North Hyde Review Interim Report

6 May 2025

NESO
National Energy System Operator

Contents

Introduction

1. Foreword

1.1 This interim report concerns the events of 20-26 March 2025 surrounding the power outage at North Hyde 275 kilovolt (kV) substation near Hayes in West London ("the incident"). The power outage led to the loss of supply to 66,919 customers, including Heathrow Airport and a number of commercial customers.

1.2 NESO has been commissioned by the Secretary of State for Energy Security and Net Zero (the "Secretary of State") and Ofgem to review the incident; to identify lessons and recommendations for the prevention, and management, of future power disruption events; and to identify lessons for Great Britain's energy resilience more broadly.

1.3 This interim report solely focuses on:

a) establishing the timeline and sequence of events of the outage,

b) explaining the roles and responsibilities of the key stakeholders involved, and

c) outlining areas of further investigation required to deliver the final report in June 2025, in line with the Terms of Reference set by the Secretary of State and Ofgem dated 28 March 2025 (see Appendix A).

1.4 This interim report has been produced by NESO's review team based on an initial examination of the available evidence gathered and provided by key stakeholders as of 6 May 2025. All evidence and information, including anything received after this date, will be subject to further review in advance of publication of the final report in June 2025.

1.5 NESO would like to thank all stakeholders for their collaboration, cooperation and timely provision of information and evidence to support this review.

2. Executive summary

2.1 On Thursday 20 March 2025 at 23:21, one of three supergrid transformers ("SGT3") at North Hyde 275kV substation and its associated circuit, connecting it to the wider transmission system, tripped. SGT3 was later confirmed to have caught fire. Shortly after, the adjacent transformer ("SGT1") also tripped, resulting in the simultaneous loss of connection to the remaining transformer ("SGT2"). The consequence was the loss of all supplies from North Hyde 275kV substation, impacting thousands of customers including Heathrow Airport.

2.2 The resulting outage led to 66,919 domestic and commercial Scottish and Southern Electricity Networks Distribution ("SSEN Distribution") customers losing power, including the complete loss of power to part of Heathrow Airport's private internal electrical distribution network.

2.3 Heathrow Airport Limited took the decision to close Heathrow Airport due to the disruption caused to operationally critical systems following the power outage.

2.4 London Fire Brigade worked with National Grid Electricity Transmission and SSEN Distribution to ensure power was isolated on the substation site, in line with the National Fire Chiefs Council's National Operational Guidance, before tackling the fire.

2.5 Network restoration efforts led to North Hyde 275kV substation being re-energised on Saturday 22 March.

2.6 SSEN Distribution sought to restore power to its customers, restoring approximately 42,000 customers within an hour of the loss of supplies at the North Hyde site. All domestic customers had power restored by 12:24 on Friday 21 March.

2.7 Heathrow Airport closed for the majority of Friday 21 March, partially reopening that afternoon. To enable this, Heathrow Airport Limited, utilising its two other electrical connections to SSEN Distribution's system, reconfigured its own internal electrical distribution network to restore power to its terminals and wider airport infrastructure. Heathrow Airport reopened for business-as-usual operation on Saturday 22 March.

2.8 The root cause of the fire remains unknown whilst forensic fire investigations are ongoing. The Metropolitan Police Service confirmed on Tuesday 25 March that it had "*found no evidence to suggest that the incident was suspicious in nature*".

2.9 Looking ahead, NESO anticipates that the final report will contain findings and recommendations relating to the resilience of energy infrastructure, the response and restoration of energy infrastructure including cross-sector incident management, and the resilience of critical national infrastructure to energy disruption.

3. Roles and responsibilities

3.1 This table outlines the roles and responsibilities of relevant parties to this review.

Organisation	Role and responsibilities in this review
National Energy System Operator ("NESO")	The electricity system operator responsible for balancing and directing configuration of the electricity transmission system during the incident.
	The independent organisation commissioned under condition C7.5 of the Electricity System Operator Licence, to review the incident, to identify lessons and recommendations for the prevention, and management of future power disruption events, and lessons for Great Britain's energy resilience more broadly.
National Grid Electricity Transmission	The owner of transmission assets and responsible for the control of all equipment, maintenance and incident response at the North Hyde 275kV substation. National Grid Electricity Transmission owns the North Hyde 66kV substation, with SSEN Distribution owning a number of assets within the site.
Scottish and Southern Electricity Networks Distribution ("SSEN Distribution")	The electricity distribution network operator responsible for maintaining and controlling the distribution network in the area, including switching to change its network configuration. It has a connection agreement with Heathrow Airport Limited and operationally controls North Hyde 66kV, 22kV and 11kV substations.
UK Power Networks Services	The private network service provider with responsibilities under a service contract with Heathrow Airport Limited for maintaining the high voltage (HV) electricity distribution network at Heathrow Airport. UK Power Networks Services also owns and is responsible for the replacement of any HV network assets built before 2016 at Heathrow Airport.
Heathrow Airport Limited	Heathrow Airport is owned and run by Heathrow Airport Limited, which is owned by Heathrow Airport Holdings Limited. Heathrow Airport Limited is responsible for the control of all electricity networks at Heathrow Airport and directs UK Power Networks Services to carry out switching and maintenance on this network. Heathrow Airport Limited also owns and is responsible for the replacement of any HV network assets built after 2016 at Heathrow Airport.
London Fire Brigade	London Fire Brigade is one of the emergency services for the Hayes area that responded to the incident. London Fire Brigade also worked closely with the Local Resilience Forum to manage local concerns. This included control of the site during the incident. London Fire Brigade is undertaking a forensic fire investigation of the fire at the North Hyde site with National Grid Electricity Transmission and transformer experts Doble, to establish details of its root cause and spread.

Roles and responsibilities continued

Organisation	Roles and responsibilities in this review
Metropolitan Police Service	Metropolitan Police Service is one of the emergency services for the Hayes area that responded to the incident. The Counter Terrorism Command of the Metropolitan Police Service (SO15) conducted initial investigative assessment of the fire.
Department for Energy Security and Net Zero	The Department for Energy Security and Net Zero is the government department responsible for enhancing UK energy security, protecting billpayers, supporting economic growth for the UK and generating and protecting jobs, and reducing the UK's emissions. The Secretary of State for Energy Security and Net Zero (the "Secretary of State"), working with Ofgem, has commissioned the National Energy System Operator, under condition C7.5 of the Electricity System Operator Licence, to carry out this independent review.
Office of Gas and Electricity Markets ("Ofgem")	The energy regulator for Great Britain with responsibilities related to deciding how investment is made on the electricity network, who, jointly with the Department for Energy Security and Net Zero, commissioned the National Energy System Operator to undertake this review.
Department for Transport	The Department for Transport is the government department responsible for working with agencies and partners to support the transport network. Amongst other responsibilities, it sets national aviation policy, working with airlines, airports, and the Civil Aviation Authority.
Civil Aviation Authority	The Civil Aviation Authority is the UK's independent specialist aviation regulator, a public corporation, established by Parliament in 1972. Amongst other responsibilities, it regulates all certified UK airports to ensure they comply with relevant international and UK safety standards. It is also the economic regulator for Heathrow Airport.

