Statement by the Gas and Electricity Markets Authority, following an investigation into compliance by National Grid Company plc with its obligations under section 9(2)(a) of the Electricity Act 1989 and Special Licence Condition AA4.1 of its Electricity Transmission Licence in relation to a transmission failure in London and in relation to a transmission failure in Birmingham

25 June 2004.

1. The Gas and Electricity Markets Authority (the Authority) has as its principal objective to exercise its functions to protect the interests of gas and electricity consumers.

2. The Authority grants licences for the transmission of electricity. It has a duty to keep under review activities in the areas to which electricity licences apply.

3. NGC is a wholly owned subsidiary of National Grid Transco plc.

4. This document follows an investigation into National Grid Company plc's (NGC's) compliance with section 9(2)(a) of the Electricity Act 1989 and Special Licence Condition AA4.1 of NGC's Electricity Transmission Licence in relation to the transmission failure in London and in relation to the transmission failure in Birmingham. The London transmission failure occurred on 28 August 2003 and resulted in an interruption to the electricity supply of 476,000 customers in South London and Kent. Supplies were restored to the transmission system within 37 minutes and the loss of supply was calculated by Ofgem to be 446MWh. The Birmingham transmission failure occurred on 5 September 2003 and resulted in an interruption to the electricity supply

of 201,000 customers. Supply was restored to the transmission system within 42 minutes and the loss of supply was calculated by Ofgem to be 211MWh.

5. Immediately following the transmission failure in London Ofgem announced that it would investigate the causes and implications of what had occurred. The investigation was later expanded to incorporate the Birmingham transmission failure.

6. The preliminary findings of the Ofgem investigation team were published in September 2003. The findings were based on information provided by NGC and the distribution companies involved in both incidents.

7. Consultants, PB Power, were appointed by Ofgem to examine the technical circumstances of the transmission failures. Their report is being published alongside this statement.

8. Ofgem's investigation of the London transmission failure indicated that it was the result of the following sequence of events:

    - In March 2003 a shunt reactor at Hurst substation was found to have an oil leak. NGC decided to address this by topping-up the oil at intervals of three months until they made permanent repairs.
    - On 28 August 2003 the low oil level in the reactor triggered a Buchholz alarm. The alarm was interpreted wrongly as indicating a problem with an associated

transformer and switching action was taken to remove the transformer from service.

- During the resulting reconfiguration it was necessary for the load to be carried by a single circuit at Wimbledon. The automatic protection on this circuit then operated and resulted in the loss of supply to parts of South London and Kent.
- This protection system, which is designed to operate to protect equipment against excess load, had operated because of an incorrectly rated protection relay which had been installed in June 2001. A 1 Amp relay had been installed rather than a 5 Amp relay.

9. Ofgem's investigation of the Birmingham transmission failure indicated that it was the result of the following sequence of events:

- On 5 September 2003, a recently re-commissioned transformer at Hams Hall substation required urgent removal from service for safety reasons. The problem was caused by wiring in a measurement circuit ("current transformer wiring") which had been cut after the engineer involved had used an incorrect wiring diagram which did not accurately reflect the situation at the substation.
- The substation demand was then shared by the remaining transformers.
- Newly commissioned protection equipment then operated unexpectedly because unwanted functionality had not been disabled. This led to the interruption to supplies in parts of Birmingham.

10. Further details of the circumstances surrounding the two transmission failures are provided at **annex 1**.

11. The Authority considered the following potential breaches of statutory and licence obligations:

    a) that NGC failed to comply with section 9(2)(a) of the Electricity Act 1989 in respect of the London transmission failure on 28 August 2003 in regard to:

        i. the handling of the oil leak at Hurst,

        ii. ambiguous labelling of the Buchholz alarm, and

        iii. the failure to apply established commissioning procedures to the protection relay.

    b) that NGC failed to comply with Special Licence Condition AA4.1 of its Electricity Transmission Licence in respect of the London transmission failure on 28 August 2003 in regard to the labelling of the Buchholz alarm

    c) that NGC failed to comply with section 9(2)(a) of the Electricity Act 1989 in respect of the Birmingham transmission failure on 5 September 2003 in regard to:

        i. the failure to verify the master drawings at Hams Hall, and its failure to pay due attention to the decision taken on site to cut current transformer wiring; and

        ii. the failure to ensure that the protection equipment at Hams Hall was appropriately designed, installed and commissioned.

d) that NGC failed to comply with Special Licence Condition AA4.1 of its Electricity Transmission Licence in respect of the Birmingham transmission failure on 5 September 2003 in regard to the failure to ensure that the protection equipment at Hams Hall was appropriately designed, installed and maintained.

