

Unaccounted for Gas Report

National Grid
Gas Transmission

February 2013

Target audience

Ofgem and other interested industry parties

About this document

This document sets out the work done by National Grid Gas in its role as System Operator, to investigate potential causes of UnAccounted for Gas. It is published to meet Special Condition C29: Requirement to undertake projects to investigate the causes of UnAccounted for Gas (UAG).

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Changes made since the last report are shown in black text.

Text that has not changed since the last report is shown in blue text.

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1 Introduction

1. This report provides an update on our activity in investigating potential causes of UnAccounted for Gas (UAG) since the last report which was published in July 2012. For ease of reading this report retains the same format as the previous report.
2. [National Grid Gas \(NGG\) in its role as System Operator \(SO\) for the National Transmission System \(NTS\) has a role in the identification and management of UAG.](#) UAG is the quantity of gas that is required to maintain the energy balance i.e. the difference between NTS inputs and outputs.
3. This report discharges National Grid's responsibilities under Special Condition C29 (Appendix A) of our licence.
4. In 2011/12 the total UAG (net of reconciliations) was 4,357 GWh. From the 1st April 2012 to 7th Jan 2013 the total UAG is 2,324 GWh. At current volumes, 2012/13 UAG is likely to outturn at less than 2011/12.
5. We have continued to refine our data centred techniques for the analysis of the system data in search of causal factors of UAG, which are discussed within this document. We have not identified any specific UAG remedial actions.
6. We have continued to undertake meter reconciliations and witnessing of meter validations in addition to a range of projects initiated with independent experts which focus on specific areas. These are covered later in this report.
7. Industry fora, including the System Operators forum and the Gas Operations forum as well as bi-lateral discussions with various stakeholders have been conducted and have allowed us to discuss progress to date.

2. Our activities July 2012 to January 2013

8. This section provides brief details of our activities since the last report in July 2012 and summarises our findings. For further details consult the relevant appendices at the back of this report.

NTS Shrinkage (see Appendix B for more detail)

9. NTS Shrinkage continues to steadily decrease on an annual basis and the total for 2012/13 is expected to be the lowest for 5 years. We believe that this shows National Grid's initiatives to efficiently manage shrinkage continue to be effective.

UAG Trends (see Appendix D for more detail)

10. Daily UAG data is now routinely published on National Grid's website, the link is as follows.

<http://www.nationalgrid.com/uk/Gas/Data/uagdv/>

11. Although the Monthly assessed UAG (which is the total volume of positive and negative UAG) has grown steadily in the last few months of 2012, average daily UAG (which is net of positive and negative UAG and gives an indication of cost to the community) has been around 7.5 GWh/day since July 2012. This is the most stable that the daily average figure has been for the last five years.

12. While the 2012/13 data so far is not a full year (to January rather than the start of April), the current trend suggests that this year's UAG will outturn well below last year's total, and may well be the lowest for 5 years.

Meter reconciliation (see Appendix E for more detail)

13. NGG continues to reconcile measurement errors on behalf of the gas community. The corrected UAG (net of 9 GWh of reconciliations) for 2012/13 so far (to 7th Jan 2013) is 2,324 GWh.
14. As in the July 2012 report many recent meter errors can be traced to physical faults with equipment on site but since the last report the equipment errors rather than human errors now account for the majority of energy reconciled on DN Offtakes.

Meter validation witnessing (see Appendix F for more detail)

15. Our site meter validation witnessing programme has made steady progress throughout the year. 2012/13 is the final year of our five year programme designed to visit all NTS Offtake sites.
16. In terms of the total numbers of site visits, we expect to exceed those done in each of the 2 previous years.
17. We continue to find that maintaining a good working relationship with the asset owners is the most fruitful approach, and therefore continue with our periodic liaison meetings with respective parties to review all aspects of metering associated with their network.
18. We will continue our site witnessing programme in the coming years. We will prioritise our selection of sites to visit based on evidence.

Data Centred Investigations (see Appendix G for more detail)

19. We have continued to develop our UAG identification analysis techniques namely Data Mining, UAG Statistical Process Control, Power Station Efficiency monitoring, Composite Weather Variable and 6 year Data Trending. Many of the techniques are now automated (to work more efficiently) and all are done every week. They are identifying potential UAG anomalies which may warrant further investigations.
20. These analysis methods and their outcomes are now being discussed at many gas industry forums.
21. A number of potential sources of UAG identified by these techniques have been thoroughly investigated.

NTS Uncertainty level study (see Appendix H for more detail)

22. A pilot cumulative measurement uncertainty research programme has been conducted with the research company TUV NEL; this is now complete. This report contains the Executive Summary, Conclusions and Recommendations from the TUV NEL report.
23. The key finding of this work was that the level of UAG on the NTS is caused by a combination of factors from a variety of sources. The difference between orifice plate meters and ultrasonic meters could increase UAG although more data and further work would be needed to explore this.
24. Following significant review, the decision has been taken not to proceed to subsequent stages of this study as it has become clear that this would involve

significant complexity, with associated cost and it is not clear how this would lead to the industry being able to take steps to reduce UAG.

IFI Funded Programmes (see Appendix I for more detail)

25. We have initiated two programmes under the Innovation Funding Incentive (IFI).
26. Potential uncertainties in the measurement of Liquid Natural Gas (LNG) gas properties. The results of the programme are currently being compiled and will be made available through National Grid's IFI annual report.
27. NTS measurement low flow project. A research project was undertaken at the calibration facility at Bishop Auckland where a series of orifice plates were installed downstream of a reference turbine meter. It was concluded that the spread in the test results were greater than the bias in meter performance that the project was investigating and it was therefore not possible to progress the low flow work.

Appendix A - Special Condition C29: Requirement to undertake UAG Projects to investigate the causes of Unaccounted for Gas (UAG).

