nationalgrid

Unaccounted for Gas Report

National Grid Gas Transmission

October 2013

Target audience

Ofgem and other interested industry parties

About this document

This document sets out the work undertaken by National Grid Gas in its role as System Operator, to investigate potential causes of Unaccounted for Gas (UAG). It is published to meet Special Condition 8E: Requirement to undertake UAG Projects to investigate the causes of UAG.

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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 May 2013 report and covers the period up to and including 31st August 2013. Work continues as planned and there have been slight changes in the trend of UAG (the quantity of gas required to balance the NTS i.e. the difference between NTS gas inputs and outputs) since the last report.

2. The previous reports on this subject are available via the following link:

   http://www.nationalgrid.com/uk/Gas/soincentives/SupportingInfo/

3. This report discharges National Grid Gas's (NGG's) responsibilities under Special Condition 8E "Requirement to undertake UAG Projects to investigate the causes of Unaccounted for Gas (UAG)", available via the following link:

   https://epr.ofgem.gov.uk

2.0 NTS Shrinkage Summary

2.1 Shrinkage for 2007/08 to August 2013 inclusive

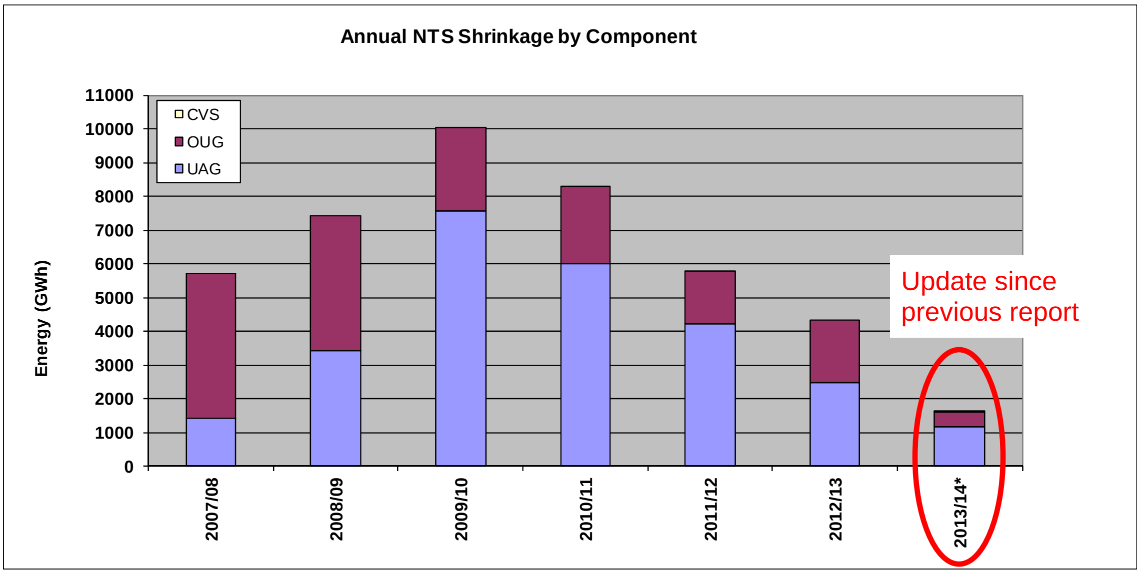

Figure 1: Shrinkage for 2007/08 to August 2013 inclusive. Note: * data is until end August 2013

In the above figure 1, the last column contains data for only part of the year but the whole of the year is trending to about the same level as 2012/13.

