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Assessing the risk profile to security of supply in the electricity market of Great Britain

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ABSTRACT

Security of electricity supply has been an important topic of growing concern in the United Kingdom as the margin of supply over demand tightens and the risk to security of supply widens. The risk profile to security of supply is presented, in the United Kingdom, in terms of the conventional metrics capacity margin and loss of load expectation. However, increasing levels of disruption in the power sector, arising from a combination of policy, technological and customer change, challenge this traditional approach to characterise the risk to security of supply. The paper presents a framework to evaluate the risk profile to security of supply through a series of probabilistic metrics that establish the expected magnitude (power and energy), likelihood, frequency and duration of encountering supply shortfalls. This detailed characterisation of the risk profile enables risks to be fully identified, assessed and prioritised facilitating effective risk management.

1. Introduction

The trilemma of energy security, energy equity and environmental sustainability underpins the core objectives of energy policy in the United Kingdom (UK) (DECC, 2011). The security of electricity supply objective refers to the ability of the electricity system to supply final customers with electricity. Security of supply has been an important and politically sensitive topic with growing concerns over the last and current decades as the margin of supply over demand tightens and the risk to security of supply widens. Environmental directives together with ageing power plants are leading to the widespread closure of coal and nuclear power stations. Rising and volatile gas prices in combination with declining coal prices are squeezing the profit margin between the gas price and the electricity price resulting in both temporary and permanent retirement of gas-fired power plants and are discouraging investment in new gas-fired power plants. Moreover, uncertain energy policies are causing a loss of momentum in the energy industry, are creating an unstable environment for investment in supply infrastructure and are further amplifying the risk to security of supply.

In response to these challenges, the Government of the UK placed an obligation on the energy regulator of Great Britain (GB) to provide the Secretary of State with an annual report assessing different electricity capacity margins and the risk to security of supply (Parliament of the United Kingdom, 2011). Subsequently, the Government introduced a Capacity Mechanism to ensure security of supply in the GB electricity system (Parliament of the United Kingdom, 2013). Additionally, the System Operator (SO) of GB publishes the Winter Outlook Report (WOR) to inform the market on the expected security of supply position of the electricity system for the winter ahead (NG, 2016a). In these distinct activities, the Government, the energy regulator and the SO use a similar approach to present security of supply for electricity that is based on a combination of deterministic and probabilistic metrics.

The de-rated capacity margin is a deterministic metric that estimates the excess of available supply capacity over peak demand. The metric is commonly used by the electric utility industry as an indicator of security of supply as it is simple and intuitive. However, the de-rated capacity margin provides limited information to stakeholders as it represents the supply demand position under average conditions of the electricity system. In practice, the system is unlikely to present an average behaviour due to outages of power plants and uncertain variations in electricity demand.

The loss of load expectation (LOLE) is a probabilistic metric that quantifies the expected number of hours per year in which the available supply falls short of the demand. The metric is a widely used security of supply criterion due to its flexibility and simplicity of application. However, evaluating the risk to security of supply based on the LOLE metric only offers a simple indication of the expected likelihood of encountering supply deficits as it does not provide any information about the magnitude (power and energy), frequency and duration of supply shortfall conditions.

The transition to a low carbon economy is creating significant disruption in the energy sector arising from a combination of policy, technological and customer change. It is transforming the way stakeholders think about, produce and use electricity. The effects of

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disruption in the power sector are likely to drive a dissimilar impact on the risk profile to security of supply to that historically observed. Therefore, there is a need to establish a comprehensive framework to evaluate the risk profile to security of supply in the electricity market of GB.

To this objective, this paper presents a framework to evaluate the risk profile to security of supply through a series of probabilistic metrics that establish the expected magnitude (power and energy), likelihood, frequency and duration of encountering supply shortfalls. These metrics are termed loss of load probability (LOLP), loss of load expectation (LOLE), expected power not supplied (EPNS), expected energy not supplied (EENS), loss of load frequency (LOLF), and loss of load duration (LOLD). The framework not only details the expected value of these metrics but also the distribution around their mean value. The distribution of these risk metrics provides important insights into the behaviour of the electricity supply system under uncertainty and of its implications to security of supply. The framework further characterises the risk profile to security of supply via the identification of the severity of the most likely supply shortfall conditions to occur, their respective frequency and duration. This detailed characterisation of the risk profile to security of supply enables the risks to be identified, assessed, and prioritised to allow effective risk management.

The paper first introduces the main aspects of energy policy that are a cause of concern to security of supply in the UK. It then lays out the concept of security of supply in the electricity market of GB and details how it is quantified, assessed and presented to industry stakeholders. The paper subsequently explores the need for changing the traditional approach used to characterise the risk to security of supply as disruption increases in the power sector. Finally, it presents the framework to evaluate the risk profile to security of supply through a series of probabilistic risk metrics that establish the expected magnitude (power and energy), likelihood, frequency and duration of encountering supply shortfalls.