12. Section 9(2)(a) of the Electricity Act 1989 states that it shall be the duty of the holder of a licence authorising him to transmit electricity "to develop and maintain an efficient , co-ordinated and economical system of electricity transmission". The full text of the section is attached at **annex 2**.

13. NGC has in its Electricity Transmission Licence a Special Licence Condition "AA4: Licensee's Procurement and Use of Balancing Services". Paragraph 1 of this condition states that the "licensee shall operate the licensee's transmission system in an efficient, economic and co-ordinated manner". The full text of this paragraph of the condition is attached at **annex 2**.

14. Section 27A of the Electricity Act 1989 permits the Authority to impose a financial penalty on a licensee where it is satisfied the licensee has contravened or is contravening a licence condition or relevant statutory requirement.

15. After careful consideration of the information provided to it the Authority has concluded that it is not satisfied that NGC has contravened its obligation under section 9(2)(a) of the Electricity Act 1989 and its obligation under Special Licence Condition AA4.1 in

respect of the circumstances relating to the transmission failure in London on 28 August 2003.

16. After careful consideration of the information provided to it the Authority has also concluded that it is not satisfied that NGC has contravened its obligation under section 9(2)(a) of the Electricity Act 1989 and its obligation under Special Licence Condition AA4.1 in respect of the circumstances relating to the transmission failure in Birmingham on 5 September 2003.

17. In considering the potential infringements which related to the obligations referred to above, the Authority gave careful consideration to the approach it would adopt.

18. The Authority considered that in relation to these two interruptions the relevant questions to be considered in deciding whether NGC had complied with its duties to develop, maintain and operate the system in an economic and efficient manner were:

- whether NGC had, in the particular instance, failed to establish proper and reasonable procedures directed towards preventing or detecting the type of fault or failure in question; and/or
- whether there had been a material failure by the licensee to ensure that appropriate procedures were applied.

19. The Authority considered that a materiality test was important. In deciding on materiality, the Authority considered all the circumstances of the case, including the impact on consumers. Given the scale and complexity of the transmission system it is

not possible to ensure 100% compliance with all procedures and hence the test of materiality is important, to avoid a situation where every mistake could be considered a breach. Equally, the Authority did not consider that there would have to be a general failure to apply the processes and procedures across the system before NGC could be considered potentially to be in breach of Section 9(2)(a) of the Electricity Act 1989 and/or Special Licence Condition AA4.1. If the failing were sufficiently material an individual incident could constitute a breach. Where the consequences of a failure to comply with a procedure were potentially serious, the Authority would expect NGC, acting as an economic and efficient operator, to take appropriate steps to ensure that procedures were adhered to.

20. In respect of each incident the Authority considered whether the acts and omissions noted in paragraph 11 amounted to a breach of NGC's duties, taking into account also the impact of the failures on end consumers.

21. The Authority was satisfied that there had been an exhaustive investigation into the circumstances which led to the blackouts in London and Birmingham. NGC has acknowledged that it made a number of mistakes in relation to each of these incidents, including, for example, in the fitting of an incorrectly rated protection relay in London and in the use of the wrong set of site drawings in Birmingham. The Authority was concerned about the adequacy of some of NGC's procedures and the fact that NGC could not provide evidence to show that their procedures had been followed in all cases.

22. The Authority considered, in reaching its decision about whether there were breaches of statutory and licence obligations, the experience of consumers in relation to loss of supply incidents relating to transmission over the last decade. NGC's record compares favourably internationally, with its network operating at reliability levels of between 99.9997% and 99.9999% of energy requirements supplied in any given year over the last decade.

23. The Authority notes that NGC has taken the incidents seriously, and has undertaken extensive work to identify improvements it needs to make in the light of these events and to take forward the necessary actions. NGC explained to the Authority that following the London incident they had established five workstreams, each led by a senior manager. These workstreams had examined issues of co-ordination, communication, the integrity of the automatic protection equipment, the management of the protection system and control room procedures. A similar exercise was carried out following the Birmingham incident to identify remedial actions which are being pursued in the workstream on the management of protection systems. Through these workstreams a number of improvements have been made to existing processes. Where appropriate further improvements should continue to be introduced.

