Unaccounted for Gas (UAG) Report

National Grid
Gas Transmission

April 2015

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.

If you have any feedback or questions on this document please get in contact with us at:

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Background

This report provides a review of National Grid's Unaccounted for Gas (UAG) management covering the period up to and including the 1st of October 2014 to the 31st March 2015.

To compliment this report, National Grid also provides a range of UAG related data including:

- All the previous UAG reports
- Daily UAG data

which are available at:

http://www2.nationalgrid.com/uk/industry-information/gas-transmission-system-operations/balancing/unaccounted-for-gas

This report discharges National Grid Gas's (NGG's) responsibilities under Gas Transporter Licence 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

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Executive Summary

The underlying UAG trend has seen a gradual decline over the last six months, although this reduction in the UAG daily run rate was particularly significant in January and February 2015 which has continued into March 2015. The cause of this reduced run rate is being examined and it is too early to draw any conclusions, as there are no significant indications being highlighted from the current suite of UAG tool analyses already performed.

To further enhance UAG management, a set of initiatives have been specifically developed to assist meter validation and on going UAG analysis. The main thrust of these initiatives is the development of a fully featured ‘free to use’ meter validation software application that will enable asset owners across the NTS to easily provide detailed meter validation data with associated analysis.

To complement our innovative initiatives, the existing PSET and CWV analysis tools are being further refined to improve functionality and detection capability.

UAG management is multi-faceted and relies on the widespread expertise of technicians, engineers and managers across the asset owner community. The recent reductions in UAG bear testament to the continued high levels of commitment by all concerned within gas transmission measurement.

National Transmission Unaccounted for Gas Trends

1.1 Annual NTS Shrinkage

The annual NTS shrinkage trend since 2007 is presented in Figure 1.

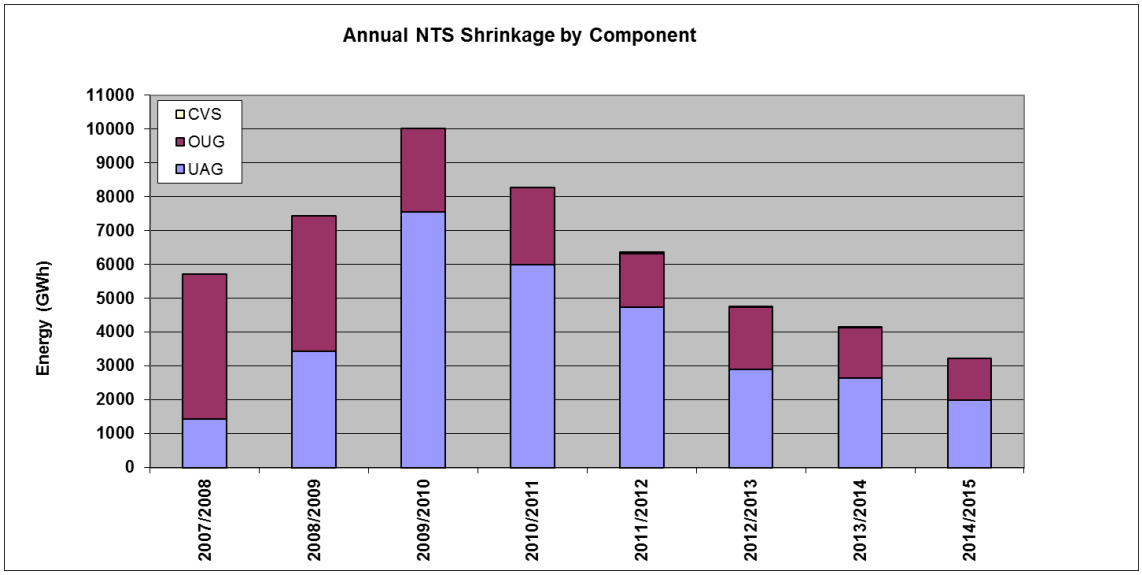

Figure 1: Annual NTS Shrinkage by component since 2007.