4. Electricity explainer

4.1 This section explains how transmission and distribution networks function to contextualise the North Hyde incident.

4.2 The transmission network is the electrical equivalent of the motorway network, transporting electricity over longer distances at higher voltages. The distribution networks are comparable to A and B roads, moving electricity around at lower voltages to where it is needed. At a national level, NESO, as the electricity system operator, makes sure that there is enough electricity to meet what is needed at any time of the day by balancing supply and demand. NESO is also responsible for directing the configuration – how it all connects together - of the electricity transmission system.

4.3 Transmission and distribution networks use both overhead lines and underground cables, to create circuits and transport electricity. Substations are situated at multiple points on the network.

4.4 In a substation, a circuit delivers electricity at one voltage level, and in many places is reduced or 'stepped' down to a lower distribution voltage using a transformer. This is a large, specialist piece of equipment, generally with a tank containing an iron core with copper windings and filled with insulating oil. Electricity flows in from the incoming circuit via connectors through the three high voltage connections (or HV bushings) through the windings in the transformer, insulated and cooled by the oil which circulates through the transformer tank and its connected external radiator. Once the voltage is stepped down, it flows out through the three low voltage connections (or LV bushings). This electrical process creates heat, so monitoring equipment is used to measure transformer winding temperatures and dissolved gas in the oil as indications of possible faults, alongside the protection equipment that monitors electrical flows.

4.5 Transformers contain a significant amount of oil, so they are mounted on a concrete pad within a transformer bund. This is a very large capacity pit that sits around and underneath the transformer itself to contain oil and water if necessary, minimising further impact to the site and its surrounding environment.

4.6 Supergrid transformers connect between the high-power transmission system and the lower power distribution system, transforming between different voltage levels (e.g., 400kV to 132kV, or 275kV to 66kV). Grid transformers then connect within the distribution system as the voltage levels further reduce to a standard domestic 230-volt (V) connection.

4.7 Substations are also where resilience can be built into the network, installing extra equipment including transformers and switches (including circuit breakers) on an internal network or busbar. Busbars are electrical crossroads that allow the configuration to be switched around manually or automatically, swapping in or out equipment for maintenance or in case of faults.

The incident

5. Incident timeline

Thursday 20 March

- 23:21 — SGT3 at North Hyde 275kV substation out of service following circuit trip
- 23:21 — SGT2 automatically switches into service, restoring two transformer supply to North Hyde
- 23:22 — London Fire Brigade receives the first call about a fire at North Hyde substation
- 23:28 — London Fire Brigade's first fire appliance arrives on site
- 23:49 — SGT1 and its circuit, which was also feeding SGT2, trips meaning there are no supplies to North Hyde 66kV substation. 66,919 customers lose power, including Heathrow Substation A

Friday 21 March

- 00:47 — SSEN Distribution has restored approximately 42,000 customers
- 01:11 — Heathrow Airport Limited decides to close Heathrow Airport in response to disruption
- 06:25 — Heathrow Airport Limited's control centre re-energises all primary substations by reconfiguring its private network
- 09:49 — Busbars at North Hyde 66kV substation re-energised using SSEN Distribution's circuits from Iver 66kV substation
- 12:24 — All SSEN Distribution's domestic customers restored
- 13:30 — Heathrow Airport Limited begins safety checks to reopen for some repositioning and repatriation flights

Saturday 22 March

- 00:55 — Re-energisation of North Hyde's SGT2
- 02:22 — North Hyde's SGT2 was put on load
- 19:22 — Iver SGT4B switched and supplying load to two 66kV circuits from Iver to North Hyde