24. In both the London and Birmingham interruptions to supply the Authority concluded that the procedural weaknesses identified were not so material as to constitute a breach of NGC's duty under Section 9(2)(a) of the Electricity Act 1989 and Special Licence Condition AA4.1 of NGC's Electricity Transmission Licence to develop, maintain and operate an economic, co-ordinated and efficient transmission system, taking into account the consistently high level of reliability of the system over the last ten years.

25. In London, there was a lengthy disruption to transport services, resulting in considerable inconvenience to consumers. This disruption principally reflected the arrangements put in place by transport companies. These arrangements did not directly involve NGC. NGC has, however, informed the Authority that it is collaborating with the relevant distribution network operator (DNO) and transport companies to review and improve relations between all parties.

26. The Authority also concluded that it would be beneficial to introduce a new regulatory mechanism to complement but not replace the existing licence and legal obligations under which NGC operates. Such a scheme would strengthen the incentives on NGC to maintain a high standard of system performance, for example, NGC would be penalised automatically for any blackout of the kind seen in London and Birmingham. However, the application of this new mechanism will not preclude the use of the powers under 9(2)(a) and AA4 in the event of any future material incident.

Sir John Mogg

For and on behalf of the Gas and Electricity Markets Authority

Date

Annex 1

Description of the transmission failures

1. This annex provides a description of the transmission failures that occurred in London and Birmingham in 2003.

Overview of both transmission failures

2. Shortly after 6.00pm on 28 August 2003, electricity supplies to some 476,000 customers in South London and Kent were involuntarily interrupted. A total demand of 724 MW was lost on the EDF Energy distribution network, amounting to about 20 per cent of the total demand in London at that time. Even though supplies were fully restored to the transmission system in 37 minutes, Ofgem estimates that this loss of supplies is equivalent to some 446 MWh. This is a material loss of supplies, equating to roughly double the total amount of MWh unsupplied in 2002-03 which, incidentally, resulted from 12 separate incidents on the transmission system throughout that year.

3. Just after 10.00am on 5 September 2003, electricity supplies to 201,000 customers to the East of Birmingham were also involuntarily interrupted. The loss of supply resulted in the disconnection of 213 MW of load on the Aquila distribution network and a further 88 MW on the EME distribution network. On this occasion, supplies were restored to the transmission system in 42 minutes, which suggests that, according to Ofgem's estimates, the total loss of supplies (301 MW) is equivalent to

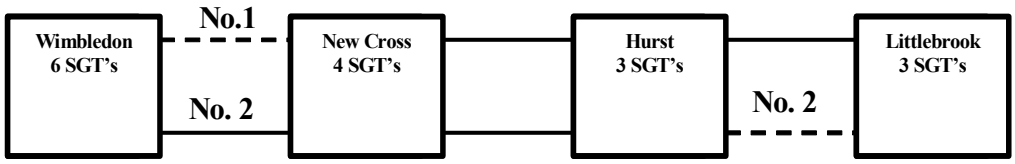
around 211 MWh[1] — a figure not dissimilar to the total amount of electricity unsupplied in 2002-03.

4. There were significant disruptions to normal activities, particularly transport systems in London, which were beyond the control and responsibility of NGC as transmission system operator.[2] Some customers' standby arrangements (airports etc.) minimised the impacts whereas for others (e.g. London Underground) the short interruption of supply led to an extended disruption to services.

London transmission failure

5. NGC's transmission system delivers electricity to the distribution network supplying South London through a series of connected substations at Wimbledon, New Cross, Hurst and Littlebrook (Figure 1).

FIGURE 1: Status of transmission system that supplies South London, 28 August 2003



Note: SGTs are supergrid transformers that are contained within electricity substations and supply the electricity distribution network. Dotted lines show transmission circuits out of service on 28 August 2003 for planned work.

[1] NGC calculate the unsupplied energy at Hams Hall to be 83.7 MWh.
[2] Once supplies are restored to the transmission system by NGC (as transmission network operator), the extent to which supplies are restored to downstream customers is generally the responsibility of the distribution network operator (DNO) and the customer, but not NGC.

6. These substations are connected to their neighbouring substations by two separate circuits, which are designed to ensure that the network is robust to the failure of at least any one circuit as specified in the Security and Quality of Supply Standard (November 2002), an NGC standard that is approved by Ofgem (and which NGC is obliged to comply with under Special Licence Condition AA2 of NGC's Electricity Transmission Licence).