The component breakdown of the annual shrinkage[1] trend presented in Figure 1 is summarised as:

- The reduction in Own Use Gas (OUG) over the period has been due to a combination of changes in underlying supply patterns and the increased efficiency in compressor operation.
- Low levels of CV Shrinkage (CVS) with annual levels less than 50 GWh have been a feature of NTS Shrinkage throughout this period. However the recent introduction of numerous bio-methane sites embedded within the gas distribution zones has resulted in a slight increase in total NTS CVS volumes[2] as the commissioning and operation of these sites is refined.
- Unaccounted for Gas (UAG) levels continue to show year on year reductions from the 2009/10 peak, which was heavily influenced by the subsequent discovery of two large meter errors.

[1] Definitions of the components of NTS Shrinkage are to be found at: Unaccounted for Gas | National Grid
[2] The treatment of bio-methane sites with respect to the NTS Flow Weight Average CV (FWACV) process is the subject of an ENA consultation document. For further details see: ENA CV Direction Options Initiative (www.ena.org.gov)

UAG volumes since 2012 are largely considered to be more representative of typical NTS behaviour, although even this period has been characterised by gradual reductions in the annual totals as enhanced UAG management and initiatives begin to have an effect. Despite these reductions, UAG has still been the major NTS Shrinkage component since 2009.

1.2 Unaccounted for Gas

UAG has always been closely associated with data and meter error. The spike in annual volumes observed in 2009/11 for example, were heavily influenced by the discovery of two significant[3] meter errors. While the subsequent reconciliation of these meter errors reduced the net UAG positions for the 2009/2012 period (see Section 1.3.3), it is the post 2012 UAG behaviour that is considered the most indicative of the current status of UAG management. This is due to the reduction in the number of reported long duration meter errors as a consequence of improved data handling and meter asset management across the gas community skewing the observed trends. This view is further supported by the fact that all asset owners have completed a minimum of three annual meter validations in this period. Another contributory factor is considered to be the gradual roll out of a number of meter asset upgrade programmes across some sectors of the distribution and transmission network. These programmes further reduce meter measurement uncertainty.

A general set of UAG statistics since 2011 is presented in Table 1. The Table highlights the reduction in the annual UAG volumes although they conform to a normal (Gaussian) distribution as indicated by the constancy of the standard deviations (spread) and skew of the data across the period. The skew[X] parameter has been presented to determine the nature of the UAG data distribution and this parameter transitioned from a positive (positive UAG tail distribution) skew in 2011 and 2012 to a negative (negative UAG tail distribution) skew to date. The magnitude of the skew in all instances was within the expected range for the data to be considered normally distributed[4].

[3] Significant meter error is defined as a total reconcilable measurement error of greater than 50GWh.
[4] D.P. Doane., L.E. Seward. Applied Statistics in Business and Economics, 3e. Page 155. (McGraw-Hill) 2011.

The UAG trend throughout the majority of 2014/15 was very similar to that of the 2013/14 although November and December 2014 were characterised by a gradual diminution of the daily UAG averages. In January and February 2015 the daily UAG averages continued to decrease further culminating in daily averages significantly below 4GWh. To emphasise this point the combined January and February 2015 statistics are presented separately in Table 1.

UAG Statistics	2011/2012	2012/2013	2013/2014	2014/15*	Jan to Feb 2015 inc.
Assessed Annual Level (GWh)	4737	2894	2648	2030	185
Daily Average (GWh)	12.941	7.929	7.254	6.078	3.134
2σ (Std. Deviation) (GWh)	22.116	19.308	21.516	20.02	19.28
Skew[X]	0.275	0.125	-0.135	-0.140	-0.102
Percentage of NTS Throughput	0.45	0.29	0.29	0.25	0.09

* Data to end of February 2015 inclusive

Table 1: The statistical performance of UAG since 2011.