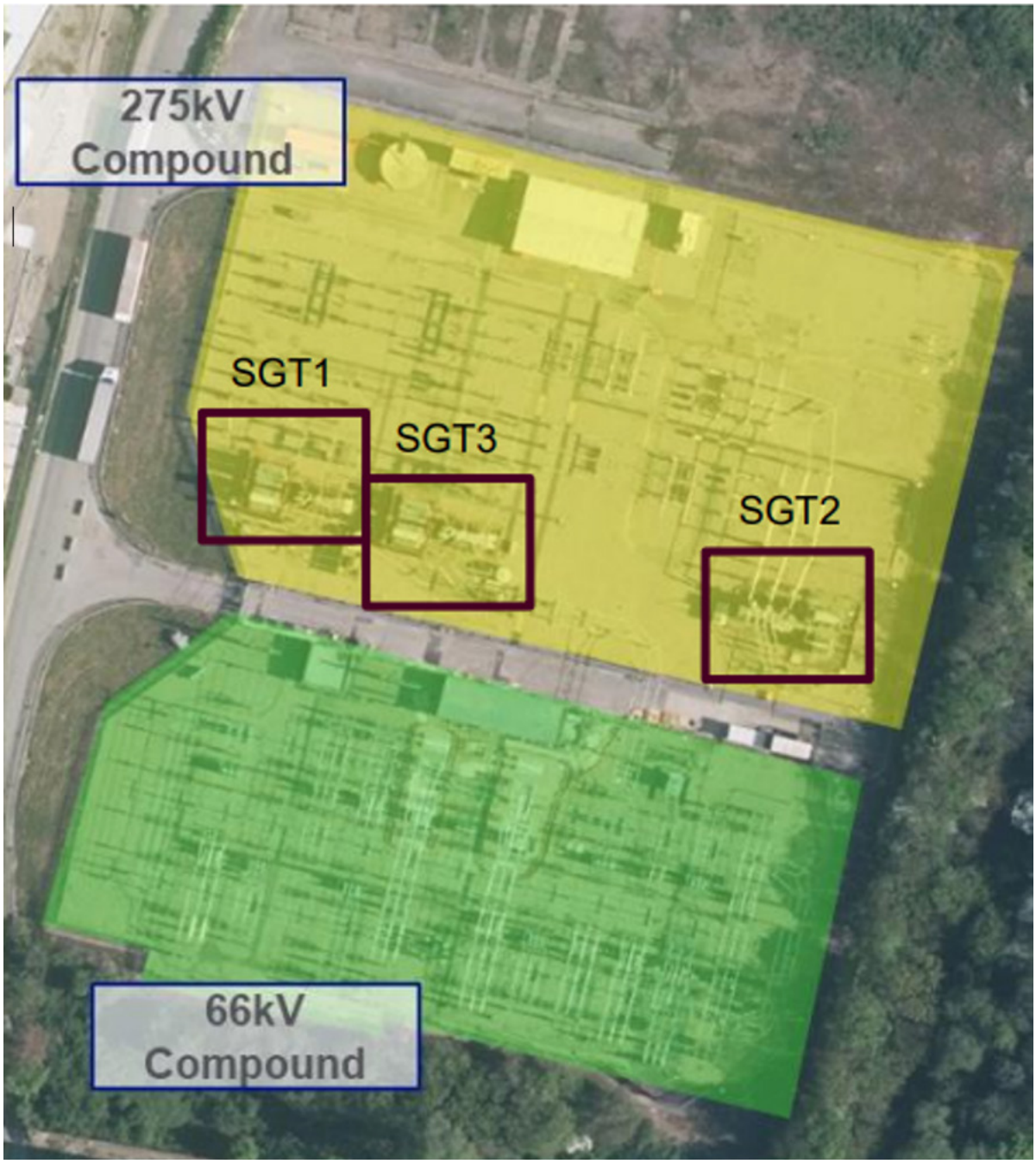

Figure 1: Image of North Hyde site from National Grid Electricity Transmission

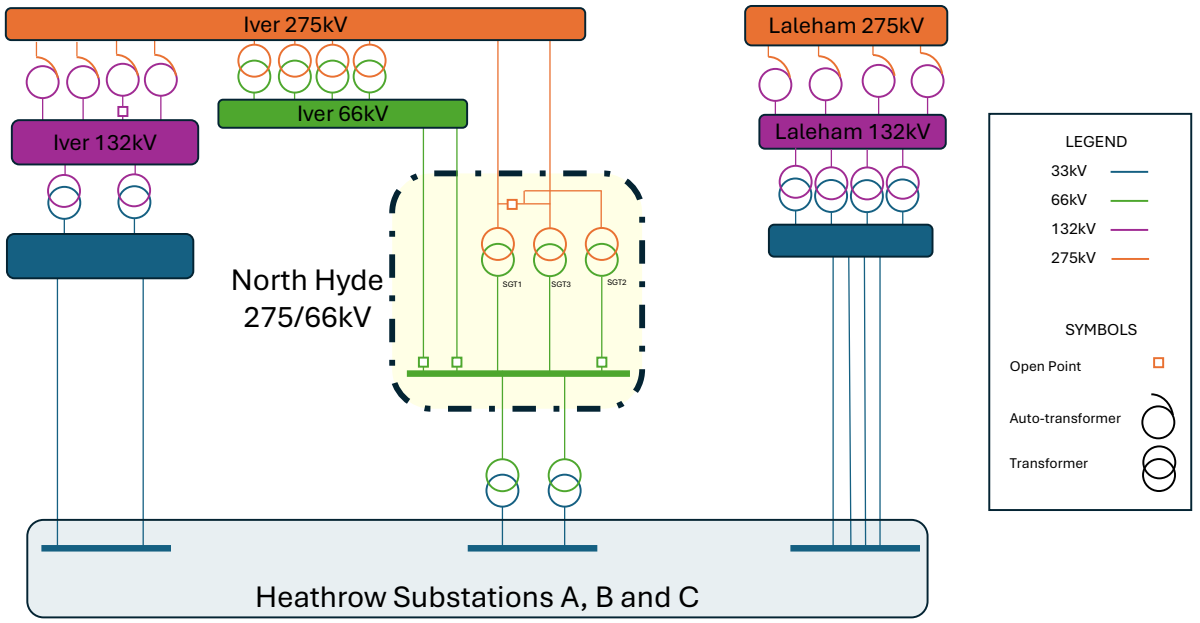

Figure 2: Illustrative standard network configuration and supply to Heathrow Airport

5. Incident description

5.1 This section describes the network configuration at the North Hyde substation site and Heathrow Airport, how the incident unfolded, and the subsequent steps taken to restore electricity supplies.

North Hyde site

5.2 The North Hyde site is located east of Hayes in West London. There are four substations at the site: the 275kV (controlled by National Grid Electricity Transmission) and the 66kV, 22kV and 11kV (all operationally controlled by SSEN Distribution).

5.3 There are three supergrid transformers (SGT) at North Hyde, located in the 275kV substation compound; SGT1, SGT2 and SGT3. These transformers are designed to step down the voltage from 275kV to 66kV and are owned by National Grid Electricity Transmission.

5.4 SGT1 and SGT3 were commissioned in 1968 and are adjacent to one another. SGT2 was commissioned in 2010 and sits over 30 metres away from the other two transformers (see Figure 1).

5.5 North Hyde 275kV substation is designed to operate with two transformers on-load and the third on "hot-standby" (i.e., energised and ready to switch in as needed). This is achieved using an autoclose scheme which operates automatically following the loss of either of the two in service transformers, SGT1 or SGT3. The scheme is designed to switch SGT2 into service automatically if a problem is detected on either SGT1 or SGT3 that results in one of them having to be disconnected.

Heathrow Airport configuration

5.6 Heathrow Airport is the largest airport in Europe and connects to over 230 destinations. It serves over 82 million passengers a year, and over 26% of the UK's exports by value.

5.7 Heathrow Airport's private internal electrical distribution network is fed from three independent supply points. One of these (referred to in this report as "Heathrow Substation A") is usually fed from North Hyde 66kV substation. Heathrow Substation A in turn supplies some of the airport terminals, key airport operations and other facilities.

5.8 The three independent supply points each supply different areas and systems across the airport, and normally these points are not connected. When necessary, for example in the event of a fault, it is possible to reconfigure supplies to be fed from a different point. This takes significant network switching, and prior to the event was understood to take a number of hours to enact.

Power outage at North Hyde site

5.9 At 23:21 on Thursday 20 March, SGT3 at North Hyde 275kV substation and the circuit connecting it to the wider transmission system tripped. This left North Hyde 275kV substation being fed by a single transmission circuit. Multiple alarms associated with North Hyde's 275kV SGT3 circuit were received by NESO's and National Grid Electricity Transmission's control centres, indicating that SGT3 had been automatically disconnected from the network via switching triggered by its protection systems.

5.10 Immediately following the loss of SGT3, SGT2 - which had been running on hot standby - automatically switched into service and connected to the same 275kV circuit that fed SGT1. This operated as designed and restored a two-transformer supply into North Hyde 66kV substation, with no interruption of supply to customers.

5.11 At 23:49, 28 minutes after the loss of SGT3, SGT1's protection systems operated, automatically switching SGT1 and the circuit connecting it to the wider transmission system out of service. As SGT2 was connected to the same circuit as SGT1, SGT2's direct connection to the wider transmission system was also lost.

5.12 At this point, as all three SGTs could not be fed from the wider transmission system, there were no supplies to the North Hyde 66kV and 22kV substations. This resulted in 66,919 of SSEN Distribution's domestic and commercial customers who were being supplied via North Hyde 66kV and 22kV substations losing power, including a loss of supply to Heathrow Substation A.

Management of the site and fire

5.13 London Fire Brigade confirmed it received the first call about a fire at the North Hyde site at 23:22. The first fire appliance arrived at the site at 23:28, positioned outside the perimeter fence.

5.14 Over the following 30 minutes, London Fire Brigade requested nine additional fire appliances in order to safely tackle the fire. At 00:42 the Metropolitan Police Service declared a major incident.

5.15 In order to tackle the fire, London Fire Brigade worked with National Grid Electricity Transmission and SSEN Distribution to ensure power was isolated on the substation site, providing engineers with access, as required.

5.16 The National Grid Electricity Transmission standby engineer had arrived at site by 23:50, and by 00:11 confirmed that the site was off supply and London Fire Brigade was attempting to contain the fire from the substation perimeter. By 06:00, permits were in place confirming electrical safety, which allowed London Fire Brigade to enter the site. This was in line with the National Fire Chief Council's National Operational Guidance for London Fire Brigade.

5.17 When required, and following risk assessments, London Fire Brigade worked with National Grid Electricity Transmission and SSEN Distribution to enable parts of the site to be reenergised whilst firefighting actions continued.