7. There were a number of scheduled outages on the transmission and distribution networks in South London on the evening that the transmission failure occurred. On the transmission system, scheduled maintenance was underway on one circuit from Wimbledon to New Cross and on one circuit from Littlebrook to Hurst (represented by the dotted lines in the above figure). These planned outages met the required Transmission Security and Quality of Supply Standards for the demand on the remaining system.

8. To understand better the context for the subsequent events that occurred on the transmission network on 28 August 2003, it is helpful to note that the Hurst substation (shown above in Figure 1) houses a number of items of equipment, including shunt reactors. A shunt reactor is a physically large piece of high voltage equipment used to control excessive system voltages. In March 2003 at its scheduled maintenance, one of the five shunt reactors at Hurst (SR3) was found to have an oil leak. Such leaks are not uncommon, and as such, inspection, monitoring, and maintenance of the oil-level in a shunt reactor is standard maintenance practice.

9. NGC decided to address the leak by means of regularly topping-up the oil (every three months). A regular site inspection at Hurst on 19 June 2003 noted low oil in the reactor, but prior to the recommended top-up taking place, the oil level fell low enough to trigger a Buchholz alarm in the Electricity National Control Centre (ENCC) on 26 June 2003. The oil level was then topped up the next day. Although NGC was confident that a work request would have been raised following the 19 June inspection, no record of the request could be found.

10. A Buchholz alarm is a protection device used on oil-filled electrical equipment. It has sensors to detect (i) the generation of gas in the oil, (ii) a pressure surge in the oil, or (iii) low oil level. Consequently, a Buchholz alarm will activate for one of two reasons:

    - gas is being created within the oil contained inside the transformer or shunt reactor, which can signal the onset of equipment failure; or

    - the level of the oil contained within the transformer or shunt reactor is too low, possibly caused by a leak.

11. The pressure surge sensor and the second stage low oil level sensor directly trip the transformer or reactor, rather than initiating an alarm only.

12. National Grid has nearly 900 items of oil-filled equipment connected to its transmission system and 13 Buchholz alarms are received each year on average. The Buchholz alarm on 26 June 2003 was interpreted correctly as relating to SR3, and no switching action was undertaken as SR3 was already out of service and had been since the morning, as it is generally not required during the day. The reactor

was subsequently topped up with 135 gallons of oil on 27 June 2003. NGC did not undertake any further maintenance on SR3 during the period 1 July to 28 August 2003.

13. On 28 August 2003, the low oil level in the reactor again triggered the Buchholz alarm which set in motion a sequence of events in the control room that led to the eventual loss of supplies in London. This is explained further below.

14. At 6.10pm on 28 August 2003, NGC's ENCC received the Buchholz alarm indication for Hurst substation. Given that a Buchholz alarm can be an early warning sign of a more serious failure, it is standard practice to remove the equipment from service for investigation when a Buchholz alarm activates, unless there are extenuating circumstances, as the catastrophic failure of such equipment could lead to fire or explosion plus the loss of a high value (in excess of £1 million) asset and impaired system security for many weeks whilst a replacement is brought to site and installed.

15. Believing that the alarm indicated a possible problem with supergrid transformer 3 (SGT 3), NGC instigated switching actions to remove it from service. This is not to suggest that the Control Engineer responsible for interpreting the alarm on 28 August 2003 had not fulfilled his or her duties in a competent manner, but rather that the alarm was ambiguously labelled.

16. For most transformers, removal from service is simply achieved by opening the switches at the high and low voltage connections to the transformer. However,

because this transformer is connected to a Mesh type substation[3], a more complex switching action is required involving the temporary reconfiguration of the network. In this case the low voltage connection switch was opened (as normal) and then it was planned to open three high voltage switches (two at Hurst and one at Littlebrook) to disconnect both the mesh corner and associated transformer as one. Once disconnected, motorised links that can only be opened off-load, are operated to separate the suspect transformer from the mesh corner, after which the mesh corner is re-energised by the closure of the three high voltage switches opened earlier in the sequence. Such a sequence would normally take around 10 minutes and the reduced security whilst it is carried out is permitted by the operational security standards.

