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SECURITY OF ELECTRICITY SUPPLIES

Modern societies are vulnerable to unreliable electricity supplies. The recent power failures in London, storm damage to UK electricity networks in 2002, as well as widespread blackouts in North America, highlight the impact of disruptions to electricity networks. Electricity generation shortages are another potential threat to electricity supplies. This briefing outlines the main issues linked to maintaining electricity supplies. It also reviews the role of government in ensuring the security of supply in electricity markets.

Key points:

- **since the introduction of the new electricity trading arrangements (NETA) in 2001 reserve capacity for electricity generation in England and Wales has fallen to its lowest recorded level**
- **the energy regulator, Ofgem, argues that the system was suffering over-capacity and that market forces are restoring equilibrium**
- **there are concerns over whether current arrangements provide sufficient incentives to maintain supply security**
- **the winter 2003-04 of could present significant challenges to the security of supplies**
- **if security of supply is seriously jeopardised, there are questions over how, and under what conditions, the government could intervene to 'keep the lights on'.**

The UK electricity industry

Liberalisation of energy markets is a key Government policy objective. This is widely acknowledged to have created a highly competitive market in which suppliers can sell energy nationwide and customers can choose the supplier which best meets their needs (see box). With electricity there are different market structures in England & Wales, Scotland and Northern Ireland.

The electricity industry in England and Wales

- **generation** is the production of electricity in power stations
- **transmission** is the bulk flow of electricity across the country from power stations to areas of demand. The National Grid Company (NGC) operates the high voltage transmission network and interconnectors with France and Scotland. Interconnections with Norway, the Irish Republic and the Netherlands are under consideration
- **distribution** is the flow of electricity from the high voltage network to final customers
- **supply** is the direct sale of electricity to customers.

In England and Wales the monopoly elements of the business (transmission and distribution) have been separated from those which are subject to competition (supply and generation). A large north to south power flow results from the location of many power stations in the midlands and north, while demand is concentrated in the south. In Scotland, the electricity industry is dominated by two companies, Scottish and Southern Energy and ScottishPower, which provide generation, transmission, distribution and supply. Scotland will become a part of the British Electricity Trading and Transmission Arrangements, BETTA, expected to be introduced in 2005. This will introduce a common set of rules for trading and transmission access within Great Britain. The industry in Northern Ireland consists of four generating companies and a range of supply companies, Northern Ireland Electricity having the responsibility for both transmission and distribution.

What is security of electricity supply?

Security of electricity supplies can be affected on a range of timescales (see boxes on the next page). The focus of this briefing is on short and medium term aspects.[1]

Recent power failures

USA and Canada

On 14 August 2003, six states in the USA and one in Canada lost electric power in North America's worst ever blackout, affecting millions of people and thousands of businesses. Power was restored gradually within a week. Despite much speculation, the causes of the blackouts and why they were so widespread have not yet been determined. Many commentators have suggested that the system itself was under-funded, with insufficient investment to upgrade the transmission system as electricity demand and the number of power stations grew substantially over the last 30 years. US and Canadian authorities have launched an inquiry, but there is no date set for the inquiry to report.

London

On 28 August 2003, two faults in rapid succession in equipment operated by the National Grid Company led to loss of electricity at 6.20pm to an area of south London between Wimbledon and Hurst in Kent. This led to a loss of 20% of the total electricity supply to London at the time. 410,000 customers were affected, with supplies lost to a large part of the London Underground and Network Rail. Full restoration was completed by NGC within 37 minutes and by the distribution company (EDF Energy) shortly after. Disruption to the transport system lasted many hours. NGC published its report into the loss of supply on 10 September 2003. It found that an incorrect piece of equipment had been installed when old equipment was replaced in 2001, and this had not been detected *"despite extensive quality control and commissioning procedures."*[2]

Risks to the security of electricity supplies

Very short term risks - the 'quality' of electricity supply, e.g. power interruptions, frequency and voltage variations
Short term risks - matching supply and demand over a few hours to a day. Shortages arise from reduced generation capacity, unusual demand, or network failures
Medium term risks - maintaining generation and network assets up to 2 years into the future. Investment in new plants is unlikely, but decisions are made about operating existing plants, cancelling planned maintenance, or returning previously redundant ('mothballed') plants to service
Long term risks - investment planning more than 2 years ahead to ensure that sufficient electricity can be generated to match demand and to maintain network reliability
Very long term risks - demand trends and technological changes 10 or more years ahead: generating electricity closer to where it is used ('embedded' in local distribution networks) and more renewable electricity sources which may be intermittent.