1. This appendix contains a copy of the licence condition that this UAG report is published under.
2. The licensee shall use reasonable endeavours to undertake the UAG Projects as specified in this condition for the purposes of investigating the causes of Unaccounted for Gas in the formula year $t=11$. The UAG Projects shall include but need not be limited to those set out in paragraph 4. Where the licensee does not undertake certain UAG projects it shall clearly set out its reasoning in the UAG Reports referred to in paragraph 2.
3. The licensee shall publish UAG Reports of the findings of these UAG Projects on its website and provide a copy of the UAG Reports to the Authority. The licensee shall publish the UAG Reports by 1 August 2012, 1 February 2013 and 1 May 2013, or such other dates as agreed by the Authority.
4. Within one month of publishing a UAG Report the licensee shall publish on its website all the relevant data referred to in the UAG Report. Where there are legitimate reasons for not publishing certain data on the website the Authority may consent for the licensee not to do so.
5. For the purposes of this condition: “UAG Projects” means the projects currently undertaken by the licensee including:
 - (i) the witnessing by the licensee of the validation of Measurement Equipment (as defined in the network code OAD Section D1.2.1) at NTS System Entry Points (as defined in the network code TPD Section A2.2.1) or Supply

Meter Installations (as defined in the network code TPD Section M1.2.2) at NTS Exit Points (as defined in the network code TPD Section A3.4.1);
 - (ii) investigation and analysis of data in order to seek to identify causes of UAG (which may include data-mining analysis and a pilot project to consider the assessment of inherent NTS measurement uncertainty).

“UAG Report” means the report of the findings of the UAG Projects undertaken by the licensee. The UAG Report shall detail the UAG Projects the licensee has undertaken in the previous period, the UAG Projects it proposes to undertake in the next period and the licensee’s views on how the findings of the UAG Projects may be taken forward in order to reduce the volume of UAG. The UAG Report shall also detail the reasons why any UAG Projects have not been undertaken in the formula year $t=11$.

“Unaccounted for Gas” (UAG) means the amount of gas (GWh) that remains unaccounted for after the Entry Close-out Date (as defined in the network code TPD Section E) following the assessment of NTS Shrinkage performed in accordance with the network code TPD section N paragraph 2.3.

Appendix B – NTS Shrinkage

1. One of the key aspects of our management of the NTS is our role as the Shrinkage Provider. This role is defined in the Uniform Network Code (UNC)¹ and places a responsibility on National Grid to forecast, procure and manage NTS Shrinkage appropriately on behalf of all system users.
2. The UNC also defines NTS Shrinkage in terms of three components:
 - I. Own Use Gas (OUG), which is predominately the fuel gas used for the compressors that maintain pressure and flow in the NTS;
 - II. Unbilled Energy, normally referred to as CV² Shrinkage (CVS), which is the difference between delivered and billed energy of a charging zone as a consequence of the Flow Weighted Average CV (FWACV) process; and
 - III. Unaccounted for Gas (UAG), which is the quantity of gas that is required to maintain the energy balance (the difference between NTS inputs and outputs). UAG is considered to be the consequence of data and or meter error and is thus a relatively complex component of shrinkage, involving not only the mechanical behaviour of high pressure metering systems but statistical variations in their operation.
3. NTS Shrinkage is calculated (assessed) and forecast daily. Its cost is recovered through the SO commodity charging mechanism. Since April 2002, NTS Shrinkage has formed part of the SO Price Control Review (Incentive) process and there has been considerable community interest in its behaviour. The NTS shrinkage performance between 2003/04 and 2012/13 (inclusive) is presented in Figure B.1 in terms of the magnitude of each principle component.

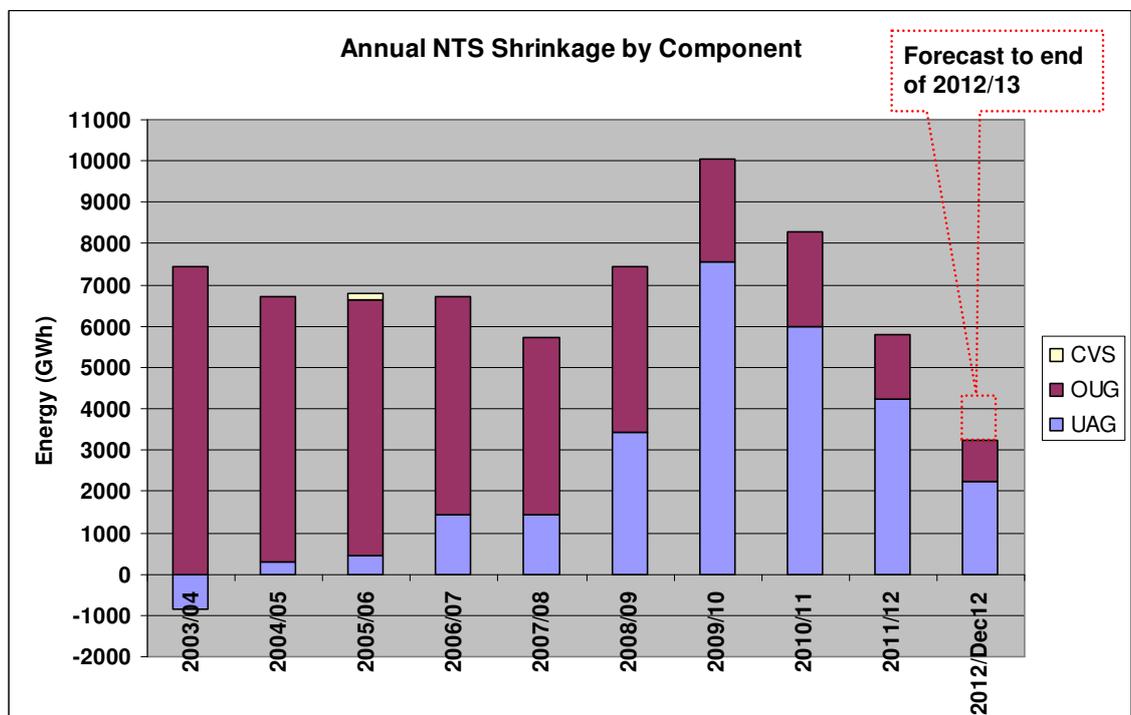


Figure B.1. Shrinkage from 2003 to 2012 inclusive.