The monthly UAG totals since April 2013 are presented in Figure 2, indicating a relatively consistent monthly UAG behaviour up to October 2014. Between April 2013 and October 2014 inclusive, twelve (12) months had monthly totals in excess of 200 GWh whereas no month has exceeded this level since. January and February 2015 recorded the lowest cumulative totals respectively since August 2013.

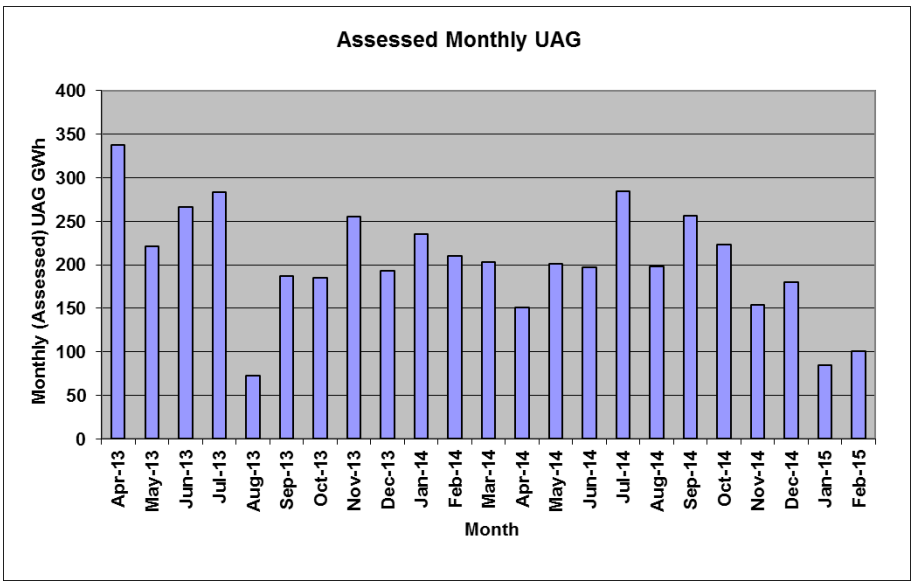

Figure 2: Monthly UAG since April 2013.

The latest January and February 2015 UAG trend still exhibits a similar standard deviation to that of previous periods but the data is more normally distributed (Table 1). While these statistics can explain the reduced daily averages, as the ratio of positive and negative daily UAG values approach unity, further analysis is required to understand the causal effects of this latest behaviour. Only now is there sufficient UAG data available, that it is possible to realistically analyse the current trend as it is now considered free from a short-term bias.

To assist the focus of UAG management, techniques to provide a more dynamic view of UAG behaviour are continuously being developed and reviewed. The inherent volatility of day on day UAG makes any statistical metrics very problematic although the skew parameter presented in Table 1 does provide some indication of data distribution about a mean. While the use of a skew metric is statistically valid, it requires sufficient data to make it representative. It is an understanding of the composition of the UAG trend profile that is considered a more useful barometer of underlying trends. A favoured approach is to define the UAG behaviour in terms of a ‘magnitude by order’ approach.

This technique orders daily UAG for each month solely in terms of magnitude. The resulting chart for the period September 2014 to February 2015 inclusive is presented in Figure 3.