2.2 Assessed daily UAG from April 2007 to August 2013 inclusive.

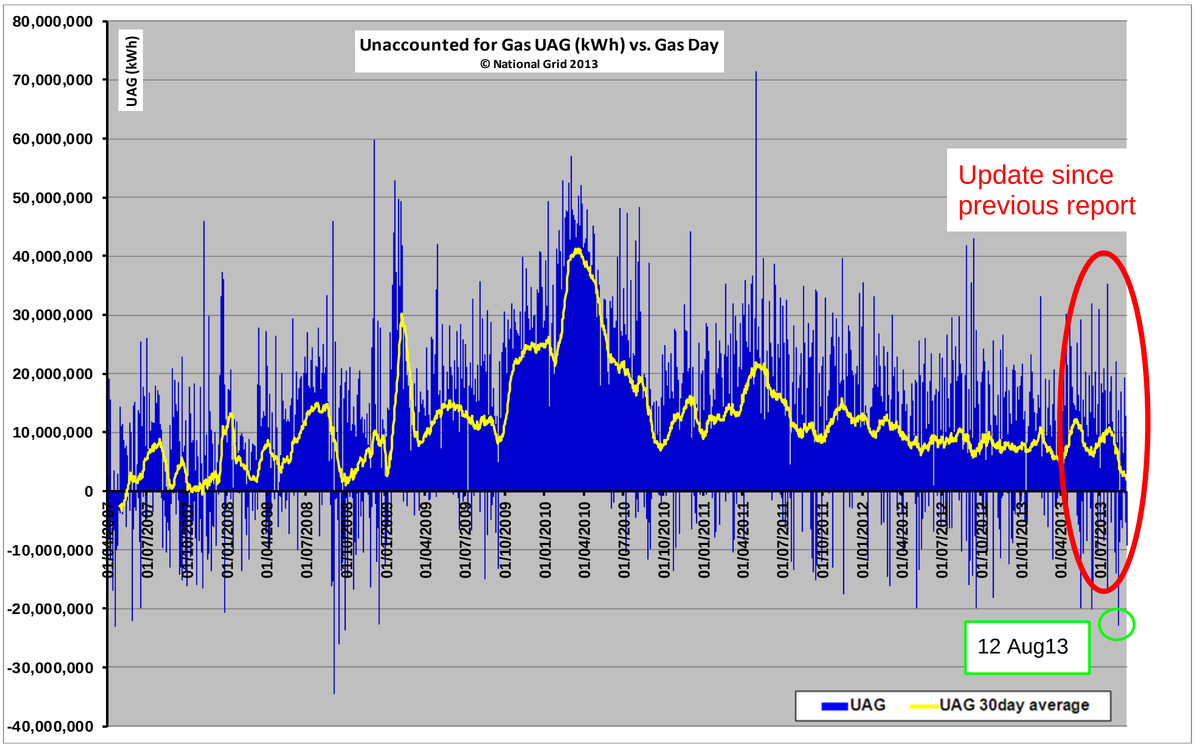

Figure 2: Assessed UAG from April 2007 to August 2013 inclusive.

Figure 2 shows that since the May 2013 report, average daily UAG (yellow line) has become slightly more volatile than the previous period. There are also an increasing number of negative UAG days with the 12th August 2013 being the most negative for almost 5 years. The daily UAG data continues to be published on the National Grid website (since October 2012) and is available via the following link:

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

2.3 Assessed Monthly UAG April 2007 – August 2013 inclusive

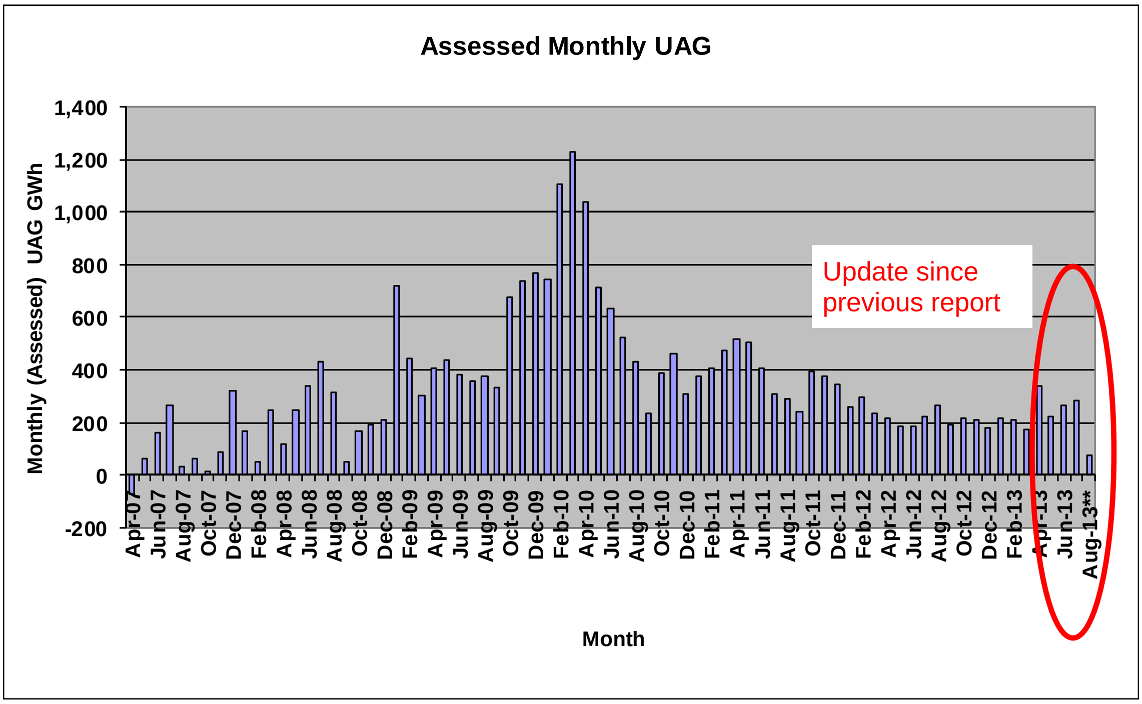

Figure 3: Assessed Monthly UAG April 2007 – August 2013 inclusive Note: ** July & August 2013 data is provisional.

The assessed monthly UAG values (which is the total volume of positive and negative UAG) has also become much less consistent, April 13 was larger than might have been expected, while August is half what would have been estimated and the lowest for around 5 years. At the time of writing this report not all the values are closed out (not M+15) hence the August total may change in the next report.