Cutting across these timescales is a range of domestic **system risks** originating from possible failures in the domestic infrastructure or markets. These may derive from: low or inappropriate investment in electricity equipment (as is suspected in the case of the recent US/Canadian blackouts), technical failure, deliberate interference, fuel shortages (e.g. gas), or protests or strikes. There are also **strategic risks** such as possible interruptions in the supply of fuel from overseas as result of cartels restricting supplies, political instability, or lack of investment in overseas infrastructure.

Until 2001, the electricity market in England and Wales contained a specific mechanism to encourage generators to provide reserve capacity. The New Electricity Trading Arrangements (NETA), introduced in 2001, now leave the issue of adequate supply to market forces. Indeed, the market is designed to encourage electricity prices to rise as the demand for additional capacity increases, thus encouraging generators to bring mothballed plants back into use. However, some question whether NETA can encourage investment in new plants as there is no mechanism to encourage such long-term investments.

The Office of Gas and Electricity Markets (Ofgem) is the regulator of the electricity industry in Great Britain. It has 'security of supply' objectives to ensure that all reasonable demands for electricity and gas are met and to secure a diverse and viable long-term energy supply. Ofgem provides incentives to ensure timely expansion of network capacity and efficient system operation.

Achieving adequate security

Quality of supply

Maintaining good power quality through investment in transmission and distribution infrastructure is crucial for the operation of a modern industrialised society. Voltage dips and spikes or interruptions in supply even for milliseconds can damage industrial processes and information technology equipment.

Balancing supply and demand

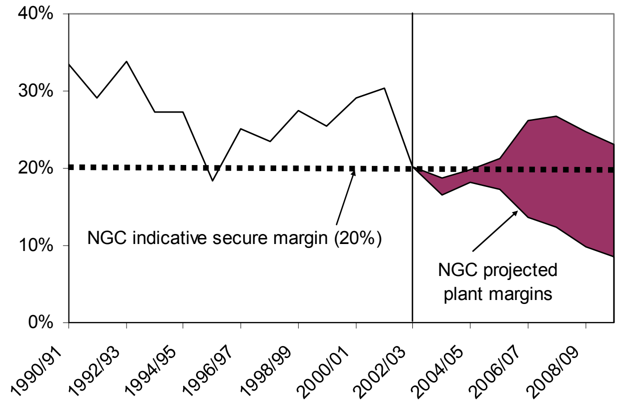
Electricity is difficult and inefficient to store, so demand and supply have to be matched by the system operator in real time. Problems of supply arise from generation plant or transmission failures, while demand variability results from the combination of weather conditions and consumption patterns. NGC manages a mechanism to 'balance' generation and demand that operates up to an hour before the electricity is generated. Further, NGC uses 'balancing services', such as paying large energy users to reduce demand or generators to keep plant ready to respond rapidly, to ensure that production and consumption are matched minute by minute.

For instance on 10 December 2002, there was (for a short time) very little spare generation capacity in England and Wales, and prices to maintain balance rose to up to 500 times the usual power price. The risk of facing such high prices gives suppliers and generators strong financial incentives to avoid such exposure. However, the balancing market averages out price spikes and hence the actual prices paid are not revealed widely across the market. Consequently, others in the market do not face the full price for additional generation seen in the balancing market. As a result, NGC has proposed that the terms of the balancing market are altered to allow market participants to face the actual peak prices, not reduced by the current averaging formula.

Maintaining plant margins

The 'plant margin' is the percentage of installed generation capacity in excess of peak electricity demand in a given period. Since NETA, falling wholesale prices have contributed to the mothballing of some plant and the postponement of construction of a number of new power stations which had received planning permission. As a result, the projected plant margin for the coming winter now stands at 16.5%, which is low by historic standards (see chart on the next page).

