

## **Report on the NIE response to the loss of two generating units (520MW) at Kilroot Power Station on Thursday 4 December 2003**

### **1. Executive Summary**

On Thursday 4 December at 15.59hrs the two generating units at Kilroot disconnected from the Northern Ireland electricity system as a result of a fault within the power station. This reduced the generating capacity in Northern Ireland by 520MW. The cause of the incident was a single valve in the auxiliary steam main failing to operate when required.

A report received from Kilroot indicates that the fault on a single steam flow control valve has been rectified. It states that by Friday 12 December a modification will have been designed and implemented to provide at least 100% back up in the event of the single valve failing in the future.

The failure of a single valve in power station auxiliary equipment should not result in the loss of two generating units and the consequent loss of electricity supplies to customers.

Electricity supplies to 123,653 customers in NI (representing 234MW of demand) were disconnected in order to maintain the integrity of the system and secure supplies to the remaining customers. These disconnections were made in accordance with the NIE emergency plan which exists to cover a sudden generation capacity shortfall. Customers were restored as quickly as system conditions permitted. The first customers were disconnected at 16.38hrs and restored again at 17.46hrs and all remaining customers were reconnected by 18.42hrs.

SONI<sup>1</sup> called on Scottish Power to provide assistance with additional emergency energy flow on the Moyle Interconnector in order to minimise the disruption to customers. A high level of cooperation from RoI enabled the combined system to be operated with a minimum level of operating margin over the post-incident period thus facilitating the speedy restoration of supplies. This meant that customers were quickly reconnected after the evening peak as the demand throughout the island fell.

This report has been prepared by NIE at the request of the Minister for Enterprise, Trade and Investment.

### **2. The NI Electricity System**

The expected available generation capacity to meet demand in NI, including the capacity available via the Moyle Interconnector, is 2052MW (See Appendix 1). This is sufficient generation capacity to meet the Generation Security Standard for the peak demand predicted for this winter.

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<sup>1</sup> System Operator Northern Ireland Ltd (SONI) is the Transmission System Operator and is a wholly owned subsidiary of NIE

The generation capacity available for SONI to dispatch on Thursday 4 December totalled 1763MW (See Appendix 2). This was adequate to meet the expected peak demand of 1550MW. (An example of the anticipated load curve is included as Appendix 3).

The new 600MW combined cycle gas turbine (CCGT) at Ballylumford was commissioned in September of this year. The new CCGT is intended to replace the original station, which is due to be retired. However, it was agreed that retiring plant would be retained until the new plant was proven. Due to a fault on a generator transformer bushing on Saturday 27 September the capacity of the new CCGT was reduced to 350MW. As a result of this capacity shortfall Oreg agreed to NIE contracting for substitute capacity cover at Ballylumford until the full CCGT capacity was restored. This cover was provided by other generating units at Ballylumford.

However on Thursday 4 December Ballylumford Power Station Unit 6 (190MW) was out of service due to a tube leak in the boiler and was not expected to be back in service until 24.00hrs on Friday 5 December. Unit 5 also had a tube leak in the boiler and had an arranged outage starting on the evening of Friday 6 December. Unit 6 was to be re-established before Unit 5 could be released. As both generators had faults that could potentially cause their sudden loss, it was agreed with the station that they should be repaired as quickly as possible.

In addition the fast start open-cycle gas turbine OCGT2 (58 MW) was on outage on Wednesday 3 December. OCGT2 had been tripping due to high vibration levels and was proving unreliable. It was not expected to be available until 16.00hrs on Friday 5 December.

In total, out of a potential 1076MW, Ballylumford had 788MW available to meet NI demand and the NIE/ESB contract<sup>2</sup>.

For the evening peak on Thursday 4 December the RoI system was reliant on an import from the NIE system to meet its evening peak demand and allow ESBNG to meet its primary reserve commitments. For this reason Unit 5 was operating under the NIE/ESB contract and was nominated by the ESB at 167MW. The N-S market nominated flow at the peak was 93MW making a total nominated transfer of 260MW to the RoI.

The import on the Moyle Interconnector nominated by market participants was 400MW. The maximum allowed capacity on the Moyle Interconnector is 450MW.