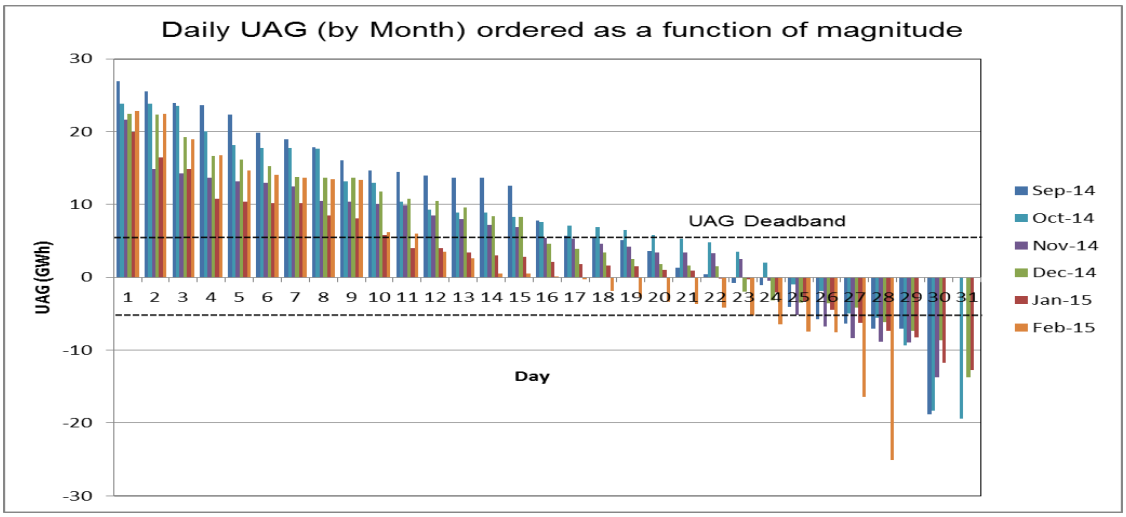

Figure 3: Daily UAG sorted by magnitude per month

The magnitude analysis confirms the change in UAG trends since December 2014 with a reduction in the number of daily values exceeding 5GWh and a corresponding increase of daily UAG values within the previously mentioned +/- 5GWh Dead band. The number of days falling below the lower tolerance of the Dead band was largely invariant throughout this period. The data is summarised in Table 2.

Days	Sept 14	Oct 14	Nov 14	Dec 14	Jan 15	Feb 15
>5 GWh	19	21	17	15	10	11
Within +/- 5GWh Dead band	6	6	7	12	16	11
< -5 GWh	5	4	6	4	5	6
UAG Stability Metric	0.2	0.2	0.23	0.39	0.48	0.38

Table 2: Summary of the Dead Band UAG Analysis.

The definition of the +/- 5GWh Dead band is purely arbitrary and a more robust determination of these limits will be the main theme of a proposed future independent Baseline study (See Section 1.3.4.2) to be undertaken. Irrespective of the Dead band limits, this approach does enable a UAG stability metric to be defined as the ratio of the days within the Dead Band to the days in the month.

Further discussion of the analysis techniques and methods currently being utilised in an attempt to quantify the latest trends is presented in Section 1.3.2. However, since UAG is strongly influenced by measurement, the recent UAG trends are recognition of the considerable efforts of all asset owners, in conjunction with National Grid, to continue to develop and maintain high levels of meter asset management.

Other contributory factors are also considered to be:

- The implementation of meter upgrade programmes by some of the distribution networks and the UK transmission operator.
- Improved data handling between sites and billing systems reducing billing uncertainty and improving within D+5 close out data quality.
- Reduction in outstanding meter errors, and the efficient treatment of issues requiring reconciliation, providing 'clean' UAG trends for subsequent analysis.

National Grid's close and transparent relationships with all meter asset owners and validation agencies offers a platform to develop further community wide activities. These initiatives and a general review of National Grid's UAG management activities are presented in the following sections.

1.3 UAG Management Activities

National Grid undertakes a holistic UAG management programme. This programme falls into four main categories:

1. Meter Witnessing
2. Data Analysis
3. Meter Reconciliation
4. Future Initiatives

Each topic is treated separately in the following sections.

1.3.1 Meter Witnessing

National Grid undertakes an annual meter validation witnessing campaign. This activity plays an important part of the continuing engagement between National Grid and the meter asset owners across the NTS network and in the general management of UAG.

The range and number of sites witnessed since 2009 is presented in Table 3.

Year/Site Type	DNO Offtakes	VLDMC	Terminal/ Storage/Interconnectors	Total
2009/2010	25	8	11	44
2010/2011	17	8	7	32
2011/2012	16	6	9	31
2012/2013	16	13	5	34
2013/2014	10	14	5	29
2014/2015	12	6	8	26

Table 3: National Grid's Meter witnessing record.