¹ NTS Shrinkage Provider role is defined in Section N of the Transportation Principle Document (TPD) of the Uniform Network Code (UNC).

² Calorific Value (CV) is a measure of the thermal energy of the gas usually quoted in MJ/m³

4. Figure B.1 has been updated since the July 2012 report with the value “2012/Dec12” and the red dotted line shows the forecast until the end of 2012/13. We believe that this shows that National Grid’s initiatives to efficiently manage OUG and CVS continue to be effective.
5. Figure B.1 shows that UAG and OUG continue to steadily decrease on an annual basis and the total for 2012/13 is expected to be the lowest for 5 years.

Appendix C - Previous UAG Reports

1. In November 2008 Ofgem requested that we publish a detailed report into the causes and remedial actions necessary to reduce the recent increases in the NTS Shrinkage assessed³ UAG component. There was a concern that there was 'little information as to the causes of the increase' with attendant cost implications to gas customers.
2. In January 2009, we published our report⁴ which provided a comprehensive review of the then current UAG thinking and presented much of our analysis. The report highlighted:
 - The prevailing ownership and operating regime of NTS metering;
 - Measures undertaken by NGG in the management and development of the understanding of the complex nature of UAG. This approach was split between practical, experimental, theoretical and statistical analyses; and
 - That despite all the research and analysis conducted and presented, there was no evidence of systematic accounting errors in the determination of UAG and therefore, UAG was still considered to be the result of meter and/or data error.
3. While the report made no firm conclusions as to the exact cause of UAG or its recent trends, it did propose a framework to improve our future management of UAG by:
 - Increased use of statistical based analysis techniques;
 - Increased site based meter witnessing activity; and
 - The development of additional research programs to improve the understanding of meter performance.
4. As part of a continued dialogue with the community, in June 2011, we published an open letter⁵ to 'inform all industry participants on the progress achieved to date by National Grid NTS in reducing Unaccounted for Gas....', and highlighted:
 - The incentive performance to date;
 - The effect of recently discovered significant meter errors at the DN Offtakes of Braishfield and Aberdeen on overall UAG performance;
 - The UAG projects being undertaken by us in the management of UAG including:
 - The formation of a dedicated UAG project team to promote best practice;
 - The development of various data mining techniques;
 - The widening of the meter witnessing campaign to include terminals and storage facilities indicating a recent success of this initiative; and

³ Assessed UAG is defined as net daily UAG as calculated as difference between the net inputs and outputs of the NTS inclusive of any linepack change, own use gas (OUG) and Calorific Value Shrinkage. UAG is also quoted in energy.

⁴ Report published at <http://www.nationalgrid.com/NR/rdonlyres/...../OfgemUAGReport.pdf>

⁵ Report published at www.nationalgrid.com/NR/rdonlyres/...../UAGIndustryUpdateJune2011.pdf

- An intention to undertake an independent pilot study to assess the combined measurement uncertainty of the NTS.
5. In July 2012 we published⁶ the first of the regular UAG Reports, and this report summarises the progress that has been made since the last report.

⁶ Report published at <http://www.nationalgrid.com/uk/Gas/soincentives/SupportingInfo/>

Appendix D - UAG Trending and Analysis

1. Daily UAG data has been published on the National Grid website since October 2012 and is available via the following link:

<http://www.nationalgrid.com/uk/Gas/Data/uagdv/>

2. Weekly updates are made to this information and cover the period from 1 March 2007 up to 7 days previous. Due to the process of data close out (Day plus 5 and Month plus 15) the recent values are subject to change.
3. The information on the website includes the daily UAG data, 7 and 30 day UAG moving averages and a graph of the UAG data. The Figure D.1. below is taken from our website, blue vertical bars are individual UAG day values and the yellow line is a 30 day moving average.
4. Figure D.1. shows that average daily UAG has been around 7.5 GWh/day since July 2012. We are in a period of relative daily UAG stability albeit that there also seems to be a bias compared to 2007/08. This has been discussed with Newcastle University Industrial Statistics Research Unit (ISRU) and there is potential to investigate this to see if there has been a shift in UAG profile, if the date at which this happened could be identified then it might be possible to identify a cause of UAG.

