. The DIIM method has the advantage of representing the dynamics of inoperability in an interdependent economic system. The DIIM method also enables us to distinguish between the physical inoperability and the economic losses from major outages. We then estimate the societal cost of energy not supplied (SCENS) due to an interruption, while taking into account the interdependencies among the different sectors.

The results of the study show that inoperability does not necessarily correspond to a similar level of economic loss and these two metrics can differ in the case of power supply shocks. The results also indicate that SCENS varies with the duration of a power cut, ranging from around £4,300/MWh for a one-minute outage to around £8,100/MWh for a three hour (and higher) interruption in the case of the Scottish economy. These estimations of SCENS are comparable with the previous studies.

The findings also indicated that SCENS initially starts from moderate values for very short duration of interruptions before increasing rapidly. The results also indicate that the ranking of the affected sectors in terms of inoperability and economic loss metrics are robust with respect to the extent and duration of interruptions. The economic impact of such estimates can be used to design incentive mechanisms and policies for contingency measures and preventive investments in to improve the security of the power sector. They also help decision makers to prioritize the most vulnerable sectors for resource allocation and resiliency enhancement against major outages.