For 2014/15 the witnessing campaign has been aligned to the financial (regulatory) year and its scope and current status is presented in more detail in Table 4.

Site Type	Planned	Completed	Scheduled
Terminals	6	3	3
Storage	2	2	0
Interconnectors	3	2	M
VLDMC			
Third Party	6	5	1
NGGT	5	2	2A+M
DNO			
NGGD	6	5	A
WWU	3	2	A
SGN	3	2	M
NGN	4	3	M
Total	**38**	**26**	**4**

Table 4: Summary of National Grid's 2014/15 Meter Witnessing Campaign.

Key:

A: - One of the selected sites was being independently audited and thus not witnessed in the 2014 campaign at the request of the DN. In all cases an alternative site was offered.

M: - It was not possible to witness the selected sites due to scheduling (SGN, NGN) or technical difficulties (NGGT).

The 2014/15 witnessing campaign completed 26 out of 38 planned visits. Where it was not possible to undertake a scheduled witness, asset owners have been very proactive in either providing an alternative site or have offered the site for the 2015/16 campaign.

The National Grid meter witnessing campaign is carefully orchestrated to maximise the potential of this activity with site selection being set by the following metrics:

- Meter Error history
- Validation record
- Witness history
- Potential UAG impact.

Although, it is not feasible or efficient to witness every site's validation, National Grid reviews all ME2 validation documentation. Again the standard of validation information and test results was high and there were very few instances where additional information was required.

The level of observed validations was, without exception, very high with the technical metering expertise in evidence being of the highest quality. There were no issues with any of the validations witnessed, other than those expected as part of normal maintenance activities.

The witnessing activity was greatly assisted by the proactive response from all asset owners and the strength of these relationships is highly valued.

Despite the high technical quality displayed during the validation process, there are still ambiguities and interpretations with the ME2[5] procedure. While there is no suggestion that validation practices are being subjugated, it has become apparent during National Grid's regular liaison activities with asset owners, that there is an appetite to undertake a formal review of the ME2 procedure. While it is considered that the current ME2 process is still appropriate, in some variants it does not accommodate the latest advances in meter or gas analysis technology and it can be considered slightly restrictive and open to interpretation.

[5] ME2 is the National Grid specification for fiscal meter validation. It is defined in National Grid Management Procedure T/PM/ME2 and in the IGEM publication IGE-GM-4 Ed.2 (see Appendix 5)

This could be considered as a future initiative and the terms of reference of this review are still to be defined. However, it would aim to produce a set of clearly defined validation parameters that will in combination provide a more comprehensive set of meter performance metrics. This overarching framework will place the onus on the individual asset owner to demonstrate compliance with the ME2 framework while allowing them to incorporate their own respective methodologies and procedures. This will allow validation flexibility within the guidelines whilst also enabling all asset owners to incorporate the latest advances in metering equipment.

The need for the review and the organisation for it are to be determined. It has been proposed that NGG Transmission facilitate this, however against the current change programme the dates are likely to be within the next review period and will need to be agreed with all interested parties.

Despite the undoubted quality of the meter validations that take place across the NTS, there is no provision of ME2 data in a consistent format. This makes subsequent reviewing and analysis time consuming and inflexible. To improve validation data provision, National Grid is developing, via funding through the Network Innovation Allowance (NIA), a fully featured meter validation tablet and laptop Application (App). There has been favourable community interest in this project which is now in the early stages of development. The current status of this programme is discussed in more detail in the Future Initiatives Section 1.3.4.1.