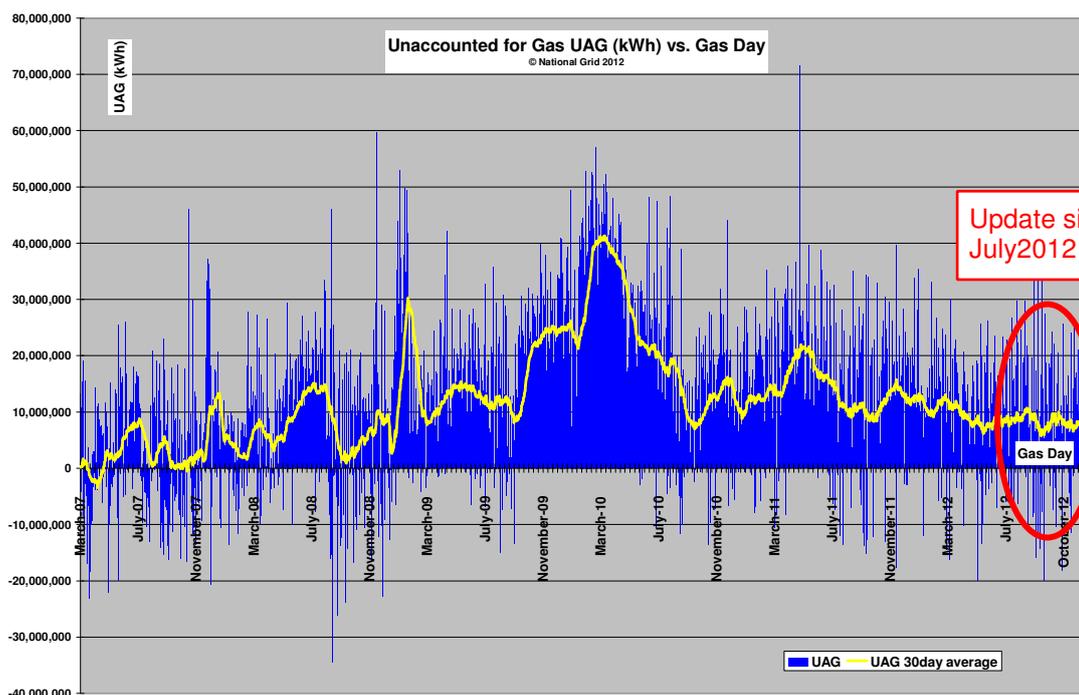


Figure D.1. Assessed UAG from 2007 to 2012 inclusive.

5. Figure D.2. shows that monthly assessed UAG has risen in October, November and December 2012. No cause of this has yet been identified. This indicates that the total UAG, in absolute terms, has increased. This compares to the rolling average figure, reported above, which shows the steady net rolling average figure and gives an indication of cost to the community of around 7.5 GWh/day since July 2012, the most stable that the daily average figure has been for the last five years.

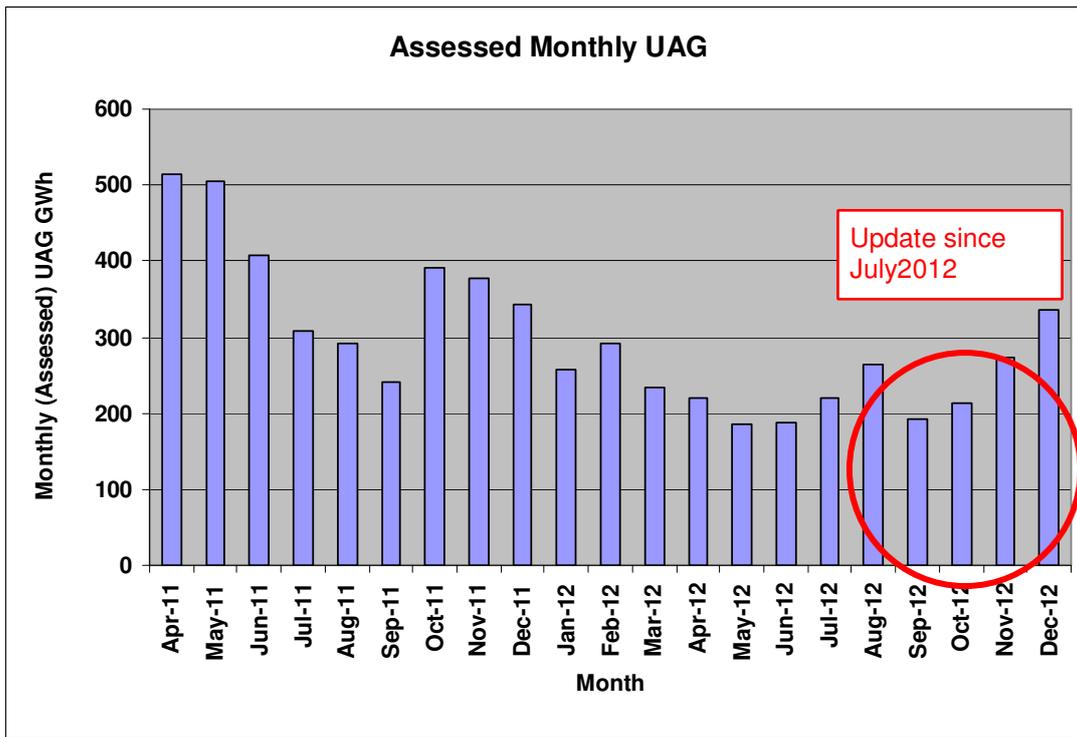


Figure D.2. Assessed Monthly UAG April 2011 – Dec 2012

Appendix E - Meter Reconciliation

1. NGG continues to reconcile measurement errors on behalf of the gas community and this is the primary mechanism for the re-apportionment of costs associated with NTS meter errors.
2. All demand meter errors that result in measurement bias and that are not corrected within the close out period, will be the subject of a Measurement Error Report (MER). This is produced by, or on behalf of, the respective asset owner and provides a technical assessment of the error and its magnitude. The MERs are used to define the corrected daily quantities to be reconciled.
3. To identify the underlying level of UAG, it is necessary to account for known meter errors as this will allow us to define the remaining measurement error. Table E.1 presents this analysis between 2008/9 and 2012/13. The 2012/13 data presented runs to 7th January 2013 and therefore represents only part of a year. A major proportion of the increases in UAG between 2009 and 2011 result from the discovery of significant meter errors at the Braishfield and Aberdeen Offtakes.
4. Braishfield and Aberdeen meter errors are both the subject of a Significant Meter Error Report (SMER). This means that they have to be investigated and reported on by independent experts (as per the UNC). Some of this work remains on-going and the timeframe to conclude these amendments is unclear.

	Assessed UAG	Net Reconciled	Corrected UAG (net of Reconciliations)
	GWh	GWh	GWh
2008/9	3531	-375	3156
2009/10	7551	-3178	4373
2010/11	5996	-1222	4774
2011/12	4305	52	4357
2012/13**	2315**	9**	2324**

**to 7th January 2013

Table E.1 The cumulative magnitude of meter error reconciliation on Assessed UAG.