In order to provide additional capacity the units at Kilroot Power Station which each have a contracted capacity of 220MW on coal firing were being operated on oil firing to give a capacity of 260MW. This decision was taken as a prudent measure by SONI to cover the loss of Ballylumford capacity the previous evening.

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<sup>2</sup> Due to the need for generating capacity in the RoI system a contractual arrangement exists for the use of out-of-contract capacity at Ballylumford to be supplied to the ESB. A maximum of 167MW can be nominated after the market nominations have been agreed at Day minus 2. If G6 is available (or G5 acting as cover) the flow is firm and ultimately load shedding in NI can occur to sustain this flow.

Prior to both Kilroot units tripping, the system was being operated with the normal primary reserve arrangement. The primary reserve requirement is to have sufficient plant running below its full output capability, such that there is sufficient capacity held in reserve to cover 80% of the largest single generating unit (including Moyle). In this case, the largest generating unit was 400MW (at Moyle and at Dublin Bay) and under the arrangements for sharing emergency cover throughout the island NI provides 107MW of primary reserve with RoI providing 213MW. The total loss of a major power station is not a contingency that is planned for or indeed expected.

### **3. Loss of Generating Units at Kilroot Power Station (KPS)**

At 15:59:08hrs KPS Unit 1 tripped followed by KPS Unit 2 at 15:59:13hrs. The units were generating at total of 315MW and the unscheduled disconnection of generation from the system occurred in a period of 5 seconds. The total loss of generating capacity to the system was 520MW.

The Significant Event Report<sup>3</sup> (see Appendix 5) provided to SONI by Kilroot Power Station identified the failure of a single valve on the auxiliary steam main as the cause of the loss of both Units.

### **4. SONI Grid Control Room Response**

As a result of the loss of the two Units at Kilroot the system frequency fell to 49.6Hz<sup>4</sup> from its normal value of 50Hz.

In response to the falling frequency the generating Units in RoI automatically provided up to a maximum of 240MW of rescue flow until the fast start gas turbines in NI were established.

Immediately after the event occurred the SONI Control Room staff requested all available fast start gas turbines to synchronise and load up. Some 174MW of fast start gas turbines were added to the system within 8 minutes.

At approx 16.10hrs the NIE Duty Incident Manager was contacted to initiate the procedures in the NIE Emergency Plan (see Section 6).

The SONI Control Room reached an agreement with Scottish Power to provide 50MW of 'Emergency Assistance' to load the Moyle Interconnector to 450MW; its maximum operating capability. The period of provision was from 16.40hrs to 22.00hrs.

Appendix 5 shows the status of NI Generation at 16.10hrs.

Following the incident the all-island system was operated and all available plant was utilised. The level of reserve was reduced from 320MW to provide approximately 120MW of regulating reserve which is the minimum required for stable operation of

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<sup>3</sup> This report was requested by Grid Control on Thursday 4 December in accordance with the NIE Grid Code

<sup>4</sup> When the frequency on the electricity system falls the governor valves controlling the flow of steam to the turbine generator unit open to increase its electrical output thus restoring the frequency towards its previous value.

the system. The export flow to the RoI from NI was reduced from 250MW to an import flow to NI of some 16MW at one stage. With both system loads increasing towards system peak it became necessary at 16.38hrs to load shed on the NI system. It is agreed procedure that the system in deficit (ie NI or RoI) will act to remedy its own problem. This was required to maintain a balance between generation and load. The load shedding was activated in specific load blocks as set out in a pre-planned Manual Load Shed Schedule (see Appendix 6).

## **5. Customer Disconnections/Restoration**

To prevent the automatic load low frequency shedding scheme being initiated by the falling system frequency a series of customer disconnections were initiated directly from the Grid Control Room as follows: -

The area supplied from Banbridge substation was disconnected at 16.38hrs (approx 30MW) affecting some 21,994 customers.

The area supplied from Ballynahinch substation was disconnected at 16.40hrs (approx 48MW) affecting some 30,676 customers.

50MW of Emergency Assistance was available from Scottish Power from 16.43hrs.