1.3.2 UAG Data Analysis

National Grid continues to analyse UAG employing the Power Station Efficiency Tool (PSET) and Composite Weather Variable (CWV) techniques. While these techniques cover a wide range of site types, accounting for 90% of the demand side of the NTS energy balance, they can only provide a daily site by site comparison. With the recent UAG daily averages around 3GWh, corresponding to approximately 0.1% of throughput, the current suite of techniques is not reliably highlighting any issues requiring further investigation.
This is not considered a failing of the analysis techniques themselves, but more indicative that the current UAG trend is free from significant meter(s) bias(es).

It has always been recognised that holistic tools will be at the limit of their detection capability in circumstances of low and relatively stable UAG conditions.

Nevertheless, it is considered that the PSET, with further refinement, still offers insight into site behaviour. The PSET analyses the relationship between gas usage and the electricity output for the majority of the direct connection NTS power stations, where this approach is valid (i.e. no secondary fuel supply or significant steam load bleed), analysis of the near linearity of this input output ratio has considerable potential. Figure 4 below shows this relationship during the January 2015 period for all the major power station sites.

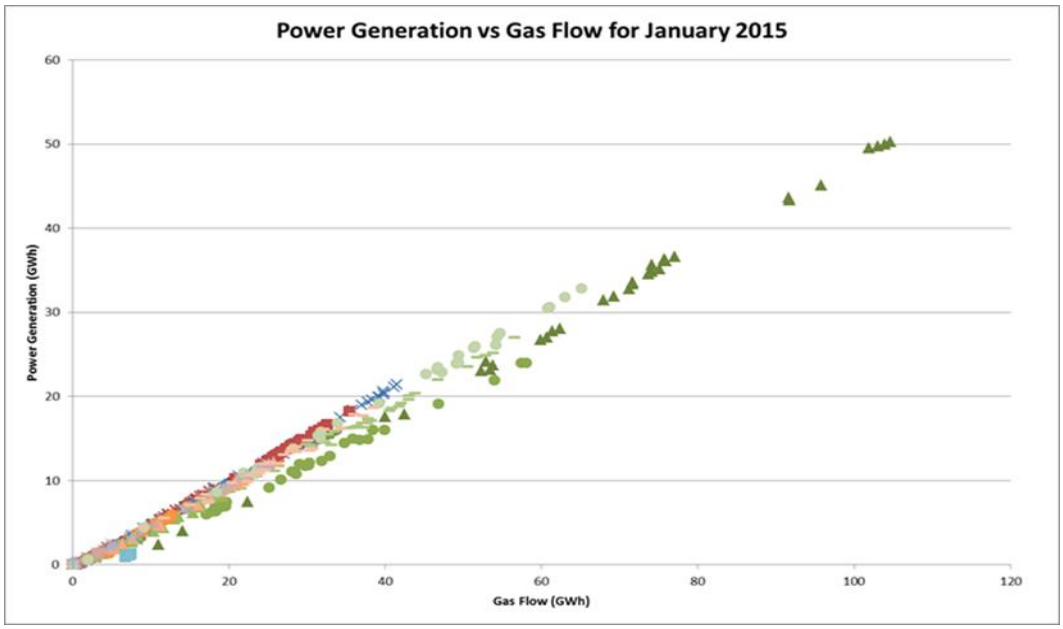

Figure 4: Gas usage against electrical output relationship for the major power stations. (Date period: - January 2015)

This tool is an indicative tool and thus deviations from the expected normal linearity allows for user defined tolerances to be added and automated within the model.

With the current average UAG levels being comparatively low and relatively stable, the PSET technique has been further refined to show more accurate efficiency tolerances for the various power stations.

The original data cone analysis as shown in Figure 5 shows the upper and lower efficiency tolerances (solid blue and red lines respectively) for a typical power station.

By examining a historical regression line of best fit, the set upper and lower tolerances can now be narrowed to reflect its true efficiency performance, as shown in Figure 5 by the dotted blue and red lines respectively. Hence any points outside this new tolerance band would be a genuine cause to investigate further.