5. Whilst the 2012/13 data is not a full year, the current trend suggests that this year's UAG will outturn below last year's total. Table E.1 also indicates that the underlying level of UAG when corrected for all reconciled meter errors still has measurement bias in the system (as Appendix D point 4) which has neither been found or corrected during this period.
6. The projected UAG outturn for 2012/13 (See Figure D.1) based on prevailing levels of UAG show a significant fall in the annual forecast when compared with previous years. Current investigations have not identified a direct cause of this

reduction, however there are a number of factors, as a result of the work undertaken over the last few years which may be contributing to this overall reduction in UAG levels:

- The close links between asset owners and ourselves are beginning to result in a more proactive approach to measurement and data quality which is feeding through to all levels of metering management across the NTS;
- NGG and some DN asset owners have embarked on a comprehensive series of meter upgrade programmes. These programmes are installing the latest meter and flow computer technologies which give a greater range of on-line diagnostic capabilities;
- The expansion of the EUETS⁷ carbon trading arrangements has placed the onus on all participants in the scheme to demonstrate their compliance. This has seen considerable emphasis being placed on the gas metering equipment and its on-going management; and
- Through the DN liaison meetings and increased NGG site presence, there is greater awareness of the significance of metering and its management in terms of the direct causal link to UAG.

7. All meter errors, with the exception of entry point meter errors, are reconciled through the neutrality and commodity charging mechanisms. Any entry point meter correction is subject to a different reconciliation rule to that of NTS Offtakes. These rules preclude any subsequent adjustment to the end of day figures of the entire month after the 15th business day of the succeeding month. Therefore, any issues identified at entry after this closeout period will not result in reconciliation.
8. As in the July 2012 report many recent meter errors can be traced to physical faults with equipment on site and these are summarised in Figure E.2 below. Since the last report the equipment errors rather than human errors now account for the majority of energy reconciled on DN Offtakes and the results of the fault diagnosis are summarised in Figure E.1 below.

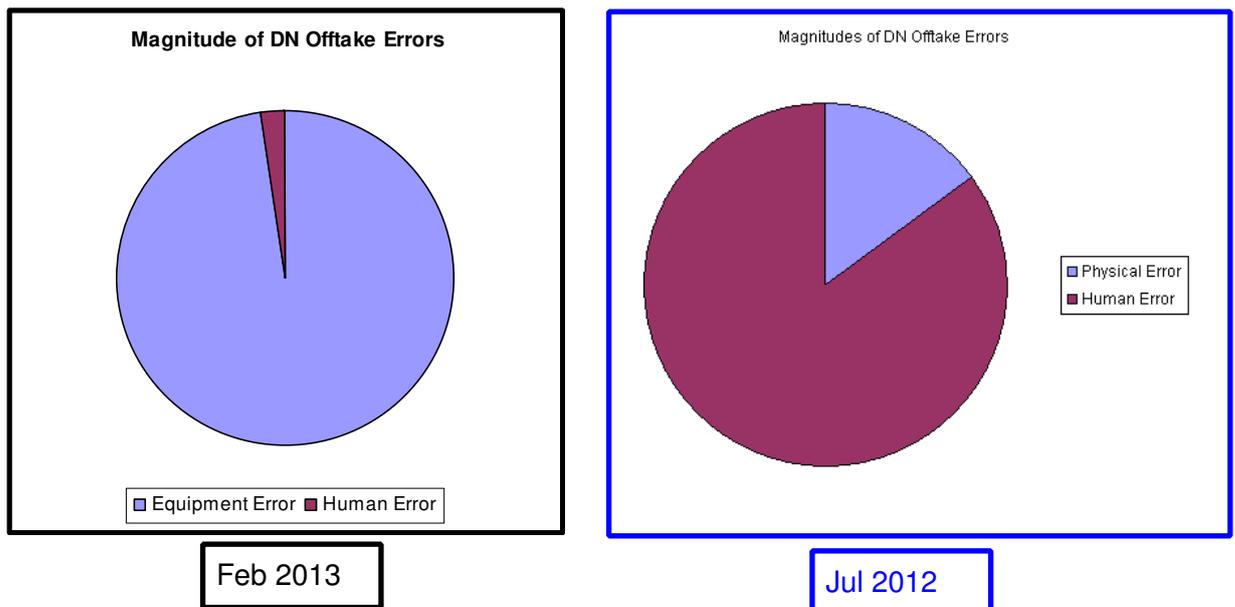


Figure E.1 Change in magnitude of DN Offtake errors July 2012 to Feb 2013 reports