2.4 Cumulative magnitude of meter error reconciliation on Assessed UAG.

	Assessed UAG GWh	Net Reconciled GWh	Corrected UAG (net of Reconciliations) GWh
2008/9	3,531	-375	3,156
2009/10	7,551	-3,178	4,373
2010/11	5,996	-1,222	4,774
2011/12	4,305	52	4,357
2012/13	2478	-151	2327
2013/14**	1,183**	-20**	1,163**

Table 1: Effect of meter errors on UAG. Note: ** to end August 2013 and includes some provisional information

In FY 2012/13 the total net UAG (i.e. adjusted for meter errors) was 2,327 GWh and for FY 2013/14 to the end of August 2013 this is at a level of 1,163 GWh.

3.0 Meter Validation Witnessing

3.1 Our site meter validation witnessing programme continues to make steady progress as shown in the following table 2.

Year / Site Type	DN Offtakes	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	16	13	5	34
2013/14**	8**	4**	2**	14**

Table 2: Note ** data is until end of August 2013

3.2 The sites selected for our site witnessing programme will be evidence based using the following criteria:

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) Those with a history of meter failures
e) Those operating close to the extremities of their metering ranges.
f) Sites identified by the data centred techniques.

3.3 The following table 3 summarises the lessons learnt and points noted by the National Grid site witnessing staff from our visits to date.

#	Information point
1	It has been observed that the quality of some site billing data can be degraded as a result of telemetry problems despite the metering installation operating normally. Additional checks and confirmation procedures have been adopted in some instances to ensure accurate billing data is adopted.
2	Additional telemetry tests have been introduced to ensure that volume and energy integrator signals are connected correctly. Several wiring faults have been identified and rectified since the May 2013 report.
3	During site visits we verify that Ultra-Sonic Meters (USMs) connected to measure gas in or out of the NTS are calibrated using high pressure gas, that the calibration range is appropriate for the site operational range, that the calibrated profile is linearised correctly and that the meters comply with the uncertainty calculations for the meter system. We have noted that this best practice is not always followed.
4	We have observed that occasionally, orifice plate inspection/replacement intervals exceed the recommended 12 month period. This can be as a result of deferred maintenance, a change to maintenance regime or resource limitations. Where this is the case we prioritise these locations for their next site visit to ensure any significant performance change is captured.
5	We have seen several instances of metering faults resulting from the failure of electrical connections on temperature probes. These units have very fine 4-20mA loop wires which can be easily damaged when disconnecting /reconnecting for testing purposes. We have shared this information with the asset owners and are engaging with them to prevent issues occurring.
6	We have identified through our site visits that some turbine meters with manual lubrication systems do not have their operation checked in routine site maintenance procedures and it would be necessary to do so to adhere with best practice.

Table 3: Site visits lessons learnt and points noted

3.4 We believe our site visits have been beneficial for a number of reasons. We have seen issues at one DN which we have been able to bring to the attention of a different DN. We have co-ordinated with other companies to effect a problem resolution, for example when there were telemetry issues and input was needed from site, the telemetry equipment provider and National Grid Control Centre, our contact knowledge enabled the issue to be quickly rectified.

3.5 Since the last report in May 2013 there has continued to be regular structured interaction been National Grid and the asset owners so that joint efforts are being made to identify then reduce UAG. This has taken the form of regular (approximately 3 monthly) liaison meetings with the DN owners of the Offtakes and through ad-hoc meetings with operations staff during visits to Power Stations, Terminals, Storage sites and large industrial customers. This work will continue in the period leading to the next report.

4.0 Data Centred Investigations

4.1 The following table 4 presents a summary of the frequency of data centred investigations which are used to identify potential UAG issues. For an explanation of these analysis techniques see appendix B.

#	Analysis method	Frequency of analysis
1	Update UAG Statistical Process Control (SPC) & Cumulative Summation (CUSUM) charts	Weekly
2	Complete Power Station Efficiency Tool process (PSET)	Every 2 weeks
3	Complete 6 year trending analysis	Every 2 weeks
4	Complete Composite Weather Variable analysis	every 4 weeks
5	Complete Data Mining analysis	every 4 weeks

Table 4: Frequency of UAG analysis techniques

4.2 Processes have also been developed to allow all the issues from 4.1 to be quickly investigated. It is now possible for us to check our records to see whether they are issues which are known to the business in which case there would be little value in investigating them further. The following table 5 briefly lists the checks that are done:

#	Investigation	Number of potential issues resolved since May 2013
a.	Review whether the issue coincides with the site validation	8
b.	Check whether the records show there were flow computer integrator issues	0
c.	Check whether the records show there were Telemetry issues at the facility	0
d.	Check whether the records show there were known site issues recorded in control room logs	0

e.	Check whether the records show there were Non Routine Operations (NROs) undertaken which may result in non-standard site flow patterns	2
f.	Investigate whether the observed issues were due to flow swaps between Offtakes, i.e. standard but infrequent flow patterns	0
g.	Review the compiled database of operational intelligence gathered from other teams and internal National Grid documentation	0

Table 5: Checking potential finds with known issues

4.3 Table 5 also contains a summary of how many potential UAG issues may have been resolved since 1st May 2013. It can be seen that many of these potential issues seem to correlate with site validation activity and further investigations are therefore being carried out in conjunction with the asset owners to confirm if this is the case. The table also shows that a smaller number of potential issues occurred at the same time as Non Routine Operations (NROs) were completed, so it is likely that the sites were operated in a non-standard manner which could explain the observations and this is also being confirmed by the site owner.