5.18 Power was returned on Friday 21 March to North Hyde 22kV substation at 00:39, North Hyde 66kV substation at 09:49, and on Saturday 22 March at 00:55 SGT2 at the North Hyde 275kV substation was energised and was put on load at 02:22 (see paragraphs 5.20 - 5.25).

5.19 London Fire Brigade issued the stop message, confirming cessation of firefighting, at 17:13 on Wednesday 26 March, five days and 18 hours after it first arrived on site.

Figure 3: **Aerial photo of SGT3 taken by London Fire Brigade drone, 21 March 02:22:50**

Figure 4: **Aerial photo of SGT3 taken by London Fire Brigade drone, 21 March 07:55:38**

Network restoration

5.20 After the tripping of SGT3 at 23:21 and SGT1 at 23:49, the 275kV, 66kV and 22kV substations at North Hyde had no supplies.

5.21 Following discussions between SSEN Distribution, National Grid Electricity Transmission and London Fire Brigade, at 09:49 on Friday 21 March, North Hyde 66kV busbars were re-energised. This used interconnection to Iver 66kV substation, elsewhere on the SSEN Distribution network. This facilitated the full restoration of domestic customers (see paragraphs 5.26 - 5.29), and the ability to provide supplies to the Heathrow Substation A and other commercial customers (see paragraph 5.34).

5.22 At 00:55 on Saturday 22 March, North Hyde 275kV substation's SGT2 was energised and connected to the wider transmission system. At 02:22, SGT2 was used to supply the 66kV bars at North Hyde. The 66kV interconnector circuits from Iver were switched out at this point to manage the flow on the circuits. This left North Hyde 66kV fed from a single transmission circuit.

5.23 NESO, National Grid Electricity Transmission and SSEN Distribution agreed a proposal to return the SGT4A and SGT4B circuits at Iver substation, which had been undergoing repairs following a fault in January and had already been planned to return to service on Saturday 22 March. The successful return of Iver SGT4A and SGT4B allowed the Iver network to be reconfigured with SGT4B switched and supplying load to two 66kV circuits from Iver to North Hyde from 19:22.

5.24 Following the return of SGT4A and SGT4B at Iver substation, the substation was reconfigured to allow two SGTs to supply North Hyde 66kV substation via the 66kV interconnectors if needed, while the other two Iver SGTs supplied the Iver 66kV load. In this arrangement, North Hyde 275kV substation SGT2 and the 66kV interconnectors could supply customer demand at North Hyde 66kV substation. This provided additional resilience to supply this demand.

5.25 North Hyde 275kV SGT1 and SGT3 remain out of service at the time of publication.

SSEN Distribution customer restoration

5.26 At 00:06 on Friday 21 March, SSEN Distribution began work to restore supplies to its customers using interconnections with substations that were not affected by the outage. By 00:47, SSEN Distribution had restored approximately 42,000 customers using 22kV and 11kV interconnections. Restoration of customers continued using these interconnections until 04:00 when available capacity on these cables was fully utilised, and 4,868 domestic customers remained without supplies.

5.27 Once North Hyde 66kV had been reenergised at 09:49 (see paragraph 5.21), SSEN Distribution was able to restore supplies to the remaining domestic customers. By 12:24, all domestic customers had power restored.

5.28 A number of commercial SSEN Distribution customers were also impacted by loss of power. The review is pursuing a line of enquiry to understand the response of these other commercial customers to the incident, including their use of back-up generation.

5.29 SSEN Distribution reported that they had updated all Priority Service Register customers via mobile and landline text by 03:37 on Friday 21 March.[1]

1 The Priority Service Register is a free service for customers who may be vulnerable in the event of power outages, for example due to medical conditions.

Heathrow Airport restoration

5.30 At 23:49 on Thursday 20 March, power was lost to Heathrow Substation A, meaning power was lost to some airport terminals and some shared systems required for overall airport operations. Heathrow Airport's airfield ring generators automatically started to maintain supplies to the runways and essential safety systems, maintaining the ability to land aircraft safely.

5.31 At 01:11 on Friday 21 March, Heathrow Airport Limited took the decision to close Heathrow Airport due to the disruption caused to operationally critical systems following the power outage, and at 02:14 issued a media statement confirming closure until 23:59 later that day.

5.32 From 02:00 on Friday 21 March, Heathrow Airport Limited's Airport Control Engineer began to re-energise terminals and other impacted systems, which had lost supplies from Heathrow Substation A (having been fed from North Hyde 66kV substation). Heathrow Airport Limited's engineers used interconnections between Heathrow Airport's intake substations.

5.33 All of Heathrow Airport's primary 33kV substations connected to Heathrow Substation A were re-energised by 06:25, following which Heathrow Airport Limited's engineers re-energised the wider network of around 300 low voltage substations. By 10:56 it was confirmed that power had been restored to all of Heathrow Airport's terminals and re-energisation of the wider Heathrow Airport Limited network was completed by 14:23. Once power had been restored, there was a period of safety checking to allow all parties operating the airport to access their systems and to ensure safety critical systems were fully operational prior to passengers arriving at the airport.

5.34 From the afternoon of Friday 21 March, Heathrow Airport Limited continued to discuss with SSEN Distribution options for switching back to supplies from North Hyde 66kV substation but by 22:30, ultimately decided to remain using the new configuration utilising its two other intake substations.

5.35 Heathrow Airport reopened for some repositioning and repatriation flights on Friday 21 March, and for business-as-usual operation on Saturday 22 March.

Incident response and communication

5.36 Throughout the incident, Heathrow Airport Limited, National Grid Electricity Transmission, SSEN Distribution and NESO all followed incident response and crisis management plans, including activating Silver and Gold Commands where relevant.

Metropolitan Police Service investigation

5.37 The Metropolitan Police Service, supported by the Metropolitan Police Counter Terrorism Command, confirmed on Tuesday 25 March that it had "*found no evidence to suggest that the incident was suspicious in nature*" and closed its investigation into the fire.

5.38 National Grid Electricity Transmission Network's and London Fire Brigade's forensic fire investigations of the incident remain ongoing. The London Fire Brigade has also liaised with the Health & Safety Executive due to the technical/specialist nature of the site. London Fire Brigade is also concurrently running a fire safety investigation due to its regulatory role under the Regulatory Reform (Fire Safety) Order 2005.

Next steps

6. Next steps

6.1 There are multiple ongoing lines of enquiry in this review, which will be developed in preparation of the final report. This will be achieved through a combination of submitted factual evidence, discussions with key stakeholders, engagement with relevant experts and ongoing reviews of existing literature and legislation.

Lines of enquiry

6.2 The following areas are ongoing lines of enquiry in this review:

- The results of National Grid Electricity Transmission's and London Fire Brigade's forensic analysis of the fire to identify the root cause, and the nature of its spread.
- The implementation and legal requirements of design standards for substation sites.
- Maintenance history for assets at North Hyde site, and any potential impact that this may have had on the incident.
- Risk management and mitigation, and resilience planning by stakeholders.
- Heathrow Airport's private network configuration, its operational characteristics and its resilience.
- Incident management coordination by key organisations, at operational and crisis management level.
- The response of other impacted organisations and infrastructure, including Network Rail, Transport for London and SSEN Distribution's commercial customers.
- Communications within and between key organisations where they relate to the incident and response.