⁷ EUETS European Union Emission Trading Scheme

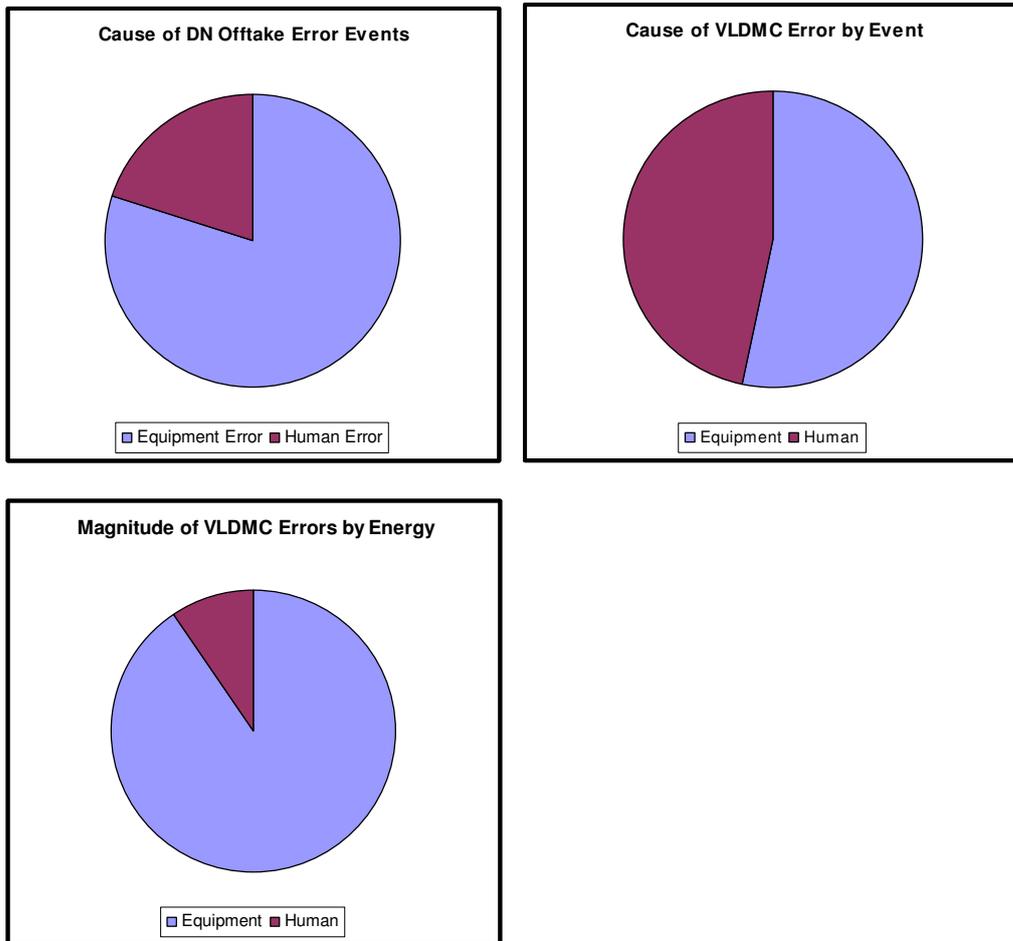


Figure E.2 Causes of Meter Errors – Proportions by Cause and Magnitude

9. There are a number of meter issues which have been raised on the Joint Office website that are being processed.
10. The importance of equipment quality, training, procedures and experience specific to the site being worked upon are highlighted as being the most significant factors in avoiding meter error.

Appendix F – Meter Validation Witnessing

1. Our site meter validation witnessing programme has made steady progress throughout the year. 2012/13 is the final year of our five year programme designed to visit all NTS to Local Distribution Zone (LDZ) Offtake sites. We have now completed 119 out of 121 Offtake site visits (including 48 Distribution sites visited prior to March 2009) involving all Network Operators⁸.

Year / Site Type	DNO Off Takes	Third Party	Terminal / Storage	Total
2009/10	25	8	11	44
2010/11	17	8	7	32
2011/12	16	6	9	31
2012/13*	13	10	5	28

2. There are still a few NTS to LDZ sites which we have not visited owing to the asset owner work plan being rescheduled or resource limitations on our part. We propose completing these remaining sites at the next convenient ME2 maintenance opportunity and it is possible that this work could be completed before the end of March 2013 in line with our five year programme.
3. We would like to acknowledge the support and cooperation provided by the Distribution companies, third parties and their staff, without which this task would have been impossible.
4. We continue to find that maintaining a co-operative working relationship with the asset owners is the most fruitful approach, and therefore continue with our periodic liaison meetings with respective parties to review all aspects of metering associated with their network.
5. One Offtake site was visited as a result of National Grid's data mining activities (Appendix G). The data mining software identified a possible correlation between UAG and site flow over a noticeable period hence this attracted further investigation. A significant collaborative investigation was undertaken by the Distribution Network Operator and National Grid, but ultimately no fault or problem was identified.
6. This year we have achieved additional visits to third party sites. The opportunity to visit third party sites generally revolve around major plant maintenance outages, and whilst these are fixed and known in advance there is a tendency for them to occur at the same time (following economic/market conditions). As a result, we do not propose setting ourselves a time frame to complete all such sites, but do ultimately envisage visiting all of them. Several recent visits were repeat visits to see the resolution to certain metering issues, e.g. Chromatograph re-calibration, or the fitment of replacement meters.

⁸ Our August 2012 publication reported there are 121 Distribution Network Offtakes, 56 directly connected loads (power stations, industrials etc), 8 storage sites and 2 interconnector sites measuring gas taken from the NTS. Additionally there are 28 terminals, interconnectors or storage sites metering gas delivered to the NTS.

7. Many third parties and some storage sites contract out their meter maintenance activities to specialist companies. We have found these specialist companies to be very supportive and conscientious and we believe their involvement provides consistency, thoroughness and efficiency.
8. We will continue our site witnessing programme in the coming years, however our selection of sites to visit will be evidence based. We also propose maintaining our initiative to visit more third party sites to provide a broad coverage, and to select sites using a risk assessment criteria which consider the following factors:
 - a) Sites with a history of errors
 - b) Sites with a history of validation issues (including no reports received)
 - c) Those yet to be selected for the audit programme
 - d) History of meter failures
 - e) Reaching or exceeding their flow measurement capacity
 - f) Those with low flows
 - g) Suspect flow profile
 - h) Sites identified by the data centred techniques.
9. In order to minimise the impact upon the downstream party, our site visits are planned to be arranged to coincide with the technicians being on site when they are undertaking their planned maintenance activities. If during the process of assessing the performance and compliance of the meter systems a generic issue is discovered, then this information will be shared across all meter owners, whilst maintaining the anonymity of the original site.

Appendix G – Data Centred Investigations

1. In recent years there has been significant effort put into the development of data centred analysis techniques capable of identifying UAG sources independently of site inspection activity and to complement network control room based monitoring.
2. National Grid believes it is unlikely that a single method or technique will be capable of identifying every potential UAG error, thus the data centred investigation approach is to build a 'tool box' of analysis techniques (discussed individually below) that supports our management of UAG by providing evidence of anomalies worthy of further investigation.
3. Any potential UAG issue highlighted by the in-house data centred analysis is investigated thoroughly via a carefully defined set of processes. If, following these checks, there is still some cause for concern, there is then a body of evidence that can be shared with the respective asset owner to assist in the clarification of the issue.
4. Since the July 2012 report when these data centred techniques were presented to all DNs (May 2012) National Grid has continued to work with interested parties / asset owners to review these analysis techniques and their findings. These have been discussed at meetings with:
 - i. Xoserve
 - ii. Quarterly asset owner liaison meetings
 - iii. System Operator forum
 - iv. VLDMCs via site visits
 - v. Gas Shipper forum
5. The remainder of this appendix presents a report on the progress of each of the analysis techniques.
6. Data Mining Techniques (SPSS software)
 - This was discussed in the July 2012 report, but this process has now been automated so that we are able to quickly analyse results very efficiently. We are using it every week to look for UAG.
 - We have reviewed what we have done with Newcastle University ISRU, they indicated that our method is sound and have recommended some of the additional mathematical techniques available within the software.
 - This technique has identified a number of potential sources of UAG and we have done a thorough investigation of 3 potential sources working with the asset owners. None was found.
7. Statistical Process Control (SPC)
 - Since the July 2012 report, progress has been made on the mathematical analysis of UAG. A Statistical Process Control (SPC) and CUSUM are now in place.
 - Currently the SPC & CUSUMs are being reviewed weekly.