A further series of customer disconnections was initiated. Parts of Belfast and areas supplied in Ballygowan/Ards/Comber were disconnected at 16.49hrs (approx 35 MW) affecting some 35,924 customers.

At 16.52hrs OCGT2 at Ballylumford synchronised onto the system but tripped at 16.54hrs.

A further block of customer disconnection was initiated directly from the Grid Control Room: -

The area supplied from Newry substation was disconnected at 16.57hrs (approx 56MW) and affected some 35,064 customers.

By this stage a total of approximately 230MW had been shed affecting some 123,659 customers.

At 17.00hrs OCGT2 at Ballylumford again synchronised onto the system but tripped at 17.01hrs. The OCGT was attempting to provide support to the system but the vibration problems that had required an outage on Wednesday 3 December prevented it operating successfully.

Throughout this period the all-island system was operated with regulating reserve only. Close co-operation with open telephone line contact was maintained between the SONI Grid Control Room and the ESBNG Grid Control Room throughout this period. Information relayed between the two Control Rooms related to the level of generation capacity available, operating margin and demand.

After 17.30hrs (the evening peak period for both NI and RoI) it was possible to commence reconnecting blocks of customers to the system as the demand fell. All available generating capacity on the island was being utilised at this time.

The SONI Grid Control Room initiated the reconnection of customers as follows: -

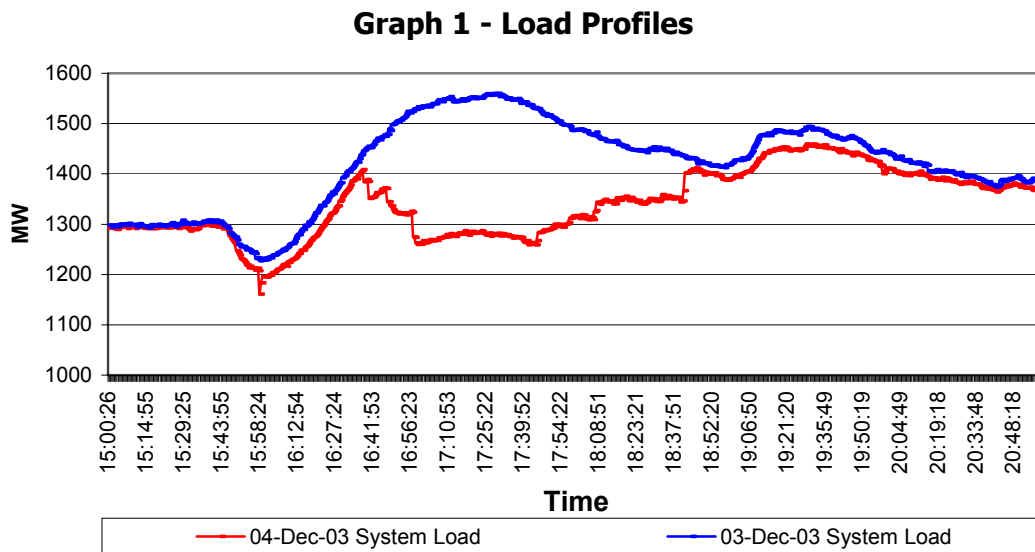
- 17.46hrs Banbridge restored
- 17.52hrs Belfast Block1 restored
- 17.58hrs Belfast Block2 restored
- 18.07hrs Ballynahinch restored
- 18.19hrs Ballygowan/Ards/Comber part restored
- 18.35hrs Ballygowan/Ards/Comber fully restored

At 18.33.12hrs Unit 1 at Kilroot was synchronised onto the system.

The final block of customers in Newry were reconnected to the system at 18.41hrs.

With all customers now reconnected and one of the Kilroot generating units back in service the all-island system was then restored to normal operation with spinning reserve levels re-established and nominated interconnector flows restored.