17. Part way through this reconfiguration, all supplies to Hurst and New Cross were left dependent on a single circuit from Wimbledon. At this point, the Wimbledon automatic 'back up' protection on the Wimbledon – New Cross No. 2 cable circuit operated. The purpose of 'protection' is to detect a fault on the power system and then trigger automatic disconnection of the faulty item of equipment. This process needs to be accomplished rapidly to minimise damage to the faulty equipment and minimise the impact to customers.

18. Failure to disconnect a faulty item of equipment swiftly (typically 0.2 seconds) has extreme consequences and therefore at least two protection systems (and sometimes three) are deployed, generally referred to as 'main' and 'back-up' protection. The main protection is configured to only protect a specified item of equipment and is

[3] A mesh substation typically comprises 4 circuit breakers connected as the four sides of a square. Circuits and transformers etc are connected via disconnectors to each mesh corner.

designed to operate first, whereas the backup protection is configured so that it will operate if either its associated main protection fails or the main protection on an adjoining circuit fails. This provides a robust arrangement for limiting the system impact of a fault that is not removed by the protection in the 'first line of defence'.

19. The operation of this protection resulted in the separation of the New Cross and Hurst substations from the NGC transmission system. The operation of the protection was due to the installation of an incorrect protection relay when the Wimbledon-New Cross protection was upgraded in June 2001.

20. The number two circuit from Wimbledon to New Cross has a current rating of 4,450 amps. The back-up protection was set up to detect excessive current, in this case over 5,100 amps. It is impractical to pass the 5,100 amps through the actual protection device and therefore a 'sensor' is employed. This device is called a current transformer and in this case produces a secondary current equal to 1/1200th of the primary current (so 5,100 amps in the main circuit = 4.25 amps in the secondary). This current is then fed into the back-up protection relay. This relay was configured to operate when this secondary current reached 85 per cent of its rating. If the correct 5 amp relay had been fitted, it would have operated at 4.25 amps as intended. However, because a 1 amp rated relay had been fitted in error, it signalled a fault when the secondary current was only 0.85 amps, equivalent to only 1,020 amps in the main circuit.

21. During the switching operation at Hurst, the Wimbledon to New Cross current had increased to 1,460 amps, therefore the protection detected this as a fault. Under normal operation there are up to four circuits carrying electricity into Hurst and

New Cross and therefore current is shared out such that the circuit normally experienced currents significantly below 1,000 amps. This is why the latent protection error had not been exposed since it was commissioned in 2001.

22. There was loss of load connected to New Cross (359 MW) and Hurst (199 MW) plus some of the load at Wimbledon (166 MW), resulting in a total loss of 724 MW of EDF Energy's demand at the time of the incident. These transformers were supplying through EDF's distribution network a key London Underground Limited (LUL) substation and part of EDF's South London ring[4].

23. Throughout the course of the power cut, NGC was in close communication with EDF Energy as a means for informing them as to the nature of the interruption, and the steps that would be taken to restore supplies to the network. Within 37 minutes of the loss of supplies occurring, control engineers at ENCC had completed a sequence of switching operations to restore supplies across the transmission network. However, in completing restoration of supplies, NGC inadvertently energised part of the EDF Energy network and 'back energised' part of the transmission network through the same switching action. Automatic protection equipment responded to the resulting abnormal condition and operated almost immediately to recover the situation.

Installation of the incorrect relay

24. The operation of the protection equipment arose because the primary current threshold for operation of the protection was 5 times lower than it should have

[4] The EDF South London Ring (SLR) system is run interconnected with Beddington, Chessington and Wimbledon supergrids.

been. This was due to the fact that, as described earlier, a 1 amp relay had been installed in error, rather than a 5 amp relay. This relay was part of a refurbished protection scheme that was commissioned in 2001.

25. The commissioning tests for the replacement 1 amp relay were in accordance with the Contractor's test procedure, but did not accord with the NGC Commissioning Procedure. The NGC procedure required a check to be made as to the correct current rating of the relay to be tested, for it to be tested with its service settings applied and for the definitive NGC settings summary sheet to be attached to the completed test document. The Contractor's procedure was based on testing virtually all the relay settings, but not the service settings.

26. The proposed use of the Contractor's own test sheets, rather than the NGC test sheets, was detailed in the Contractor's Commissioning Report Quality Plan, which had been signed as approved by the NGC Commissioning Panel on 23 March 2001 (and thus complied with NGC's Transmission Procedure TP106 document). The approved Plan also required the back-up protection tests to be 100 per cent witnessed by NGC. However, NGC witness signatures are not present on the Plan or the completed test procedure documents.