4.4 If the potential issues identified in 4.1 cannot be explained in 4.2 then these are being passed to the meter owners at the regular Liaison meetings and are being investigated to see whether UAG can be identified.

4.5 The data centred investigations discussed in this section are now standard processes and they will continue to be routinely carried out and developed appropriately.

5.0 Conclusions

5.1 Early indications are that since the last report there has been an increasing trend of UAG volatility and we are investigating this.

5.2 The site witnessing programme continues to identify site issues which we are working with site owners to resolve.

5.3 We continue to carry out data centred analysis as a key element of our UAG investigations.

Appendix A - Explanation of NTS Shrinkage Summary

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:

    a. Own Use Gas (OUG), this is predominately the fuel gas used by the gas turbine compressors that maintain pressure and flow in the NTS;

    b. Unbilled Energy, normally referred to as Calorific Value[2] Shrinkage (CVS), which is the difference between delivered and billed energy of a charging zone as a consequence of the Flow Weighted Average Calorific Value (FWACV) process;

    c. 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.

[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

Appendix B - Explanation of Data Centred Investigation Techniques

1. In recent years there has been significant effort to develop data centred analysis techniques capable of identifying potential meter errors and UAG independently of inspection activity and to complement the other site and network control room based monitoring. These techniques are capable of analysing all inputs and output facilities on the National Transmission System (NTS).

2. We are aware that it is unlikely that a single method or technique will be capable of identifying every potential error. So a range of data centred techniques have been developed to form a 'tool box', these work differently and complement each other. The methods used are as follows and will be described further in this appendix:

    1. UAG value Statistical Process Control and CUSUM analysis
    2. Power Station Efficiency Tool (PSET)
    3. Six year trending
    4. Composite Weather Variable (CWV)
    5. Data mining

3. To add confidence in the results by ignoring spurious events, a meter error or UAG is considered valid if:

    a. 2 or more of the methods find an event for similar dates, or

    b. The data mining tool identifies a very strong correlation between UAG and a facility

4. Having identified potential events at Offtakes in the previous point, processes have also been developed to allow effective investigations as to whether these are issues which are known to the business (albeit to other teams/companies) in which case there would be little value in investigating them further. Briefly, potential issues are investigated by checking against:

    a. Review whether issue coincides with site validation – did problem occur within 2 weeks? If so there could be an issue with hardware removed/installed on site or with human oversight

    b. Check whether the records show there were flow computer integrator issues

    c. Check whether the records show there were telemetry issues at the facility

    d. Check whether the records show there were known site issues recorded in control room logs

    e. Check whether the records show there were Non Routine Operations (NROs) undertaken which may result in non-standard site flow patterns

    f. Investigate whether the observed issues were due to flow swaps between Offtakes, i.e. standard but infrequent flow patterns

g. Review the compiled database of operational intelligence gathered from other teams and internal National Grid documentation

5. The results of the investigations in the previous point are shared with the Offtake asset owners in the regular (approximately 3 monthly) liaison meetings held with National Grid. If some of the findings from point 3 cannot be explained by point 4, then the asset owners continue the investigations based on their knowledge of their facility.

B.1 Statistical Process Control (SPC) and CUSUM analysis

6. We are developing statistical techniques to aid the investigation of UAG. The aim is to develop datasets or models where changes in underlying process behaviour can be detected with a view to identifying the onset of an issue which is driving UAG. As with data mining, the analysis has been developed with the aid of consultancy provided by Newcastle University Industrial Statistics Research Unit (ISRU).

7. To date, the techniques used are based on two approaches, these techniques have pedigree in manufacturing industries:

   - Control charts and action limits (Statistical Process Control (SPC)); and
   - Cusum charts to detect changes.

8. The SPC method uses previous (2012) daily UAG volume (MCM) data to construct go/no go tramline limits. The warning limits are set at +/- 2 standard deviations (SDs) from the average, and the alarm limits are set at +/- 3SDs. Most (95%) of the UAG in MCM/day should lie within +/- 2 SDs and almost all (99%) should standard +/- 3 SD, so if the daily UAG lies outside the alarm limit it is said to be very unusual. The following figure B.1 shows how the daily UAG data standard is analysed, the red circles show the very unusual days.