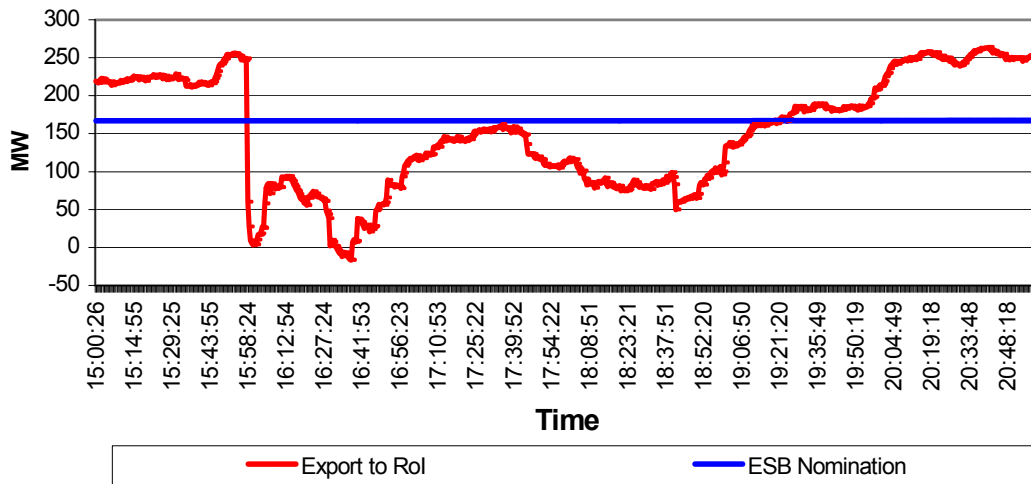
The following graph demonstrates the effect of the load shedding required to maintain the integrity of the all-island electricity system. It compares the load profiles of Wednesday 3 December and Thursday 4 December from 15.00hrs to 21.00hrs (see Graph 1).



The graph shows the 234MW that was load shed to stabilise the generation/demand balance.

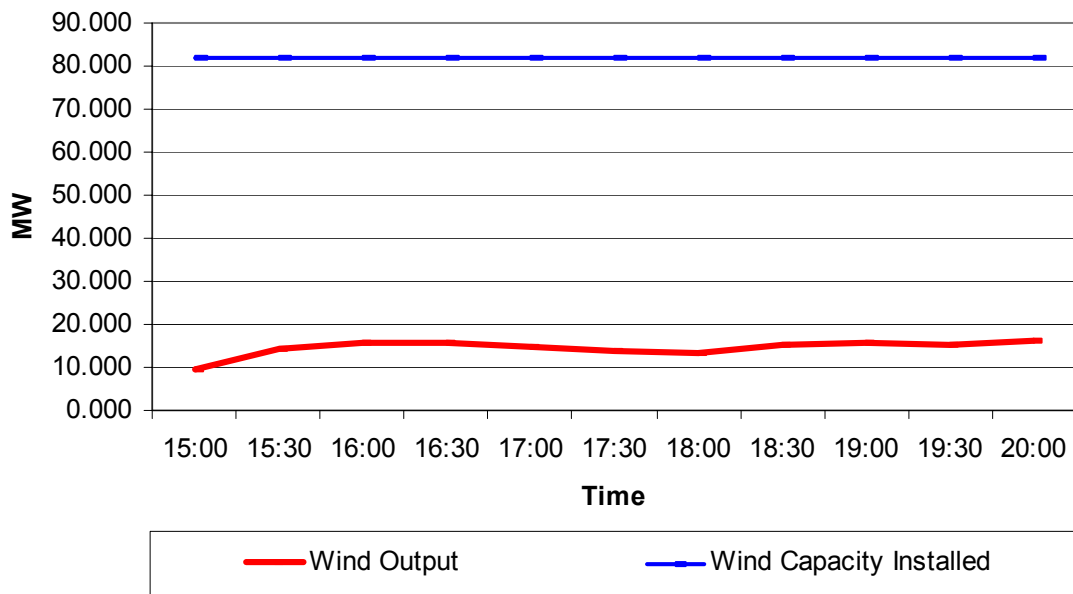
The support provided by RoI is demonstrated in the following graph which indicates the actual North-South interconnector flow during the period. The NIE/ESB contract nomination is also included (see Graph 2). The graph shows the change in transfer on the North-South Interconnector to provide relief to the NI system.