27. NGC stated that a collective decision had been taken to witness selectively certain of the secondary tests associated with the New Cross 2 circuit. Tests relevant to the back-up protection were within the scope of the supplier's responsibility and were therefore not witnessed by NGC. However, the Commissioning Report Quality Plan does not appear to have been revised and no other documentary evidence has been provided to confirm this change of plan.

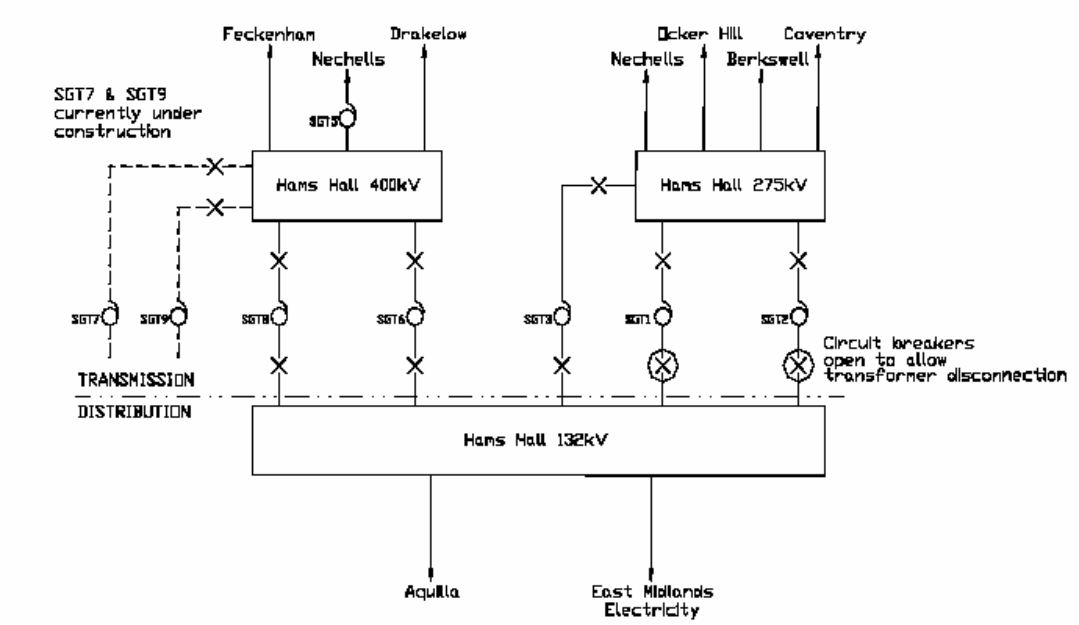
28. Further, there is no record of the actual date of relay testing. The NGC setting sheet, which displays the serial number of the relay that was tested, has the relay rating clearly listed as "5 Amps", which differs from the "1 Amp" rating that was clearly recorded in the contractor's commissioning test record. The NGC setting sheet appears to have been prepared before the date of commissioning and so it would have been available, but no documentary evidence has been provided to confirm that the sheet was in the possession of the contractor's Commissioning Engineer at the (unrecorded) time of the Commissioning tests.

Birmingham transmission failure

29. NGC supplies both the East Midlands Electricity (EME) and Aquila distribution networks from their Hams Hall substation, located near Coleshill. The Hams Hall site has three substations operating at 400 kV, 275 kV and 132 kV (Figure 2).

30. Major re-development was in progress at the time of the incident as part of NGC's plans for strengthening this part of the Midlands network. A new supergrid transformer (SGT8) was commissioned at Hams Hall on 17 August 2003 and had been operating satisfactorily. On 4 September — the day before the transmission failure occurred — the 132 kV load at Hams Hall was supplied from the new supergrid transformer SGT8 along with SGT3 and two further supergrid transformers (SGT1 and SGT2). SGT7 was out of service for re-configuration throughout.

FIGURE 2: Status of transmission system that supplies East Birmingham, 5 September 2003



31. On the evening prior to the loss of supplies, a supergrid transformer (SGT6) was re-commissioned and put back into service. After SGT6 had been operating successfully overnight on 4 September, SGT1 and SGT2 were taken out of service at 6.12am on 5 September in preparation for their de-commissioning. The load was then being supplied by SGT8, SGT3 and the newly re-commissioned SGT6.