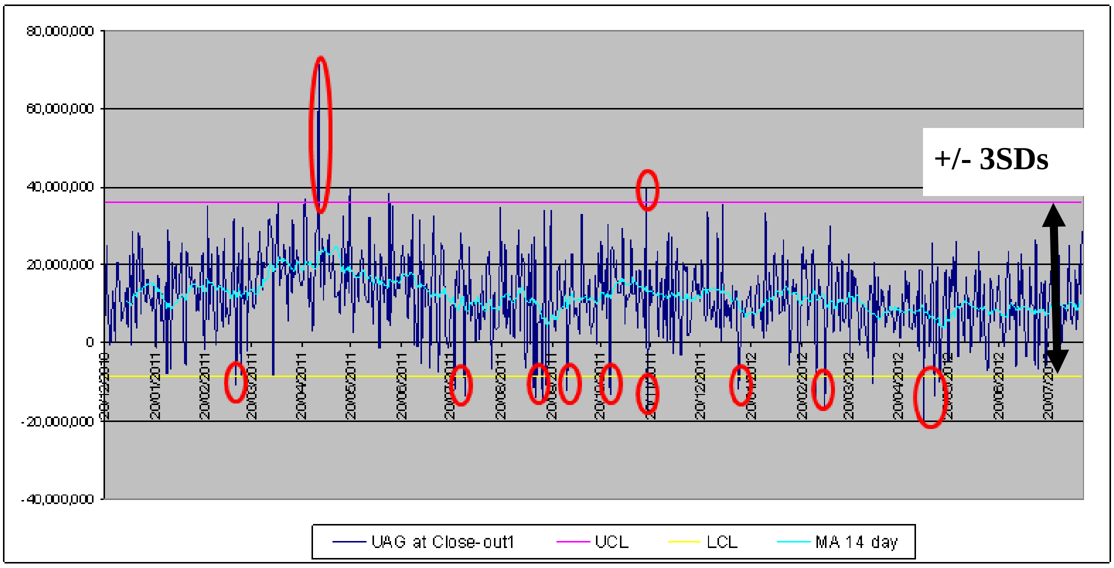

Figure B.1: example of SPC chart for daily UAG data

9. Cumulative sum (Cusum) techniques are also being applied to the trend of UAG. The approach here is to use a historic value for mean UAG and for each subsequent day, add the difference between Assessed UAG and this mean value to produce a running total. If UAG remains steady the slope of the CUSUM line will remain constant, however, a change in slope indicates

a change in underlying UAG with the date of any slope change being a period worthy of investigation. A benefit of this method is that it quickly identifies when the behaviour of UAG has changed.

10. The following figure B.2 is an example of the CUSUM chart that could be produced and the red circles show when the behaviour of the UAG has changed suggesting further analysis would be appropriate.

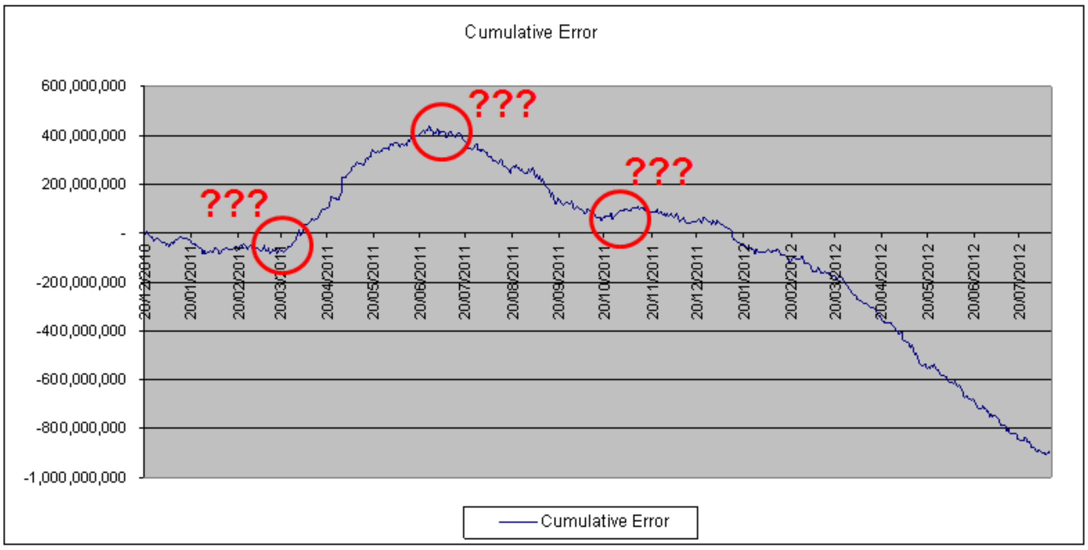

Figure B.2: example of CUSUM chart for daily UAG data

B.2 Power Station Efficiency Tool (PSET)

11. There is a large volume of data available in the public domain regarding the generation output of power stations, available via the Balancing Mechanism Reporting System (www.bmreports.com).

12. When this generation data is combined with our gas flow data, an analysis can be conducted around the efficiency of the power plant. In principle, power stations utilising gas turbines are expected to operate in a relatively narrow efficiency band for a given mode of operation. Experience has shown that generation output reading is typically reliable, so any apparent increases in efficiency are likely to be due to under measurement of gas flow, while any decreases in efficiency could be over measurement of the gas flow. These gas flow issues may indicate an event worthy of investigation.

13. For a measured generated power, this method calculates a predicted gas fuel flow based on historical data for the power station being reviewed, then compares this to the measured fuel flow for the day. Again similar to the previous SPC method, it uses statistics to construct warning (+/- 2SD) and alarm (+/- 3SD) tramlines based on historical data. If the measured gas fuel flow values are more than +/- 3SDs away from the predicted value for more than 2 days in a row then further investigation would be appropriate. The following figure B.3 shows the standard times series data for gas fuel flow and generated power for a power station.