**Graph 2 - N-S Interconnector Flows**



The contribution from wind generation is demonstrated in Graph 3 and indicates that at the evening peak only 14MW was being provided from the 82MW of wind capacity installed.

**Graph 3 - Wind Generation**



The Scottish Power Emergency Assistance was stood down at 22.00hrs.

At 23.26hrs Unit 2 at Kilroot was synchronised on to the system.

## **6. NIE Emergency Plan**

The NIE Duty Incident Manager met with the Duty Incident Team for their normal Week Ahead Review on Friday 28 October. The only item relating to generation capacity on the Weekly Risk Assessment was the continuing outage of 250MW of Combined Cycle Gas Turbine at Ballylumford.

On Wednesday 3 December the Duty Incident Manager was informed that at Ballylumford a 58MW open-cycle gas turbine had been taken out of service during the early hours of the morning and a 190MW Unit was to be taken out of service at 20.00hrs. The anticipated restoration times were Friday 5 December at 16.00hrs and 20.00hrs respectively.

On receipt of this information the Duty Incident Manager set up a meeting of the Duty Incident Team at Craigavon at 10.00hrs on Thursday 4 December to review arrangements and ensure that preparations were made should further capacity problems develop.

At approximately 16.10hrs the Grid Control Room contacted the Duty Incident Manager to inform him of the loss of the two generating units at Kilroot. It was estimated at this stage that approximately 300MW of supplies to customers would need to be shed to maintain system integrity.

The Manual Load Shed Schedule (see Appendix 6) was confirmed between Grid Control, Distribution Control Centre and the Duty Incident Manager.

The Duty Incident Team set up in the Duty Incident Centre at Craigavon. Members of the Duty Incident Team Rota were on site and immediately available to open the Duty Incident Centre.

The Central Dispatch Office was instructed to set up the Messaging System to provide a prepared message to customers likely to be affected by the load shedding.

The Press Officer was mobilised and informed of the event and the imminent load shedding.

The Key Customer Contact unit was established and with assistance from staff at NIE HQ was able to contact major industrial customers and Second Tier Suppliers to inform them of the areas to be load shed and estimated times of restoration.

The Customer Care Contact unit was established to provide for telephone contact to registered Critical Care customers should the load shedding be prolonged.

The General Consumer Committee for Northern Ireland (GCCNI), the Office for the Regulation of Electricity and Gas (Ofreg) and the Department of Enterprise Trade & Investment (DETI) were contacted and kept informed on a regular basis throughout the duration of the incident.

## **7. Call Handling and Media**

Given the nature of the incident – a generation capacity shortfall, well defined blocks of load shed and the availability of good information on estimated restoration times - it was decided to maximise the use of the messaging system for customers calling on the 08457 643643 Fault Reporting Help Line. This enabled call agents to be free to receive calls on the Councillor Hotline and the Emergency Services Hotline.

The Message Answering Service (MAS) dealt with a total of 16,598 calls. The only possible way to provide information in a situation like this that creates an avalanche of calls is via a messaging system. During the period 16.00hrs to 24.00hrs call agents dealt with a total of 867 calls. Of these calls 46 were received on the Councillor Hotline and 7 on the Emergency Services Hotline.

A recorded message was in place at 16.33hrs and provided the following information;

'Thank you for calling Northern Ireland Electricity. Unfortunately some customers are currently experiencing interruptions to their supplies due to generation problems at one of the power stations. We are working with the generating company to resolve the problem and resume normal service. Thank you for calling and we apologise for any inconvenience'.

On restoration of supplies a further recorded message was in place at 18.58hrs with the following information;

'All of our call agents are busy at present; please listen to all of this message, last updated on Thursday 4 December at 19.00hrs.

Following the generation problem we now believe all customers disconnected due to load shedding have now been restored.

However, if you are still off supply, please check your trip switch before contacting NIE on our fault reporting number 08457 643643.'

The NIE Press Office handled all requests for information from the media.

## **8. Conclusions**

A single valve failure in the auxiliary steam main at Kilroot Power Station resulted in the loss of atomising steam to the oil burners and tripped the two generating units in the station.

The failure of a single valve in power station auxiliary equipment should not result in the loss of two generating units and the consequent loss of electricity supplies to customers.