Final report

6.3 NESO is intending to conclude this review and provide a final report to the Secretary of State and Ofgem by the end of June.[2] As this review remains ongoing, information in this interim report may be refined or subject to change as the review progresses, and further evidence comes to light.

6.4 At this stage, NESO anticipates that the final report will contain findings and recommendations in relation to the following:

- Resilience of energy infrastructure, approaches to site design, assessments of asset health, and risk management.
- Response and restoration of energy infrastructure, including cross-sector incident management.
- Resilience of critical national infrastructure to energy disruption (as per Terms of Reference 3a), including working to a shared definition and understanding of resilience between sectors.

2 We note that London Fire Brigade's and National Grid Electricity Transmission's forensic fire investigations may not be completed by June 2025 and are exploring options for publication considering this.

Appendices

A. Terms of Reference

A1 The following Terms of Reference were set by the Department for Energy and Net Zero for the National Energy System Operator's review of the North Hyde incident.

Introduction

A2 Late evening on Thursday 20 March, a large fire broke out at North Hyde Electricity Substation in Hayes, London. This resulted in over 60,000 customers and businesses losing power and significant secondary impacts to the aviation sector due to the associated closure of Heathrow Airport. Power was quickly restored to impacted customers, and Heathrow restarted operations from late 21 March. However, there was significant disruption at Heathrow Airport over the weekend of 22 and 23 March.

A3 The Energy Secretary and Ofgem have therefore commissioned the independent National Energy System Operator (NESO), under condition C7.5 of the Electricity System Operator Licence, to review the incident, to identify lessons and recommendations for the prevention, and management of future power disruption events, and lessons for GB's energy resilience more broadly.

Scope

A4 NESO will identify lessons and good practice, regarding energy sector resilience, including both Distribution Network Operators, and Transmission System Operators, and, where relevant, those essential services and sites with a critical dependence on continued electricity supply, using an evidence-based approach. This review will not investigate the knock-on impacts to the transport sector as a result of the closure of Heathrow Airport, which will be covered in the Ruth Kelly review.

In particular, NESO will report on the following 3 pillars, in relation to this incident:

1. Resilience of energy infrastructure

a. Report on the root cause, other contributing factors and sequence of events, of the outage at North Hyde electricity substation and subsequent supply disruption in the surrounding area (alongside the London Fire Brigade investigation).

b. Assess direct and secondary impacts of the event across GB electricity networks, electricity customers, and critical national infrastructure, including why it resulted in the closure of Heathrow.

c. Identify areas of good practice and where improvements are required for continued energy system resilience, considering relevant aspects such as asset management (including on or off-site mitigations), networks supporting the operation of critical national infrastructure (including internal networks that connect to the transmission or distribution systems) and future development of the electricity system.

2. Response and restoration of energy infrastructure

a. Consider what contingency planning had been undertaken in relation to the failure of electricity infrastructure, and assess whether the plans were enacted as planned and delivered as expected during the incident; and

b. Timeliness and effectiveness of the response to the incident, including communications with relevant stakeholders and the public.

3. Enhancing the resilience of critical infrastructure to energy disruption

a. Make recommendations for improving the resilience of essential services, including critical national infrastructure, to power disruption.

A5 The review will focus on the resilience of GB's energy system, given NESO's remit to provide independent advice on the security and resilience of the whole energy system. However, key findings and lessons will be shared with Northern Ireland as appropriate to ensure UK wide resilience to energy risks.

A6 For certain aspects of the review, NESO may rely on information and evidence gathered from other sources; for example London Fire Brigade, who continue to investigate the cause of the fire working close with electricity networks or other internal reviews currently being undertaken with regards to the outages.

A7 A London Fire Brigade investigation will also explore the compliance of fire safety measures under the Regulatory Reform (Fire Safety) Order 2005 and any potential gaps in guidance or regulation.

A8 During the review, NESO will draw on the expertise of the companies involved in managing and operating impacted electricity systems, operators of affected critical national infrastructure, regulators, government and others. The review will not look more widely into airport operations and the impact on customers of the airport and aviation industry.

Deliverables

A9 NESO will submit an initial report to the Secretary of State and Ofgem within six weeks, with an initial assessment of the data available at this stage of the review.

A10 NESO will provide a final report to the Secretary of State and Ofgem by end of June, which will include recommendations and lessons for the future and where possible, a proposed implementation plan.

A11 Key findings and recommendations of the review will be published by NESO.

B. Roles and responsibilities

B1 The following organisations have been identified as key stakeholders in this review and have been invited to contribute through information requests and/or fact-finding discussions.

National Energy System Operator ("NESO")

B2 NESO is the independent system operator and planner established under the Energy Act 2023. It has two relevant but distinct responsibilities in this review:

- Planning Great Britain's electricity and gas systems, operating its electricity system, and making sure that Great Britain has the essential electricity it needs by ensuring supply meets demand every second of every day. NESO's System Operations directorate was actively involved in managing the system response to the incident.
- Post-event analysis and assessment of an event that has detrimentally impacted the energy sector, engaging with relevant stakeholders to the extent required. In this case the review has been commissioned by the Secretary of State and Ofgem.

National Grid Electricity Transmission

B3 The owner of transmission assets and responsible for the control of all equipment, maintenance and incident response at the North Hyde 275kV substation. National Grid Electricity Transmission owns the North Hyde 66kV substation, with SSEN Distribution owning a number of assets within the site.

Scottish and Southern Electricity Network Distribution ("SSEN Distribution")

B4 SSEN Distribution is the electricity Distribution Network Operator responsible for delivering power to customers across central southern England and the north of Scotland. It owns, maintains and controls the distribution network in the area and has a connection agreement with Heathrow Airport Limited. It operationally controls North Hyde 66kV, 22kV and 11kV substations.

UK Power Networks Services

B5 UK Power Networks Services, the commercial arm of UK Power Networks, manages private energy networks and delivers national power infrastructure projects on a commercial basis. It has a service contract with Heathrow Airport Limited for maintaining the high voltage (HV) electricity distribution network at Heathrow Airport. UK Power Networks Services also owns and is responsible for the replacement of any HV network assets built before 2016.

Heathrow Airport Limited

B6 Heathrow Airport is owned and run by Heathrow Airport Limited, which is owned by Heathrow Airport Holdings Limited. Heathrow Airport is the largest airport in Europe, connecting to over 230 destinations, serving over 82 million passengers a year and with over 26% of the UK's exports (by value) passing through the airport. Heathrow Airport Limited owns and controls its own private internal electrical distribution network to support its operations, supplied from three independent points on the SSEN Distribution's network.

B7 Heathrow Airport Limited is responsible for the control of all electricity networks at Heathrow Airport and directs UK Power Networks Services to carry out switching and maintenance on this network. Heathrow Airport Holdings Limited also owns and is responsible for the replacement of any HV network assets built after 2016.

B8 Heathrow Airport Limited commissioned its own review of the incident, the Kelly Review, which seeks to determine the chronology of events, identify the causes of the closure of the airport, evaluate the decisions leading to this, and to determine whether improvements are recommended for Heathrow Airport's resilience and preparedness for future power outage.