2. Background and literature review

2.1. Energy policy in the United Kingdom

The trilemma of energy security, energy equity and environmental sustainability underpins the core objectives of energy policy in various jurisdictions around the world (WEC, 2016). However, delivering sustainable energy policies that simultaneously address energy security; universal access to affordable energy services; and environmentally sensitive production and use of energy is one of the most formidable challenges facing governments and industries as different stakeholders tend to place greater emphasis on one dimension or another according to their own priorities.

Security of supply has been an important and politically sensitive topic in the UK with growing concerns over the end of the last and the current decade as the margin of supply over demand tightens and the risk to security of supply widens. The multitude of factors contributing to these concerns, which can be distinguished as market driven and politically driven, are subsequently discussed (RAEng, 2013).

2.1.1. EU directives

European Union (EU) environmental directives are leading to widespread closure of coal and oil power plants. The Large Combustion Plant Directive (LCPD) limits the emission of sulphur dioxide, nitrogen oxides and dust from combustion power plants (European Parliament and Council, 20011a). Those plants that have chosen to opt-out of the implementation of the required technologies to meet the emission standards of the directive must close once they have operated for a maximum of 20,000 h from 1 January 2008 to 31 December 2015. As a consequence, around 11.5 GW of coal and oil power plants have closed. The Industrial Emissions Directive (IED) consolidates the LCPD by imposing more stringent emissions limits on large combustion plant (European Parliament and Council, 2011b). Existing plant will be able to opt-in either by committing to the directive's emission limit values from 2016, or by entering into a Transitional National Plan from 2016 to 2020 and fully complying with the emission limit values from 2020. Opted-out plant will be permitted to operate for a maximum of 17,500 h between 2016 and 2023, after which they must close. The precise impact of the IED, in terms of existing power plants that will opt-out, is currently unknown, however the most significant impact of plant closures is expected to begin towards the end of the decade and to occur to a greater extent from 2020 onwards. As a result, around 4.2 GW of coal power plants have closed between the beginning and the summer of the year 2016 (BEIS, 2016).

2.1.2. End of life of nuclear plants

A significant proportion of the existing nuclear power stations will reach the end of their expected operational life time towards the end of this and the beginning of the next decade. It is expected that approximately 8.4 GW (DECC, 2012) of nuclear supply capacity will retire by 2023.

2.1.3. Low profitability of gas plants

Since late 2010, rising and volatile gas prices, in combination with declining coal prices, have changed the market dynamics in terms of gas and coal plant competition in the UK (Stokes et al., 2015). The comparatively higher fuel cost of gas means that the profit margin between the gas price and the electricity price (i.e. spark spread) is too low to justify investment in new gas-fired generation. Concerns about the low levels of profitability have led power companies to retire gas-fired power plants, either permanently or temporarily (i.e. mothballing).

2.1.4. Policy and regulatory uncertainty

The energy industry in the UK has faced unpredictable and frequently changing energy policies throughout this decade which has caused a loss of momentum, has created an unstable environment for investment in supply infrastructure and has potentially amplified the risk to security of supply.

In 2013 the UK Government legislated the Electricity Market Reform (EMR) which introduced a set of policies to incentivise investment in secure, low-carbon electricity, improve the security of GB electricity supply, and improve affordability for consumers (Parliament of the United Kingdom, 2013). Broadly, the EMR includes both a structure of long-term contracts for low carbon generation and a Capacity Mechanism to ensure adequate supply capacity. The Secretary of State for Business Energy and Industrial Strategy, advised by Department for Business, Energy and Industrial Strategy (BEIS), sets the security of supply standard and decides how much supply capacity is required to secure supply of electricity, which is then delivered through capacity auctions (Newbery, 2015).

In 2015, the new elected Government of the UK announced plans to “reset” the UK's energy policy (DECC, 2015) by prioritising the security of supply and affordability dimensions of the energy trilemma whilst pushing the decarbonisation of the energy sector firmly down in the agenda. This new direction for the UK's energy policy has placed a renewed focus on the nuclear programme, on a new dash for gas and has significantly reduced the financial support available for renewable energy sources. The lack of policy continuity with a clear and consistent direction of travel affects the willingness of people to invest and raise the cost of capital.

In 2016, the UK's decision to leave the EU has brought unknown and far reaching implications both for the UK's energy policies and for the way in which UK policies and markets will relate to those in the rest of the EU (Ekins et al., 2016; Pollitt, 2017). Ambiguity around the new UK-EU relationship raises the levels of uncertainty on energy policy potentially declining investor confidence to pursue new projects and where projects do continue they may be priced with higher risk premiums.

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