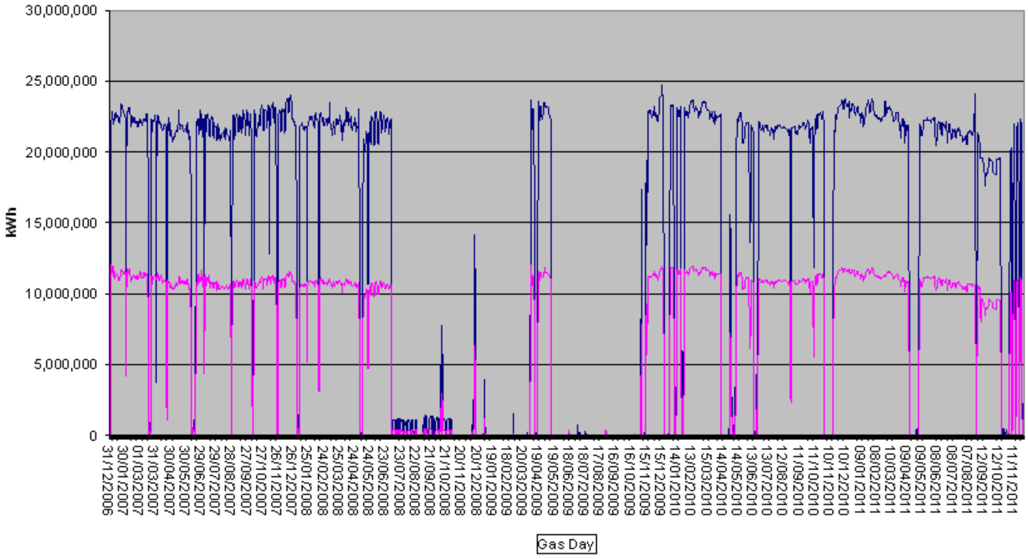

Figure B.3: example of time series for power station gas fuel and generated power

The PSET method would produce a chart as follows in figure B.4 from the data shown in figure B.3.

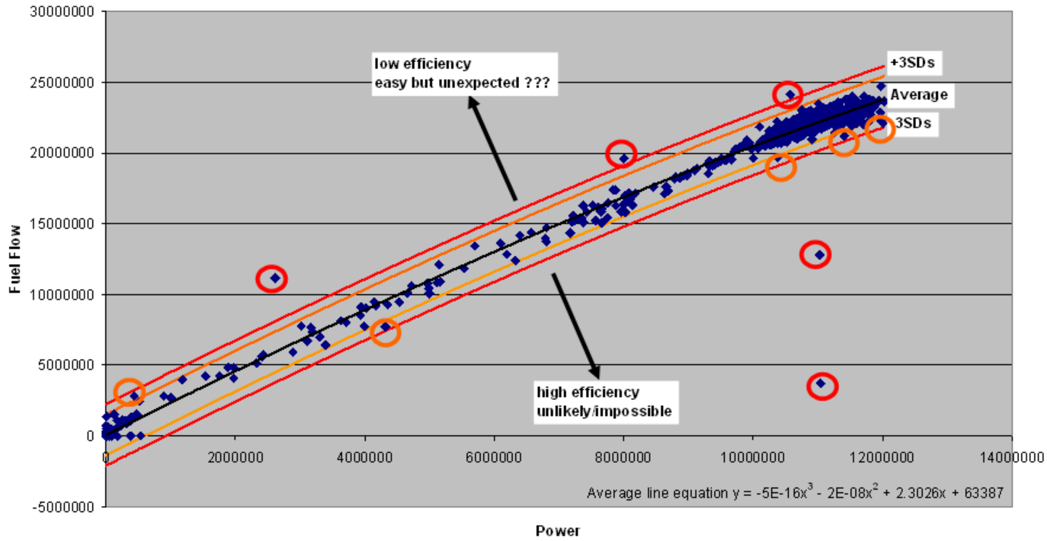

Figure B.4: example of output from PSET method

14. This method may not be suitable for all power stations as for example, some have their gas fuel metered a significant distance from the gas turbine and some blend NTS gas with offshore gas, but it is expected that the majority of directly NTS connected power stations can be accommodated by this method.

15. The performance of this method is currently being assessed within National Grid.

B.3 Six year trending

16. This method involves producing a number of time series plots for the NTS Offtakes then reviewing the demand patterns looking for deviations from normal. Some Offtakes (single feed work the best) or groups of Offtakes have cyclic and repeatable demand pattern hence when this pattern deviates from normal it may indicate an event that should be investigated. The following plots are produced.

a. For each DN Offtakes daily demand (MCM/day) vs. date.

b. For the larger Offtakes, daily demand as a percentage of total DN flow vs. date.

c. For certain flow swapping Offtakes, total daily demand for the swapping sites vs. date.