The normal operation of the electricity system is based on maintaining sufficient synchronised and part loaded generating capacity to deal with the loss of the largest single generating unit without normally disconnecting customers. It would never be

the case that spinning reserve would be provided to carry the total loss of a major power station.

The situation was exacerbated as Ballylumford Power Station was unable to provide its full capacity, due to the fault on the new CCGT and the unavailability of one of the fast start gas turbines.

The SONI Grid Control Room directed and coordinated the operational response to the event. The aim was to minimise the number of customers disconnected and to ensure that these customers were reconnected at the earliest opportunity consistent with maintaining the integrity of the electricity system. This was achieved by stabilising the system as a first priority and reconnecting customers as quickly as possible.

The NIE Emergency Plan was deployed in an efficient and effective manner and was enhanced by the risk assessment undertaken by the Duty Incident Manager on the morning of Thursday 4 December.

## **9. Recommendations**

Kilroot Power Station must ensure that no single mode failure can result in the loss of two generating units. The Recommendations contained in the Event Report from Kilroot Power Station should be implemented immediately, namely, the repair to the single valve that caused the two units to trip and the redesign and modification of the auxiliary steam main to provide at least a 100% contingency against the recurrence of a single valve failure. We understand that Kilroot have undertaken to do this by Friday 12 December.

Until the new CCGT at Ballylumford demonstrates to everyone's satisfaction that it can operate reliably then all available opportunities should be taken to provide additional cover from out-of-contract plant. SONI and NIE are already addressing this matter with Ballylumford.

As demonstrated in this event, assistance from neighbouring systems, via the interconnectors, was an extremely important aspect of minimising the disturbance. The Moyle operated as designed and provided assistance to its maximum operating capacity. The North-South interconnector continues to suffer from the limitations on import into NI caused by the constraints on the RoI system. The removal of these constraints should be prioritised. This is being actively pursued in the Joint Working Group set up between the two departments.

## **APPENDIX 1**

<b>Expected portfolio of centrally dispatched generation capacity in NI</b>		
<b>Source</b>	<b>Capacity (MW)</b>	<b>Comment</b>
Moyle	400	
BPS G4	180	
BPS G5	0	Substitute unit for loss of G4 or G6
BPS G6	180	Normally this is the ESB unit
BPS CCGT GT21/ST20	250	
BPS CCGT GT22/ST20	250	
BPS CCGT 10	100	
KPS G1	220/260	Firing on Coal/oil
KPS G2	220/260	Firing on Coal/oil
CPS G6	60	
CPS G7	60	
OCGT's	232	
<b>Capacity (inc Moyle)</b>	<b>2152/2232</b>	
<b>Capacity (inc Moyle) less export to ROI</b>	<b>1972/2052</b>	

GT21/GT22/ST20 form a 500MW CCGT which is split into two separate 250MW units.

BPS Unit 6 is the unit normally contracted to the ESB.

NI has potentially installed capacity of 2052MW available to cover system demand.

## **APPENDIX 2**

<b>Available generation capacity for NI on Thursday 4 December 03</b>		
<b>Source</b>	<b>Capacity (MW)</b>	<b>Comment</b>
Moyle	400	
BPS G4	190	
BPS G5	190	ESB unit nominated @ 167MW
BPS G6	0	Boiler tube leaks
BPS CCGT GT21/ST20	0	Under repair – failure of Generator Transformer cable connection on 27/09/03
BPS CCGT GT22/ST20	248	
BPS CCGT 10	101	
KPS G1	260	Firing on oil
KPS G2	260	Firing on oil
CPS G6	60	
CPS G7	60	
Open cycle GT's	174	BPS GT2 under repair due to vibration problems
<b>Capacity (inc Moyle) less export to RoI</b>	<b>1763</b>	