London Fire Brigade

B9 London Fire Brigade is one of the emergency services for the Hayes area that responded to the incident. London Fire Brigade also worked closely with the Local Resilience Forum to manage local concerns. This included control of the site during the incident. London Fire Brigade is undertaking a forensic fire investigation of the fire at the North Hyde site with National Grid Electricity Transmission and transformer experts Doble, to establish details of its root cause and spread.

Metropolitan Police Service

B10 Metropolitan Police Service is one of the emergency services for the Hayes area that responded to the incident. The Counter Terrorism Command of the Metropolitan Police Service (SO15) conducted initial investigative assessment of the fire.

Department for Energy Security and Net Zero

B11 The Department for Energy Security and Net Zero is the government department responsible for enhancing UK energy security, protecting billpayers, supporting economic growth for the UK and generating and protecting jobs, and reducing the UK's emissions. The Secretary of State for Energy Security and Net Zero (the "Secretary of State"), working with Ofgem, has commissioned the National Energy System Operator, under condition C7.5 of the Electricity System Operator Licence, to carry out this independent review.

Office of Gas and Electricity Markets

B12 The Office of Gas and Electricity Markets ("Ofgem") is the non-ministerial government department that supports the Gas and Electricity Markets Authority ("GEMA" or the "Authority"). Ofgem's principal objective is to protect the interests of existing and future consumers in relation to gas and electricity systems. The interests of such consumers are their interests taken as a whole, including their interests in the reduction of greenhouse gasses and in the security of the supply of gas and electricity to them.

B13 Ofgem, as the energy regulator for Great Britain, is responsible for working with government, industry and consumer groups to deliver net-zero at the lowest cost to consumers. Ofgem plays a key role in deciding how investment is made on the network through the use of price controls.

Department for Transport

B14 The Department for Transport is the government department responsible for working with agencies and partners to support the transport network. Amongst other responsibilities, it sets national aviation policy, working with airlines, airports, and the Civil Aviation Authority.

Civil Aviation Authority

B15 The Civil Aviation Authority is the UK's independent specialist aviation regulator, a public corporation, established by Parliament in 1972. Amongst other responsibilities, it regulates all certified UK airports to ensure they comply with relevant international and UK safety standards. It is also the economic regulator for Heathrow Airport.

C. Network design and history

C1 This section provides further context on the design history of relevant elements of the electricity network, including the standards that must be met. It describes how the network typically runs, and existing conditions immediately prior to the incident.

Design and history

North Hyde substation site

C2 The North Hyde substation site is located east of Hayes, on the border of Hillingdon and Hounslow in West London. There are four substations at the site: the 275kV (controlled by National Grid Electricity Transmission) and the 66kV, 22kV and 11kV[3] (all operationally controlled by SSEN Distribution). The site was commissioned by the Central Electricity Generating Board in 1968 to supply increasing demand in the Hayes and Heathrow areas, and to serve the expansion of Heathrow Airport through the late 1960s.

C3 The site is located in an urban region with residential, commercial, and industrial areas. There are main transport links in the area surrounding the substation including railway, Heathrow Airport and motorway (M4). There is also a canal to the north of the substation.

North Hyde 275kV

C4 North Hyde 275kV substation is owned and operated by National Grid Electricity Transmission. It is an outdoor air-insulated substation compound. North Hyde 275kV is fed directly from Iver 275kV substation by two 275kV circuits, each connected to the high voltage busbars which in turn connect to the transformers and their associated switchgear.

C5 There are three double-wound supergrid transformers within the North Hyde 275kV substation compound, which step voltage down from 275kV to 66kV. SGT1 and SGT3 were both manufactured by Hackbridge & Hewittic and installed with the 275kV substation in 1968. The third supergrid transformer, SGT2, is a newer Areva model, having been commissioned in 2010.

C6 The North Hyde 275kV substation is designed to operate with two transformers on-load and the third on 'hot-standby'. This is achieved using an autoclose scheme which operates following the loss of either of the two in service transformers, SGT1 or SGT3. The scheme is designed to switch SGT2 into service automatically if a problem is detected on either SGT1 or SGT3 which results in one of them having to be disconnected.

North Hyde 66kV

C7 North Hyde 66kV is an outdoor two-section double busbar substation, with air-insulated switchgear. The 66kV substation was originally commissioned in 1968, concurrent with the connection of the first two supergrid transformers, SGT1 and SGT3. It was later extended in 1977/78 with the addition of four 66kV switchgear bays for the connection of the adjacent (now demolished) Bulls Bridge power station. Since the 1990s, several circuits have been added to the 66kV switch board in order to reinforce the local network.

C8 National Grid Electricity Transmission owns the busbars and associated bus section and bus coupler bays at the North Hyde 66kV substation, as well as the common facilities, and is responsible for the physical management of the site. The majority of the circuits connecting to the North Hyde 66kV busbars site feed the distribution network and are owned by SSEN Distribution, with the rest of the circuits feeding either Network Rail or data centre demand and are owned by these parties. The site is controlled by SSEN Distribution's control room, which undertakes operational and safety switching at North Hyde 66kV substation on behalf of National Grid Electricity Transmission.

3 The detailed operation of the 11kV substation at North Hyde has not been examined as part of this interim report.

North Hyde 22kV

C9 North Hyde 22kV substation is an indoor substation owned and operated by SSEN Distribution, located to the south of North Hyde 66kV substation. It is supplied by three 66/22kV circuits from North Hyde 66kV and can be connected through to the Laleham grid supply point group via East Bedfont. It supplies the North Hyde and Hayes area 11kV network.

Iver substation site

C10 The Iver substation site is located close to Uxbridge, on the western edge of the London Borough of Hillingdon. There are three outdoor substations at the site: the 400kV and 275kV (controlled by National Grid Electricity Transmission), and the 132kV substation (controlled by SSEN Distribution). There is a further indoor 66kV substation, also controlled by SSEN Distribution.

C11 North Hyde 275kV is fed directly from Iver 275kV substation by two 275kV circuits. Iver also supplies SSEN Distribution's demand in East Berkshire, South Buckinghamshire and the London Borough of Hillingdon.

Heathrow Airport's private internal electrical distribution network

C12 Heathrow Airport's private internal electrical distribution network has developed over a number of years as the airport grew. The network is fed from three supply points, referred to in this report as Heathrow Substation A, B and C. These substations each supply a different combination of terminals, the Airport Complexes (Eastern, Central and Western), Maintenance Areas, Cargo and other key airport operations.

C13 Heathrow Airport's three supply points run as independent nodes. Under normal operating conditions, there is minimal interconnection between the three and therefore manual switching procedures must be implemented to reconfigure the network if capacity needs to be moved from one supply point to another.

How the network runs

C14 Prior to the incident, the network was configured as designed and operating within expected parameters. North Hyde 275kV was connected to Iver 275kV via two circuits and the supergrid transformers SGT1 and SGT3 were in service with approximately 100MVA (Megavolt-Amperes) in total (50MVA in each SGT) of power flowing through to the 66kV at North Hyde. SGT2 was on hot-standby, with the system designed to switch the transformer into service automatically, should it be needed.