d. Total DN daily demand vs. date

17. The following figure B.5 illustrates a significant metering error for a single feed Offtake.

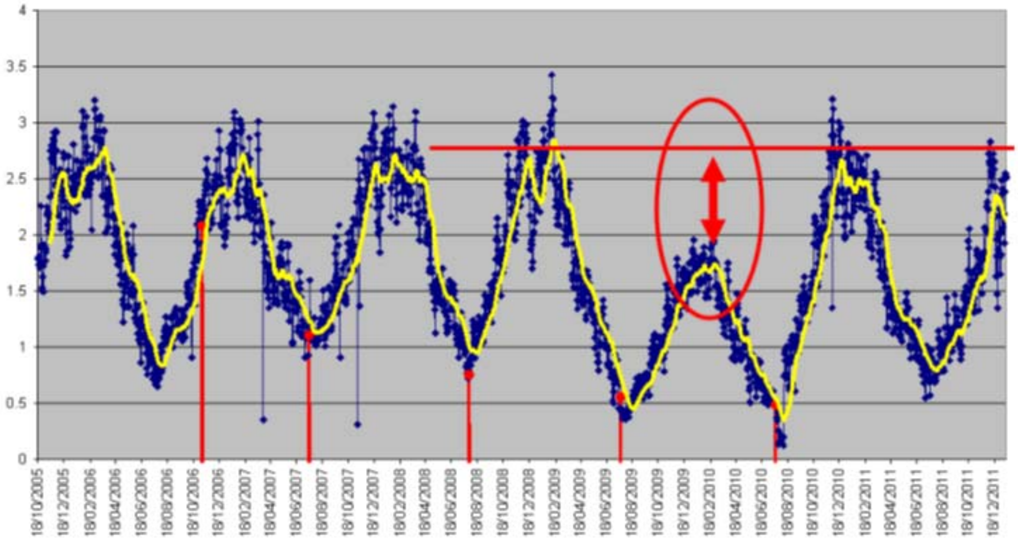

Figure B.5: example of patterns in Offtake demand flow

18. The following figure B.6 shows the same Offtake as in figure B.5 but plotted as a percentage of total DN flow. Again, in this example it is easy to see that there is an issue.

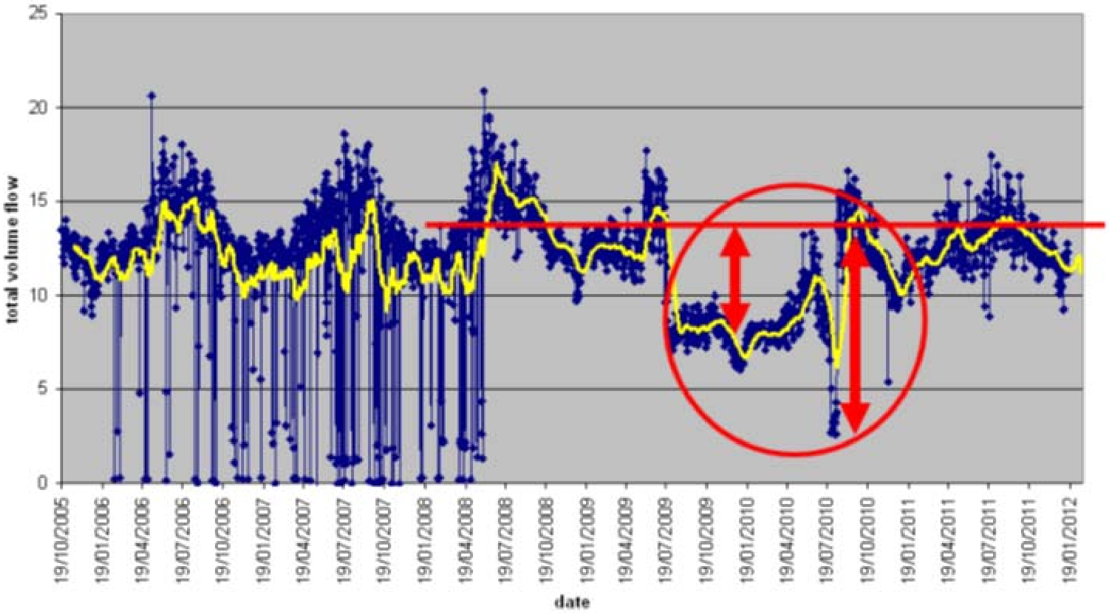

Figure B.6: example of Offtake flow expressed as percentage of DN flow

19. Finally this method can find unusual patterns of site operation or issues with data. In the following example it was initially believed that there was an

issue with the data but it transpired that the site had been operated very unusually due to maintenance work elsewhere on the network.