Electricity plant margins in England and Wales



Source: National Grid Company plc

For the near future, in the run-up to the winter peak for 2003/04, NGC has suggested that it could operate the system through a severe winter with a capacity margin of 16.5%, but that these conditions may require some control on electricity demand – for example short-term voltage reductions over peak periods. Consequently, NGC has called for the market to provide additional capacity. In response, wholesale electricity prices have risen leading to Powergen recently announcing that it will bring back generation from part of its Isle of Grain power station; this would push capacity margins up to ~18%.

Looking ahead, the chart shows that plant margins over the next 7 years are forecast to be between 8.5% (should no new generating plant be built) and 26.7% (where all currently foreseen new plant is brought into service). These scenarios take no account of future plant closures other than those already notified to NGC, which include the closure of the Magnox nuclear plant.

How much capacity is needed?

What is the ideal capacity level?

The International Energy Agency of the OECD reports that plant margins vary widely between different electricity markets.[3] It points out that the reserve requirement depends greatly on the characteristics of the electricity system, particularly on transmission and distribution capacities, storage installations, the physical size of the system, and the portfolio of generating plants. NGC uses a planning margin of 20% as a benchmark. Capacity in electricity systems can also be increased by:

- making electricity systems themselves more flexible in responding to surges in demand - e.g. large industrial consumers accepting occasional lower voltages or supply interruptions in return for lower prices
- vulnerable businesses and institutions choosing to install their own back-up sources of generation
- major users buying electricity directly from generators
- increasing embedded generation
- operating interconnectors between England and mainland Europe. However, simultaneous high demand in mainland Europe could reduce the availability of this source.

Ofgem argues that market forces can determine the appropriate level of capacity, and considers the current trend as shown in the chart as reflecting a well-functioning market. It argues that previous market failures led to over-capacity and that NETA is now enabling the market to restore equilibrium through withdrawal of capacity (either closure or mothballing). The current low capacity levels are thus seen as short-term responses while the market settles down to a more nearly optimum level. Others question the ability of price spikes in the short term market to influence medium term electricity prices.

In 2001, Ofgem and the Department of Trade and Industry set up a Joint Energy Security of Supply (JESS) group to examine energy security issues. In its February 2003 report the group concluded that there are examples of energy prices responding to security of supply issues, and of generators delivering new investment, or reinstating mothballed plant.[4]

Managing the risks

Monitoring and forecasting

NGC requires a minimum of six months' notice where a generator wishes to disconnect a power station from the network, but may receive no notice of a generator mothballing or reducing the availability of its generation. Thus, reliably forecasting supply availability over a longer timescale is not straightforward. Further, many are concerned that plant closures may not be a smooth process in the future, with tighter environmental regulations and ageing plants potentially causing rapid closures of coal and other nuclear plants after 2010. NGC monitors applications for new plants, but cannot predict reliably which will come online and when.

JESS and Ofgem also review progress by network operators in improving network reliability and have found that electricity distribution companies are now better able to recover from an emergency than they were before privatisation. Similarly, Ofgem recently completed an asset risk management survey of the electricity and gas network companies in which it identified differences in the performance of different companies. In particular, it found good practice among some companies in identifying and assessing strategic financial and technological risks.[5] However, it remains unclear at present whether sufficient attention is being paid to maintain distribution as well as transmission networks. Indeed, this is the subject of a current inquiry by the House of Commons Trade and Industry Committee. Finally, in terms of ensuring the financial resilience of network operators, the Government is consulting on whether to introduce a special administration regime which would ensure uninterrupted operation of essential services in the event of a company becoming insolvent.

Encouraging system resilience

The resilience of the electricity system to unforeseen events will be greater, the more diversity and flexibility is incorporated in the system. **Diversity** can be enhanced by using a range of fuels, generating technologies, and situating both fuel sources and generation plants across a range of geographical locations. Here, concerns have been raised about the decline in diversity that could result from growth in the use of natural gas for electricity generation. Overall, the extent of diversity required depends on the balance between the cost of adding diversity against the degree of risk reduction achieved.