8. Power Station Efficiency Tool (PSET)

- This was discussed in the July 2012 report and we now have an embedded process that is being run every week. We continue to develop the process so that it generates key anomalies worthy of investigation.

9. Composite Weather Variable (CWV)

- This was also discussed in the July 2012 report and we now have an embedded process that is being run every week.

10. 6 year trending

- This is a technique developed since the July 2012 report. It plots a time series plots of daily volume (MCMs) for all the Offtakes covering the last 6 years. For single feed Offtakes these daily volumes can be very seasonal such that trends (winter: high, summer: low) can be spotted by eye and any deviations from these could potentially be UAG.
- This method works well for large errors and can find (albeit with hindsight) most of the known large problems. It is not very fast response as trends take time to develop.

Appendix H – NTS Measurement Uncertainty Project Pilot Study

1. This work addresses measurement uncertainty on the NTS and its influence on UAG.
2. The background to this project is that there are a number of sources of uncertainty on the NTS, measurements are made at entry and exit points using a variety of different metering technologies (typically Ultrasonic meters (USM) and turbines meters (TM)) each with their own uncertainty characteristic such that their uncertainty varies across their intended working range. While these meters will operate within their respective tolerances, the cumulative effect of their measurement uncertainty and potential bias on UAG is complex and not fully understood.
3. To address this, a pilot cumulative measurement uncertainty has been the subject of a research programme conducted with the research company TUV NEL in 2012 in an attempt to quantify the magnitude of these uncertainties. This report contains the following from the TUV NEL report (v 4.01, Final Version):
 - Appendix H part 1 – Executive Summary.
 - Appendix H part 2 – Conclusions and recommendations
4. A full copy of the report will be published on our web site.
5. The key finding of this work was that the level of UAG on the NTS is caused by a combination of factors from a variety of sources, the difference between orifice plates and USMs could increase UAG although more data and further work would be needed to explore this.
6. This uncertainty work was split into a number of stages, the first stage (pilot study) is now completed and following significant review the decision has been taken not to proceed to subsequent stages as it has now become clear that this would involve significant complexity and cost and this would not be prudent as it is not clear how this could lead to the industry being able to take steps to reduce UAG.

Appendix H part 1 – EXECUTIVE SUMMARY. NEL Report v 4.01 (Final Version)

With significant levels of Unaccounted for Gas (UAG) currently being measured in the National Transmission System (NTS), NEL has been commissioned by National Grid to assess the effects of cumulative measurement bias and uncertainty on the level of UAG in the NTS. NEL is also tasked to highlight factors contributing to the bias and to suggest improvements. To facilitate this, National Grid selected a pilot study area close to the Easington Terminal, including the input from Langed pipeline in which to assess uncertainties and bias. This area was selected as it includes the required range of meter types, namely orifice plates, ultrasonic and turbine meters.

The project was divided into two parts:

1. Using data supplied by National Grid to assess the potential contributions to UAG made by flow measurement
2. Development of a spreadsheet based uncertainty model which could be used to track uncertainty in the pilot area.

It should be borne in mind that the following conclusions apply to the pilot area only and that scaling up to the full NTS should be treated with caution. In addition, the more data that are available the more confidence NEL will have in the validity of these conclusions and the magnitude of the figures associated with them.

Measurement Uncertainty

When we make a measurement of a quantity the result that we obtain is not the actual true value of the quantity, but only an estimate of the value. This is because no instrument is perfect; there will always be an element of uncertainty about the result of any measurement. In a system comprising a large number of measurements, such as the NTS, the uncertainty of measurement of individual instruments will combine and therefore will cause gas flow uncertainties to propagate through the system. Depending on the magnitude of the individual uncertainties and the configuration of the network, this can potentially cause significant uncertainties at given points in the system which will result in uncertainty levels that account for the levels of UAG in the system.

Metering Contributions to UAG

Using the measurement data available, it is concluded that there are a variety of effects that may be contributing to the levels of UAG in the system. These include

- The use of different orifice plate equations
- The change of input metering from orifice plates to ultrasonic meters
- Consistent patterns of installation leading to bias
- Differential pressure measurement.

To assess the relative contributions of each of these effects and how they combine, further investigation is required. The intention is to simulate the effects in an uncertainty calculation model.

Appendix H part 2 – CONCLUSIONS AND RECOMMENDATIONS. NEL Report v 4.01 (Final Version)

It is most likely that the level of UAG in the NTS is caused by a combination of factors from a variety of sources. Therefore the following conclusions should be placed in the context of other projects to assess UAG. The more data that are available the more confidence NEL will have in the validity of these conclusions and the magnitude of the figures associated with them.

5.1 Assessment of UAG levels

It should be borne in mind that the following conclusions apply to the pilot area only and that scaling up to the full NTS should be treated with caution.

- The difference between orifice equations may have the effect of reducing UAG where output orifice plates are used.
- The difference between orifice plates and ultrasonic meters could increase UAG where input ultrasonic meters are used. To strengthen and corroborate this conclusion more data on meter calibrations are required.
- Orifice installation effects may increase the level of UAG. Currently there aren't enough data to fully evaluate this. Therefore further data would be useful for to estimate its magnitude.
- Static pressure effects on differential pressure measurement need to be quantified.
- More ultrasonic calibration data, differential-pressure-transmitter calibration data and installation descriptions are required.