C15 North Hyde 66kV was running 'solid', meaning it was functioning as a single gathering point for power flows. The 66kV interconnections with Iver 66kV were running as normal, open (disconnected) at North Hyde and closed at Iver so they could be connected to North Hyde when needed.

C16 At Iver 66kV, three out of four 275/66kV transformers were in service. SGT4B (275/66kV transformer) and SGT4A (275/132kV transformer) had been out of service since 11 January due to a failure on the 275kV circuit breaker H40 at Iver 275kV (see Figure 5). At intact conditions, Iver 66kV substation is normally run on three SGTs, with the fourth on hot-standby.

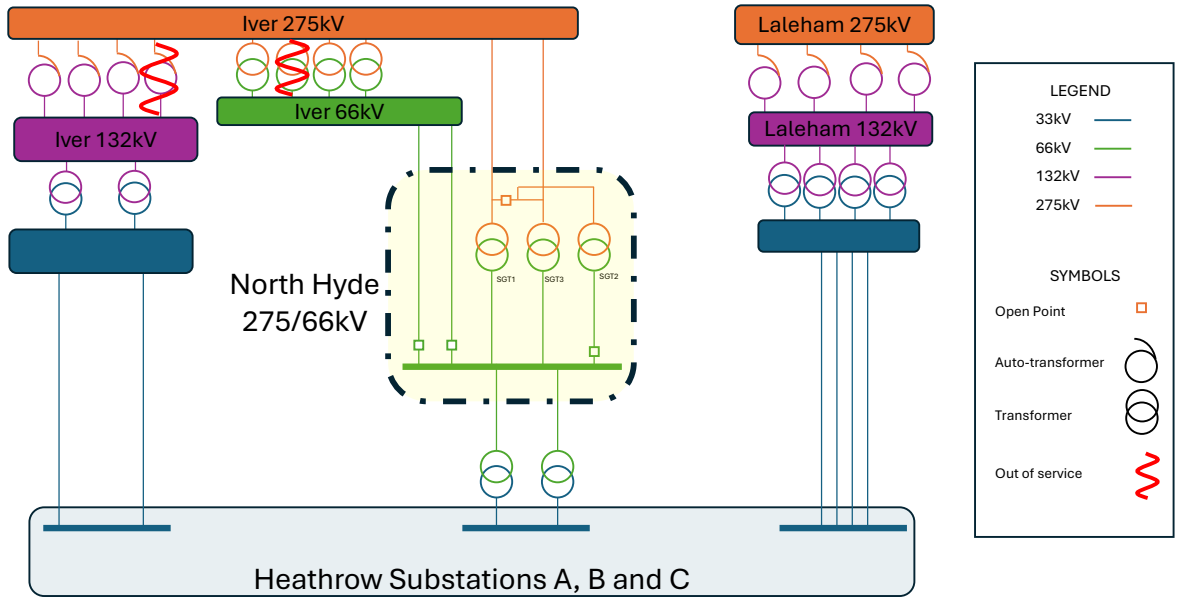

Figure 5: Line diagram of Iver and North Hyde network prior to the incident

C17 Each of Heathrow Airport's three supply points is connected to the distribution network by at least two separate circuits. Any two out of the supply points have enough capacity to supply Heathrow Airport peak demand. Immediately prior to the incident, all three connection points were operating as normal.

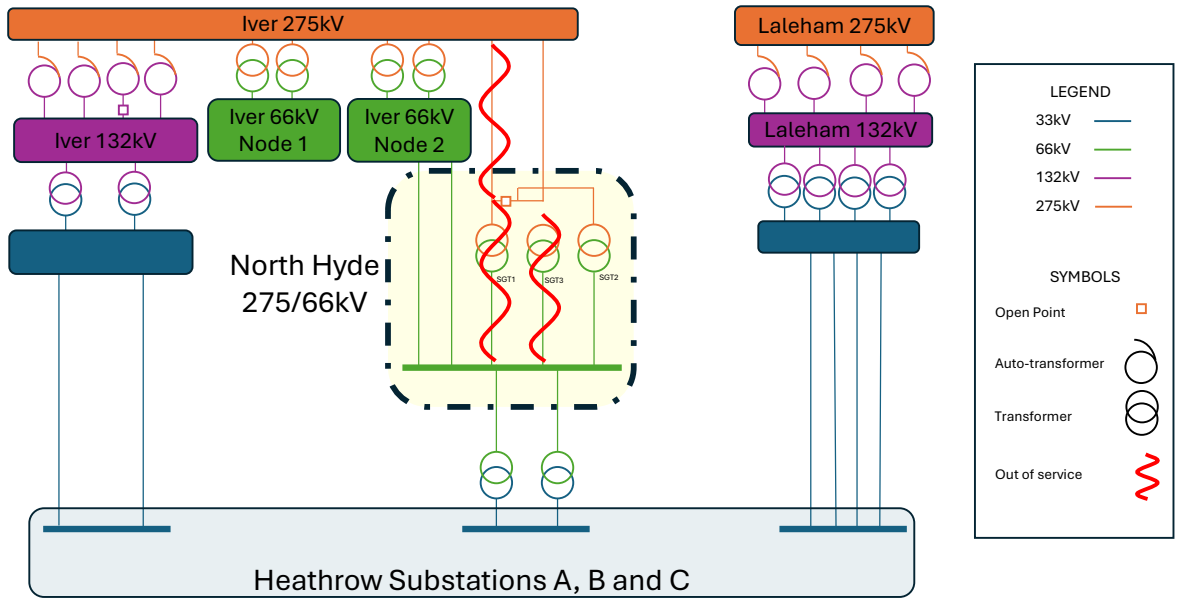

Figure 6: Line diagram showing network configuration following the return to service of SGT4B and SGT4A at Iver substation

D. Key legislation, licences and industry codes

D1 **This section provides a high-level summary of the main provisions in legislation, licences, and industry codes pertinent to resilience and restoration.**

D2 The Transmission and Distribution systems are designed against security and safety standards set out in legislation, licences and industry codes.

Legislation

The Electricity Act 1989

D3 Section 6 of the Electricity Act 1989 (EA89) contains provisions relating to the licensing of distribution and transmission activities.

Section 4 of the EA89 provides that a person who participates in the distribution or transmission of electricity for the purpose of giving a supply to any premises or enabling a supply to be so given shall be guilty of an offence unless they are authorised to do so by a licence or unless an exemption applies.

D4 Under Section 9 of the EA89, holders of transmission licences have a duty to:

(a) develop and maintain an efficient, co-ordinated and economical system of electricity transmission; and

(b) facilitate competition in the supply and generation of electricity.

D5 Section 29 of the EA89 provides for the Secretary of State to make regulations relating to supply and safety. The Electricity Safety, Quality and Continuity Regulations 2002 have been made under this section.

The Energy Act 2023

D6 The Energy Act 2023 makes provisions related to energy production and security and regulation of the energy market. Part 5 of this Act introduces the concept of the Independent System Operator and Planner (ISOP). NESO has been designated as the ISOP.

Section 163 of this Act sets out that the ISOP must carry out its functions in the way that it considers is best calculated to promote a) the net zero objective, b) the security of supply objective and c) the efficiency and economy objective.