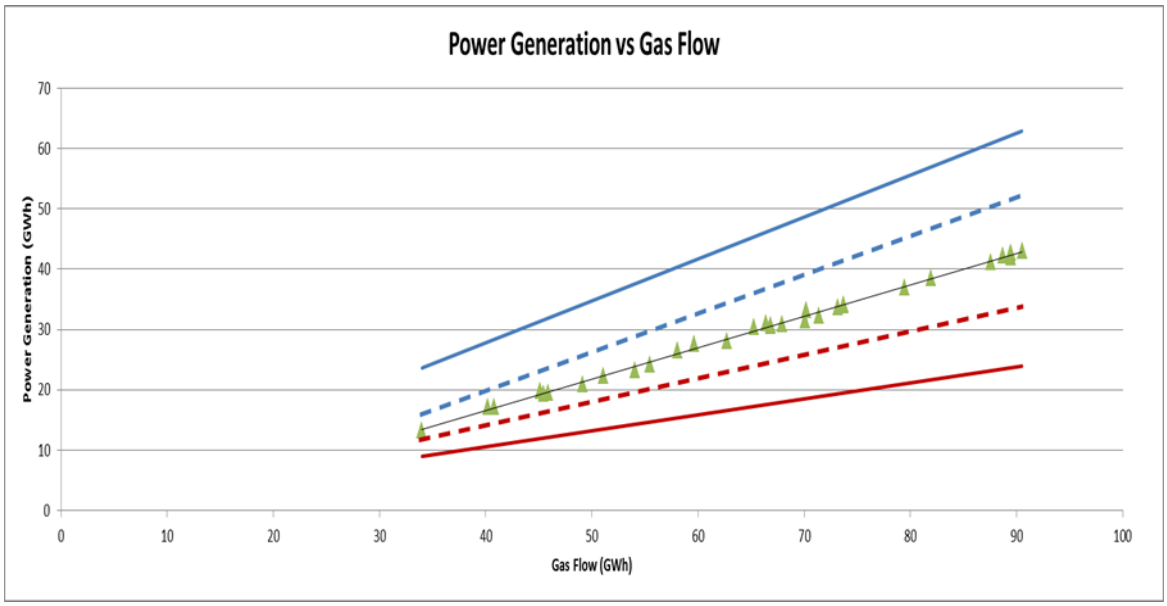

Figure 5: PSET analysis refinement showing new tramline analysis technique.

The Composite Weather Variable (CWV) tool compares the actual measured CWV for each local distribution zone (LDZ) with the daily gas flow for each offtake within that LDZ.

In general, the demand for each LDZ is inversely proportional to the CWV. Using this relationship, gas days for each LDZ are flagged for potential problems, as well as individual offtakes if the data points fall outside of a specified number of standard deviations from the average.

Like the PSET, the CWV tool is currently undergoing an upgrade process in order to implement further improvements such as graphical interpretations of results and enhanced implementation of 'flow-switching' sites within each LDZ. The refined PSET and CWV tools will still highlight potential issues under the conditions of measurement biases. However the need to development new techniques to assess UAG at potentially greater definition is already being defined and will form part of the Baseline analysis discussed in Section 1.3.4.2.

1.3.3 Meter Reconciliation

National Grid is obligated to process all NTS related meter error reconciliations for the community to ensure financial equality between the Shrinkage Provider (NGGT) and the shipping community. While a defined net UAG position will be subject to meter error detection and reconciliation within the rolling 3 to 4 year window, it does provide a further key indicator as to the underlying base UAG levels. Although the reconciliation process is a solely financial readjustment, it is still possible to present a consequential net annual UAG energy figure. These are presented for the financial years since 2009 in Table 5.

Care must be taken in using the absolute number of meter reconciliations reported each year as a true UAG indicator because a single error can be of significant magnitude. National Grid is committed to processing meter error reports (MERs) as efficiently and expediently as possible. The current MER status is such that there are **no** outstanding meter errors requiring reconciliation.