Appendix I – IFI Funded Programmes

1. We have initiated two programmes under the Innovation Funding Incentive (IFI) which aim to address areas that have relevance to UAG and may also be of wider interest to the gas community.

Appendix I.1 - Potential uncertainties in Liquid Natural Gas (LNG) gas property measurement

2. Throughout the NTS, gas composition is determined by gas chromatographs (GCs). Chromatographs are calibrated daily and validated annually. In both instances, the calibration gases used are based on traditional natural gas (UKCS) compositions which include both CO₂ and the higher hydrocarbon molecules. LNG will contain no CO₂ and limited levels of higher hydrocarbons, thus a gas chromatograph, which passes both its daily calibration and annual validation, may well be measuring, under normal conditions, gas outside the calibration limits. Initial review of these phenomena suggests that it potentially introduces a positive measurement bias. The potential effects of mis-measurement across the network impacted by LNG gas, particularly at the reception facilities, is likely to contribute in maintaining the existing positive UAG volumes. Any sustained diminution of these UAG levels reduces community exposure to these costs.
3. This programme has fully evaluated the effects of LNG gas on a range of conventional chromatograph types from both a theoretical and experimental standpoint. The initial results are currently being evaluated but there are a number of follow on actions that may be considered appropriate:
 - Introduction of a new range of chromatograph calibration gases for sites likely to experience LNG.
 - Improvements to the BS ISO 10723 standard.
 - Enable NG to better manage customer enquiries related to LNG penetration throughout the NTS.
 - Remove unexplained measurement bias thus improving UAG control and monitoring.
4. The results of the programme are currently being compiled and will be made available through National Grid's IFI annual report .
5. These results will be discussed in future versions of this report as soon as they become available.

Appendix I.2 - NTS Measurement Low Flow Project

6. The design and operating conditions of NTS Offtakes has changed. Offtake pressures are normally well in excess of the optimum design pressure. For an orifice plate metering system there are potential issues when the gas flow is at the low end of the measurement range. There are instances where sites operate at very low differential pressures for considerable periods.
7. With the exception of start up and shut down flow transients, all orifice plate meter systems are expected to operate well inside the normal operating range of the differential measurement device. There is a body of experimental evidence to suggest that low flows and hence low differential pressures result in a negative measurement bias (under read). This would lead to mis-apportionment of gas cost across the community.

8. Previous published⁹ work provided a large set of data relating to the use of low differential pressures across a range of orifice plates of differing beta ratios. This work illustrates that the measurement efficacy of orifice plates at low flow rates deteriorates rapidly.
9. A series of flow trials were commissioned by National Grid resulting in a research project being undertaken at the calibration facility at Bishop Auckland where a series of orifice plates were installed downstream of their reference turbine meters. The performance profile of the orifice plate meters was recorded and compared to the upstream reference meter.
10. Figure I.2 below shows the repeatability of the calibration assembly and it can be concluded that the spread in the test results are greater than the bias in meter performance that the project was looking for and it was therefore not possible to progress the low flow work.

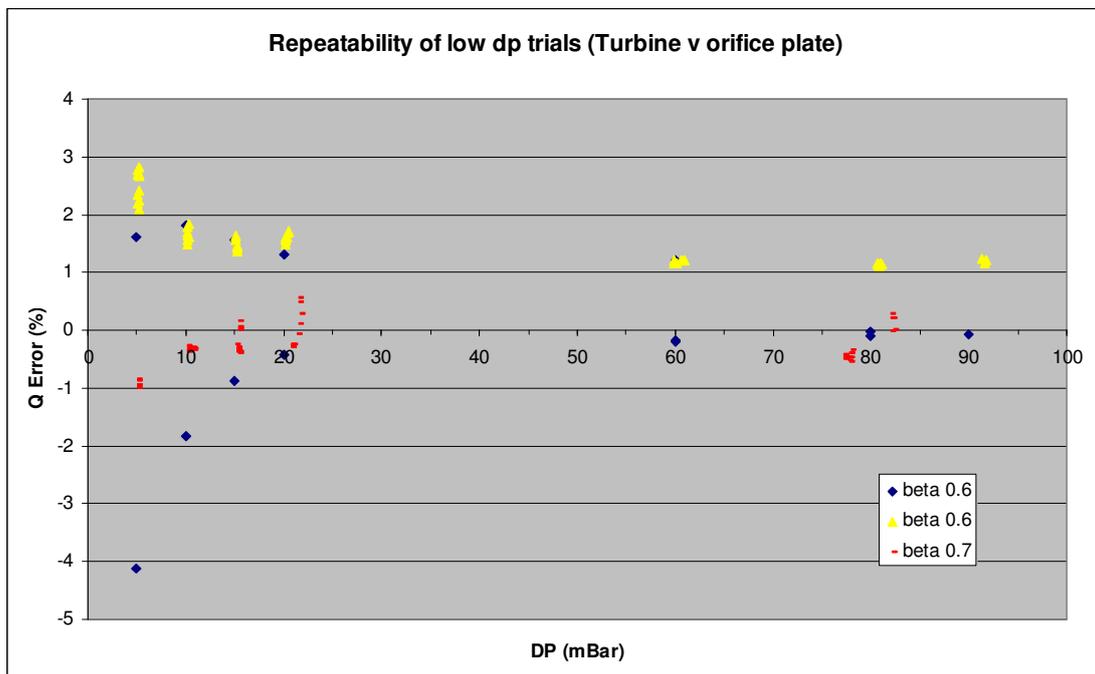


Figure I.2. Repeatability of low dP trials.

⁹ George et al. Assessment of Orifice Meter Flow Measurements with Low Differential Pressures. Final Report SwRI PR-015-08605 (2009).