Further, the **flexibility** of an electricity system (its ability to adapt quickly at low cost) is also important to ensure that it is resilient to shocks. Examples include the ability to use more than one fuel in fossil fuel plants, stockpiles of fuels (particularly coal) to cope with interruptions in supply, and providing additional generation capacity. While some of these feature in the UK energy system, concerns have been expressed that there is insufficient gas storage capacity. Other aspects of flexibility include ensuring that equipment is maintained – especially back-up systems that may remain unused for long periods – and that adequate resources, skills, and regular emergency training are in place.

Could US/Canadian style blackouts happen in Britain?

As the precise causes of the North American event have not yet been determined, it is not possible to answer this question with certainty. The recent loss of supply to London, while dramatic, was on a much smaller scale than the North American incident. Moreover, there is a fundamental difference between the British and North American situations. The US/Canadian event appears to have occurred due to insufficient planning and investment in the transmission infrastructure. In contrast, NGC and other commentators report that the UK transmission network is sufficiently robust and operates sufficient reliability criteria, backed up by penalties in the event of breaches. However, complex engineering systems always carry a degree of risk as illustrated by the recent London blackout. While additional back-up security could always be added, this comes at a price, and the issues are what level of security is considered appropriate and whether it is cost effective to provide this.

NGC and others remain concerned about whether there will be sufficient generation capacity available in a severe winter. Should capacity margins disappear altogether, NGC remains confident that widespread blackouts are unlikely but rolling blackouts still may be a last resort. A more realistic scenario may be short term decreases in voltage during short term peaks in demand (often 30 minutes or less).

Demand-side policies

As discussed earlier, security could be increased further by encouraging more flexibility in demand. Some are concerned however how the electricity trading arrangements may work against this.

In addition to managing demand for small numbers of customers during specific peaks, there is the wider issue of managing the overall demand for electricity across the economy. In its projections of reserve margins to 2009/10, NGC uses demand forecasts that show continued increase. Meanwhile, a policy goal in the 2003 Government Energy White Paper is to increase energy efficiency considerably. A question arises therefore, over to what extent managing overall energy demand can increase the plant margin.

Government intervention

In the long term, a well functioning market would provide adequate levels of security. However, in practice, various market failures could have a negative impact on security of supply. These include price caps or distortions (which may result from government policy) and cyclical patterns in prices, confidence and investment. Options to bolster capacity include reinstating dedicated payments to generators to ensure specified levels of plant margin, facilitating investment in long term generation capacity, and setting regulatory standards for security of supply to encourage investment beyond what the market would normally deliver. In a report for the DTI, consultants examined mechanisms for creating capacity obligations. It concluded that regulators are "*only beginning to identify possible solutions and have not yet led to the creation of new and successful schemes.*"[6]

However, many claim that government intervention should be carefully considered as it might worsen the situation. In its Energy White Paper, the Government committed itself to interfering as little as possible with the electricity market. Some have, however, questioned whether this commitment can be met during periods of high-prices and enforced supply reduction. This could mean that companies under-invest in supply security, relying on the government to come to the rescue, especially where the market cannot give the right incentives to encourage long-term investment. Many consider therefore that electricity should be treated differently from other commodities because of its vital importance for the economy, and its public service characteristics. While the government has been ready to intervene to ensure supply security, questions remain over how it should intervene (e.g. setting licence conditions for the maintenance of existing networks and through price control) and how this is justified in relation to the levels of risk of power losses that are politically acceptable set against its other energy policy objectives.

Endnotes

1 See *UK Electricity Networks*, POSTnote 163, Parliamentary Office of Science and Technology, October 2001.
2 www.nationalgrid.com/uk/news/mn_pr1063184923.html
3 *Security of supply in electricity markets, evidence and policy issues*, International Energy Agency, Paris, 2002.
4 *Second report of the Joint Energy Security of Supply Group*, Department of Trade and Industry, 2003.
5 *Asset Risk Management Survey, Composite Industry Report*, Ofgem, December 2002.
6 *Electricity markets and capacity obligations, A report for the DTI*, National Economic Research Associates, December 2002.

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to Fabien Roques and Cambridge University for the research undertaken in the preparation of this briefing note.

The Parliamentary Office of Science and Technology, 7 Millbank, London SW1P 3JA Tel 020 7219 2840

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