

# Security of the European Electricity Systems: Conceptualizing the Assessment Criteria and Core Indicators

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Electricity plays a vital role in the development of all economies because of its dual role in the economy. It serves as an indispensable intermediate input factor in production and a necessary final consumption good. Hence, the availability of electricity supply at an uninterrupted manner matters and remains a major energy policy goal of all economies. The economic, political and social costs of electricity supply disruptions or fluctuations can be entrenched with adverse macroeconomic consequences. The adverse impacts arising from electricity supply fluctuations can only be mitigated by ensuring a secure supply of energy across both the potentially competitive segments (generation, retail) and the regulated natural monopoly segment (networks) in a reliable and affordable manner. This paper identifies and analyses the potential risks and threat indicators faced by the electricity networks in advanced economies in the light of on-going technological advancement and their existing energy policy goals (or rather aspirations) using an ex-ante risk assessment methodology. Identifying the risks arising from various natural, accidental and malicious threats to the existing European electricity networks in the face of increasing market liberalisation and inter-connectedness can be the first step towards protecting against them. This can be especially relevant from a policymaking perspective as conventional literatures on energy security have traditionally focussed on the security of fuel supply in the generation segment with the networks receiving little attention. This research aims to bridge such gap.

Our analysis suggests that economic risks of under-investment and rising electricity demand are one of the biggest risks facing the European electricity networks along with the risks of natural calamities and severe weather conditions. The transition towards smart grids and increasing digitalization of the grid imply new cyber security threats facing the European electricity networks. The protection of the networks against exceptional events and threats will require the adoption of sophisticated technologies and system design and planning which does not exist in many European grids. The obsolete system layout of power plants under centralised structures will require addition substation sites while the existing traditional tools of power delivery planning and engineering may not be effective in current problems of aged equipment, and

modern deregulated loading levels. The high penetration of renewable in the grid will require detailed system planning coupled with accurate resource and load forecasting across Europe in the transition towards a low carbon economy. Hence, the planning, engineering and operating system using concepts and methodologies that worked under vertically integrated market structure cannot be suitable under a deregulated and liberalised industry structure when most of the electricity networks remain vertically unbundled from the potentially competitive segments. More emphasis should be placed towards energy efficiency to manage the growing economic risks of increasing electricity demand in the European electricity markets. Our study also shows that an ex-ante risk assessment technique that takes country-specific risks into account can be a useful risk assessment tool to policymakers considering the uncertainty and paucity of risk assessment tools. However, it is to be noted that the appropriateness of an ex-ante risk assessment methodology increases with the volume of available information.

As electricity networks in Europe remain a regulated natural monopoly, it is clear that the system relies on the regulatory framework in place to embrace the new risks arising from natural, accidental and malicious threats in the mechanism design and to stimulate innovation in power systems and electricity markets. Preventing against the risks arising from the integration of the different innovations such as smart grids, smart metering, electro mobility and storage is likely to be the hardest challenge for European regulators in the next future. Nonetheless, the coordination among network regulators of the EU countries is essential to prevent against natural, accidental and malicious threats as these regulatory regimes have different priorities and focus. Hence, the future of the risks and threats facing the European electricity networks is vastly linked to the future of the network regulation in Europe.

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