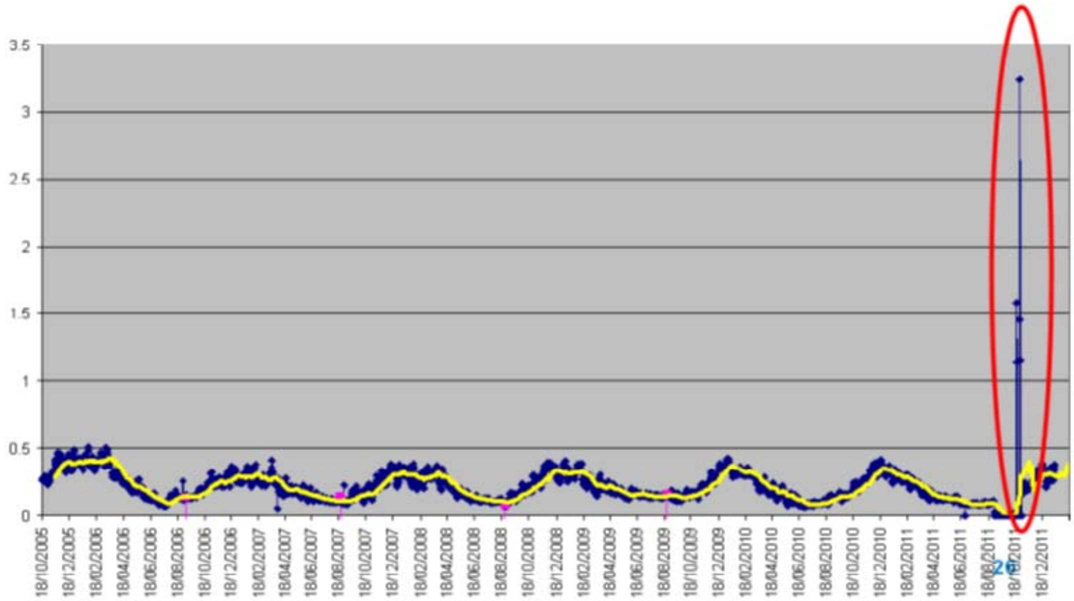

Figure B.7: example of unusual DN Offtake flow

B.4 Composite Weather Variable (CWV)

20. This technique creates a model which predicts flow through a meter or set of meters based on weather data then compares the difference between forecast and actual flows. This sort of model is applicable to Local Distribution Zones (LDZ) or sub-LDZ networks where demand is primarily temperature sensitive. For the purposes of this model, composite weather variable (CWV) has been used along with a simple linear regression model to predict demand.

21. There is a requirement to identify Offtakes or groups of Offtakes which form a demand grouping as otherwise flow through the meters may be influenced by flow switching behaviour rather than underlying demand.

22. This technique has been tested on the Aberdeen flows over the period of its significant meter error and has been found to detect its start.

23. Figure B.8 illustrates an Offtake. It can be seen that CWV is typically the mirror image of demand and when this relationship alters, an investigation would be conducted.

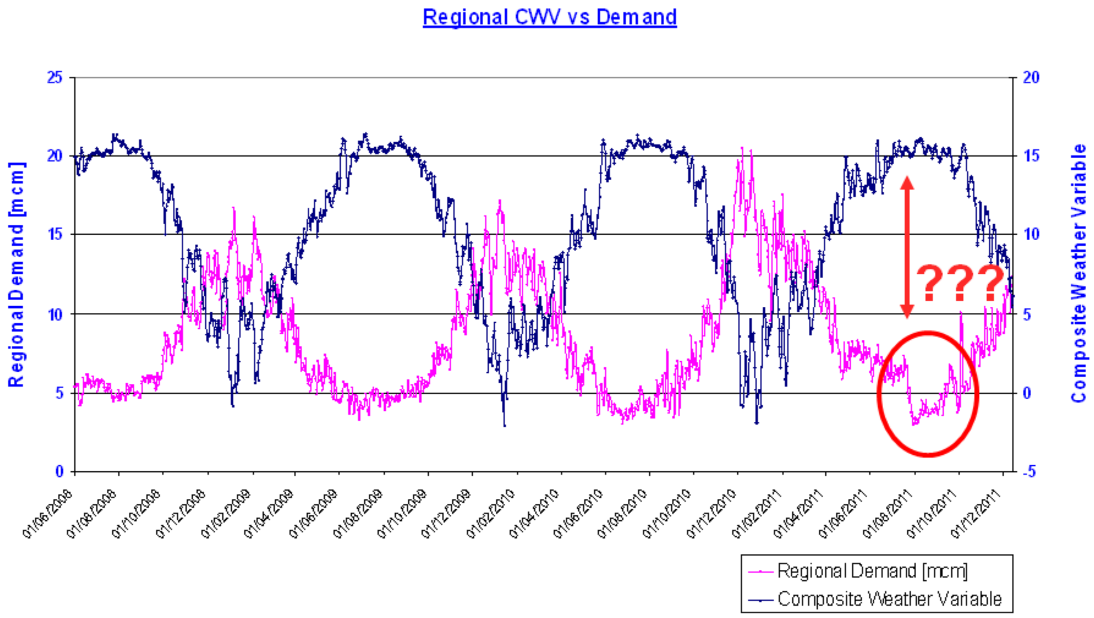

Figure B.8: example of CWV method

24. Future refinement work will include optimising the difference between forecast and actual flows before there is deemed to be a potential issue.

B.5 Data Mining Techniques

25. We are investigating the use of data mining techniques to identify potential sources of UAG. The UAG calculation uses all the metered input and outputs to the NTS such that there are over 300 meters that contribute to the UAG calculation. The aim of data mining techniques is to identify correlations between trends in UAG and the metered gas flows.

26. To implement data mining techniques, we have used IBM's SPSS[3] Modeller software package. The analysis has been developed with the aid of consultancy provided by Newcastle University's ISRU. The work has resulted in the decision to focus on the use of two advanced statistical techniques; Classification & Regression Trees (C&RT) and the Chi-squared Automatic Interaction Detection (CHAID) for the purposes of identifying possible contributors to UAG.

27. Further refinements of the data mining activities have been completed to allow a greater volume of data to be analysed as quickly as possible. The model will be piloted for a period of time before any further improvements are trialled.

[3] http://www-01.ibm.com/software/analytics/spss/