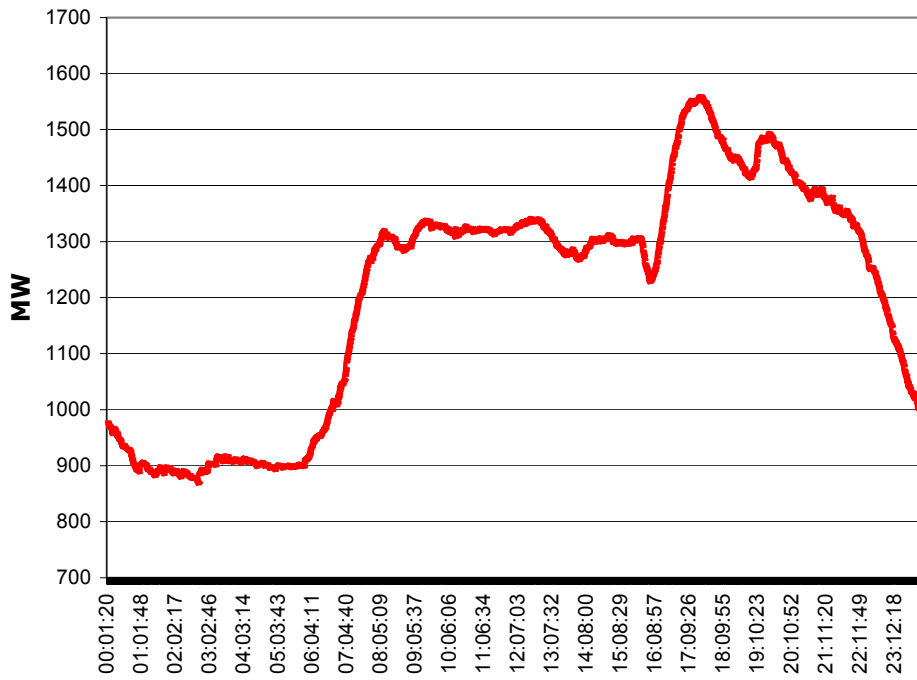
Immediately prior to the loss of the two generating units at Kilroot Power Station NI had 1763MW to cover an expected peak demand of 1550MW.

The contract with NIE to provide cover at Ballylumford following the loss of 250MW of the CCGT capacity included G4, G5 & G6 at 190MW.

### **APPENDIX 3**

This graph displays the anticipated load curve based on the previous day, Wednesday 3 December.

**NI - Expected load on Thursday 4 December 03**



## **APPENDIX 4**

The Significant Event Report received by SONI from Kilroot Power Station on Monday 8 December 2003.

### **Introduction.**

This report is in accordance with the requirements of Operating Code No 8. (OC8) of The NIE Grid Code for the electricity industry in Northern Ireland (attached for ease of reference). It is in response to a request from NIE for a written report on a Significant Incident on the User System at AES Kilroot on Thursday 4<sup>th</sup> December 2003.

In accordance with OC8.4.1.3 this report :

1. Is for the attention of the System Operations Manager,
2. Confirms the oral notification given under OC5 on Thursday 4<sup>th</sup> December 2003,
3. Provides further information, which has become known relating to the Significant Event since the oral notification under OC5.
4. Indicates that the cause of the Significant Incident has been ascertained and is highly unlikely to recur.

Whilst OC8.4.1.3 c does not require the report to state the cause of the Significant Incident, this is in fact also addressed.

AES Kilroot considers the cumulative Events on the Total System on Thursday 4<sup>th</sup> December 2003, resulting in load shedding, to also be a Significant Incident. Accordingly, a report has been requested from NIE in accordance with OC8.4.1.2 of The NIE Grid Code.

### **Sequence of Events Surrounding The Significant Incident.**

1. Both Units at AES Kilroot were dispatched for oil firing from 06.30 Hrs on Thursday 4<sup>th</sup> December 2003.
2. The dispatch instructions for both units reduced progressively during the day from 175 MWs at 06.30 Hrs to 135 MWs at 15.50 Hrs.
3. As Unit 1 approached 135 MWs, the auxiliary steam supply to both units collapsed. This in turn caused the fuel oil loops on both boilers to trip automatically, due to the loss of atomising steam, followed by the automatic trip of both units for protection reasons at 15.59 Hrs.