Licences

D7 The National Energy System Operator and Transmission Licensees are required to plan and develop the transmission system in accordance with the National Electricity Transmission System Security and Quality Supply Standard (NETS SQSS) under Condition E7 of the National Electricity System Operator licences and conditions, as well as D3 and E16 of the Transmission Licence.

D8 Under Condition E7 of the National Electricity System Operator licence, the licensee must have a statement setting out the criteria by which system availability, security and service quality of the National Electricity Transmission System may be measured and report against this criteria annually.

D9 Under Condition B6.2 of the Electricity System Operator licence, the licensee must not unduly discriminate between any persons or class or classes of persons in the provision of Use of System, or in the carrying out of works for the purpose of connection to the National Electricity Transmission System.

D10 Under condition D5 of the Transmission Licence, "the licensee shall not unduly discriminate as between any persons or any class or classes of person or person or unduly prefer itself or any affiliate or related undertaking over any other person or persons or any class or classes of persons or persons".

Industry codes

D11 Electricity transmission licensees are required by their licences to comply with the National Electricity Transmission System Security and Quality Supply Standard (NETS SQSS). NETS SQSS sets out the minimum standards that NESO is required to adhere to when planning and operating the National Electricity System (NETS).

D12 In relation to the distribution network, the ENA Engineering Recommendation (EREC) P2, as contained in Annex 1 of the Distribution Code, stipulates the minimum demand to be restored within defined time periods following the loss of supplies in different outage scenarios.

D13 These standards are complemented by various licence conditions and industry codes, including the Electricity System Operator Licence, Gas System Planner Licence, and the Grid Code, which collectively establish the obligations and operational guidelines for maintaining system integrity and reliability.

National Electricity Transmission System (NETS) Security and Quality Supply Standard (SQSS)

D14 The NETS SQSS sets the minimum requirements to which the transmission system must be designed and operated. It is possible to design above the minimum requirements where it can be economically justified.

D15 The NETS SQSS is not intended to design a system where constraints or faults do not occur but sets a design bases on what is economically judged to be appropriate on balancing cost against probability or risk. Unsecured events may occur and could be more onerous than secured events. In such conditions, additional operational measures may be utilised to maintain overall network integrity.

D16 The SQSS stipulates a level of security of supply by setting out the 'secured events' for which unacceptable conditions should not arise. When assessing demand connection capacity, this means the network is planned and operated to stay within security criteria for the secured events of a fault outage (N-1) and planned outage followed by a fault outage (N-1-1).

National Electricity Transmission System: Connection and Use of System Code

D17 Parties have the right (and obligation) under Section 2 of the Connection and Use of System Code to be and remain connected and energised.

D18 In case of demand customers, parties also have the right for power to be transported to the connection site. This is subject to other provisions in this Code and Grid Code (which would include force majeure) and in the case of transport of power "except to the extent (if any) that The Company is prevented from doing so by transmission constraints or by insufficiency of generation which, in either case, could not have been avoided by the exercise of Good Industry Practice by The Company".

D19 The rights under the Connection and Use of System Code itself are also not "absolute". It also limits liability to breach of contract resulting in physical damage.

Distribution Network Operators: Distribution Code

D20 Under Distribution Licence Condition 19 (19.1) the licensees must not discriminate in carrying out works for the purposes of connection to the licensee's distribution system. There is also an obligation on the licensee (19.8) not to show undue preference to or unduly discriminate between any person, class or classes of persons when complying with the Distribution Code. One of the objectives of the Distribution Code is "to permit the development, maintenance, and operation of an efficient, co-ordinated, and economical system for the distribution of electricity;". The Distribution Code acknowledges a distribution system with risk of supply and a minimum period for restoration.

D21 Distribution Companies are also subject to "guaranteed standards of performance" (under The Electricity (Standards of Performance) Regulations 2015 (as updated) which sets out compensation payable to customers in the event of disruption to supply for certain events.

Distribution Network Operators: ENA Engineering Recommendation P2

D22 ENA Engineering Recommendation (EREC) P2, published by the Energy Networks Association, has a similar function for electricity distribution networks to the one that the SQSS plays for transmission. EREC P2 is listed in Annex 1 of the Distribution Code and forms part of the Distribution Code. DNOs are required to comply with the Distribution Code under Condition 20.1 of the distribution licence.

D23 The distribution networks in England and Wales operate at 132kV and below. P2 stipulates minimum demand to be restored within defined periods of time in different outage scenarios. Condition 24 of the Electricity Distribution Licence requires licensees to plan their system with a standard not less than P2.

D24 North Hyde 275kV substation falls under the class of supply D, for demand of over 60MW and up to 300MW, in EREC P2. These state that for a first circuit outage, demand served by the substation minus up to 20MW should be restored immediately, and all demand should be restored within 3 hours. For a second circuit outage, for demands greater than 100MW, the smaller of either total demand minus 100MW or one third of total demand should be restored within 3 hours. There is no time limit to restore all demand from a second circuit outage.

D25 The recommendation states this is based on the assumption that the time for restoration of demand after a second circuit outage will be minimised by the scheduling and control of planned outages, and that consideration will be given to the use of rota load shedding to reduce the effect of prolonged outages on consumers.

Glossary

Glossary

Autoclose scheme
A system which automatically switches replacement equipment into service when needed, for example when equipment is on 'hot standby'.

Busbars
A busbar is a metallic strip used to conduct electricity. It is the central point that connects multiple circuits within a substation.

Configuration
Configuration is the description of how energy network components are connected together, including where electricity is supplied from, and what it in turn supplies.

Re-configuration refers to changing how the network is connected together.

Distribution network
The network of overhead lines, pylons, poles, underground cables and substations that connect electricity to and from the transmission network and generators to electricity consumers. The distribution networks in England and Wales operate at 132kV and below.

Electricity substation
Electricity substations are where overhead lines, underground cables, transformers and other electrical equipment are connected together creating the network required to connect electricity generation and the end customer.

Hot standby
Used to describe the status of an active and connected part of a system that is acting as a back-up and can take over rapidly to provide continuity of operations.

Interconnector cables
In the context of supergrid transformers and substations, interconnector cables connect different substations together.

Load
The electrical power flowing through an electrical asset or system. If the system or part of the system cannot supply that demand, it is described as off-loaded.

Power restoration
Restoration refers to the process of restarting the flow of energy following an outage. In the context of restoring power to a substation, this may be referred to as reenergisation.

Private internal electrical distribution network
A private internal electrical distribution network is the infrastructure that distributes energy to a private site, as for Heathrow Airport. These networks are operated by Private Network Operators under an exemption from holding a distribution licence regulated by Ofgem.

SQSS
The Security and Quality of Supply Standard (SQSS) sets out the minimum standards for planning and operating the National Electricity Transmission System (NETS).

Supergrid transformer
At substations, voltages are stepped up or down through electrical devices called supergrid transformers (SGTs).

Supply cable
The supply cable of a supergrid transformer is the high-voltage cable that carries electricity to the SGT.

Switching
The process of opening and closing switches and putting assets in or out of service, either automatically, for example to protect assets in the event of a fault, or manually to reconfigure the network by the party responsible for the control of that part of the network.

Transmission network
The network of overhead lines, pylons, underground cables and substations that transport electricity over long distances. The transmission network in England and Wales operates at 275kV (kilovolts) and above.

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