32. The sequence of events that led to the eventual loss of supplies commenced with the discovery of a problem with a recently re-commissioned transformer (SGT 6), whereby part of the transformer ancillary measurements wiring was emitting sparks and smoke, requiring the urgent removal of the transformer from service for safety reasons. The problem had arisen as a result of equipment and wiring having been

mistakenly disconnected from one of the SGT6 circuits in connection with work being undertaken on site.

33. This wiring was associated with a current transformer (CT) which measures the current flowing in the main transmission circuit and provides a smaller proportional current suitable for use in protection and measurements equipment. If an operational CT circuit has a break in it, the CT will attempt to achieve the proportional current by raising the voltage, which can ultimately cause sparking across the gap in the circuit or at the weakest point in the insulation. In this instance a CT circuit had been cut and left open.

34. The problems stemmed from an ahead-of-programme, marked-up copy of a master wiring drawing of Hams Hall substation that the contractor was working to, which suggested that certain equipment found on site should not have been there. This was because a contractor that had previously undertaken work at Hams Hall amended the master drawing prior to the work actually being done.

35. The contractor flagged up the matter with his supervisor and the contractor's Commissioning Engineer. NGC's account is that the contractors reviewed the situation on site with NGC staff. The contractor was subsequently directed to remove some of the wiring and equipment that was deemed to be redundant and not shown on the drawing, to make room for the new wiring. This was apparently on the understanding that the wiring to be removed was not associated with any CT circuits.

36. Due to the complexity of the operation, the contractor's Commissioning Engineer, who was regarded by NGC as being capable and experienced and who had been

approved by the project Commissioning Panel, carried out the removal of the redundant wiring himself. It was during his work that the wiring of the CT circuit was cut. When the transformer was later energised, this open circuit resulted in sparks and smoke to be observed on the CT circuit.

37. Given the potentially hazardous situation, this transformer was taken out of service without delay for safety reasons, diverting all load to the remaining transformers SGT8 and SGT3. The loss of supply then resulted due to the subsequent operation of newly commissioned protection equipment, as the load on alternative transformers increased.

38. The reason for the protection equipment operation was that NGC's contractor engineered and delivered a protection scheme, based on a multi-functional relay, which provided the required protection but also provided unwanted protection. These unwanted functions had not been disabled and subsequently resulted in the protection relay on SGT8 operating to trip the transformer inappropriately.

39. With SGT8 disconnected, the full load was carried by the remaining transformer, SGT3, exceeding its rating, and as a result the protection equipment on SGT3 operated correctly to trip the transformer and the supply to Hams Hall substation and with it the supply to Aquila and EME customers.

40. The loss of supply affected 143,000 Aquila customers and 58,000 EME customers with pre-incident demands of 213 MW and 88 MW respectively (301 MW in total).

41. NGC worked closely with both EME and Aquila thereafter to restore supplies to the transmission network within 42 minutes of the outage.

42. Overall, disruption to infrastructure in Birmingham was less than that experienced in London, reflecting the prior measures adopted by a number of customers, such as Birmingham Airport, to mitigate the risk of supply interruption.

Commissioning of the Protection Equipment at Hams Hall

43. As noted above the eventual equipment trip that led to the loss in supplies was caused by a protection relay that had been incorrectly configured by a contractor with unwanted functionality not disabled.

44. On the definitive NGC relay settings summary sheet the setting parameters for the unwanted non-interlocked protection functions had been annotated as "not used", but such settings do not exist.

45. A Commissioning Engineer could understandably have assumed that the terms indicated that the settings for the particular parameters were the equivalent of "not relevant", with the assumption that the Settings Engineer had rendered the associated elements ineffective through other settings.

46. While NGC had followed the established procedures in respect of the commissioning of the protection equipment at Hams Hall, these procedures only checked that the required functionality worked but not that unwanted functionality had been disabled. One way this could have been detected would have been by a 'loadability' test to check that the transformer could be loaded up to its full emergency rating without any protection element issuing an unwanted trip. Such testing is not yet widely applied by other TNOs worldwide, but some testing of this

form is recommended by the consultants (PB Power) for the future, when commissioning multi-function relays.

Annex 2

The Electricity Act 1989

Section 9 (2)

It shall be the duty of the holder of a licence authorising him to transmit electricity-

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

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

Electricity Transmission Licence

Special Licence Condition AA4: Licensee's Procurement and Use of Balancing Services

1. The licensee shall operate the licensee's transmission system in an efficient, economic and co-ordinated manner.