4. Upon instruction from SONI GT1 was synchronised at 16.05 Hrs and GT2 at 16.09 Hrs. SONI instructed loading to 20 MWs on each GT (contract capacity is 29 MWs).
5. Engineers and technicians at AES Kilroot worked to identify the root cause of the problem, took corrective action and returned the units to service as soon as was possible. Unit 1 was back on load at 18.32 Hrs and Unit 2 at 23.26 Hrs.

### **Cause of The Significant Incident.**

1. Atomising steam is required to maintain combustion when the boilers are firing on oil. This atomising steam, for both boilers, is fed from a common auxiliary steam main.
2. The auxiliary steam main, in turn, sources steam from either a turbine cold reheat steam line or from a boiler 2<sup>nd</sup> stage superheat steam line. One source is normally “on-duty” with the other “on-standby”.
3. As Unit 1 approached 135 MWs, the “on-duty” auxiliary steam source shut down when the cold reheat steam pressure reduced below 16 bar. This is normal operation and is designed to protect the turbine from ingress of wet steam.
4. However, the “on-standby” auxiliary steam source failed to cut in, which is not normal operation. This in turn led to the collapse of the auxiliary steam pressure and subsequent unit trips.
5. Upon examination, a fault was identified on the valve that controls the flow of auxiliary steam from the “on-standby” source.

### **Discussion.**

The AES Kilroot plant was designed with a common auxiliary steam main, supplied from “on-duty” and “on-standby” sources. Whilst coal-firing over the years the “on-standby” valve has repeatedly operated without failure when the load drops below 135 MWs. Whilst oil support to the boilers is still required when coal-firing, failure of the “on-standby” valve to cut-in is unlikely to cause instantaneous trips.

Although oil firing has been rare at Kilroot over the last 10 years or so, it has occurred on a few occasions over the 2002 and 2003 winters. Whilst the risk of failure of the “on-standby” valve is no higher when oil firing, the consequences of failure are much higher. Both units are almost certain to trip due to a loss of combustion.

AES Kilroot takes pride in having one of the highest reliability levels in the World. This Significant Incident, in combination with other system supply shortfalls, led to temporary load shedding on the NIE System. It also resulted in AES Kilroot incurring a six figure commercial penalty. AES Kilroot’s focus and commitment is to maintain its world-class reliability standard. We have accordingly taken the following actions to prevent a recurrence of a Significant Incident of this nature.

**Action Taken to Prevent Recurrence of Significant Incident.**

1. The fault on the valve that controls the flow of steam from the “on-standby” source has been rectified.
2. A modification is being designed such that there will always be at least 100% back-up in the event of the “on-standby” valve failing. This modification is to be completed by Friday 12<sup>th</sup> December 2003.

## **APPENDIX 5**

<b>Generation loading conditions at 16.10hrs</b>		
<b>Source</b>	<b>Load</b>	<b>Comment</b>
Moyle	400	
BPS G4	177	
BPS G5	178	ESB unit nominated @ 167MW
BPS G6	0	Boiler tube leaks
BPS CCGT GT21/ST20	248	
BPS CCGT 10	102	
KPS G1	0	Tripped
KPS G2	0	Tripped
CPS G6	38	
CPS G7	39	
OCGT's	119	
Export to RoI	79	
NI Capacity including Moyle	1424	
<b>System Demand at 16.10hrs</b>	<b>1229</b>	

The generating capacity at 16.10hrs was 1424MW. The NI demand was 1229MW. The flow to RoI had been reduced from 250MW to 79MW.

## **APPENDIX 6**

### **MANUAL LOAD SHEDDING : LF108\_4**

Issued: 26/09/2003

<b>Preferred Order</b>	<b>Load Block</b>	<b>Trip Location</b>	<b>Circuit Breakers</b>	<b>Size %</b>	<b>Comment</b>
1	Banbridge	TAN	MB75,MB85	2	
2	Ballynahinch	CAS	MC85,MC95	3.2	
3	Belfast 1		-	1.4	DCC
4	Ballygowan/Ards/Comber	ROS	RB 4,5,10,11	2.9	DCC
5	Belfast 2		-	2.3	DCC
6	Newry	TAN	MB20,MB50	3.7	
7	Belfast 3		-	1.7	DCC
8	Omagh	OMA	2MO, 4MO	2.6	Mesh solid?