Year	Annual No of Reported Meter Errors	Assessed UAG (GWh)	Net Energy Reconciled (GWh)	Net UAG (GWh)
2009/2010	81	7551	-3178	4373
2010/2011	48	5996	-1259	4737
2011/2012	52	4737	52	4789
2012/2013	52	2894	-151	2743
2013/2014	33	2648	19	2667
2014/2015	49	2030	25	2055

Table 5: Meter Reconciliation Statistics inclusive of UAG Net of Meter Error.

1.3.4 Future Initiatives

While the existing UAG tools are beginning to highlight areas for further analysis, there are still other areas of UAG management that will provide an alternative. This will not only provide unequivocal evidence of meter management performance but also provide indicators for potential areas for future investment. The set of current proposals and their respective status is presented below:

1.3.4.1 Meter Validation App

- National Grid development of the Meter Validation and Analysis App that will be available for a range of mobile platforms (iOS®, Android and Windows®). The Validation App will be freely available to all NTS connected parties, thus facilitating the collection of appropriate meter validation data in accordance with the current ME2 standard.

  The validation software will simultaneously perform the necessary gas property calculations (ISO 6976, GS(M)R parameters, AGA8, AGA10) and flow equations (ISO 5167, ISO 9951) as necessary during the data collection. The application will also provide a detailed review of the meter performance in terms of the individual validation test tolerances. Upon completion of the validation, the data will be automatically uploaded to a dedicated secure Cloud server. The App will provide a completely contained validation data collection platform enabling efficient offline data analysis for National Grid (whole data set) and for each registered asset owner (their own data set).

  It is also proposed that a gas property and flow calculator based on the ISO 6976, AGA8, AGA10 (gas properties), ISO 5167-1991, 2003 (flow) standards will be offered as a standalone package for both tablet formats as well as an Microsoft® excel add-in. This again will be made freely available to any interested party.

Status:

The funding for Meter Validation App was secured in November 2014 and the programme commenced in January 2015. The current progress can be summarised as:

- A set of engagement sessions between the software developers and representative validation engineers has been completed.
- A set of meter witnessing visits is being undertaken with the software development team.
- Initial wireframes of the user interface (UI) of the validation package have been developed.
- The gas property calculations are being evaluated in an MS Excel® add-in form before being integrated into the Meter Validation App. The gas property calculator will also be available as a standalone App.
- A comprehensive engagement programme with all stakeholders is continuously being undertaken and the current feedback is positive.

During the initial engagement sessions, it became apparent that other features of the App were still desirable as it allowed validation engineers to maintain continuity with their existing set of specialist software necessary for some of their processes. These requirements are currently being scoped and the necessary funding will be sought to make this a feature of the first release of the package which is anticipated to be in the autumn of 2015.

1.3.4.2 Baseline UAG Analysis

- It is proposed to develop an independent assessment of the Baseline level of UAG that could be expected from the network operating under normal measurement uncertainties. This independent study will enable National Grid to quantify UAG in terms of this baseline that will assist in the future management of UAG. The determination of a baseline will also enable a better definition of the Dead band presented in Figure 3 potentially providing a UAG management tolerance that will allow the suitable deployment of appropriate UAG analysis techniques.

This Baseline analysis will be combined with the development of other mathematical techniques outside the statistical approaches already employed, such as matrix and dynamical mathematical techniques.

Status:

The scope of the proposed programme has been defined and will commence in 2016 but an initial invitation to tender will be available to any interested party in October 2015 for the start of the academic year. It is hoped that the latest transients in UAG behaviour will add considerably to the understanding of UAG behaviour this programme can elicit from the data.

2. Summary

The underlying UAG trend has seen a gradual decline over the last six months, although there was a significant reduction of the UAG daily run rate in January and February 2015 that has continued into March 2015. The cause of this reduced run rate is being examined and it is too early to draw any conclusions, as there are no significant indications from the current UAG tool analyses as they are considered to be at the limits of their respective detection capability.

To help in the general UAG management, a set of initiatives has been specifically developed to assist meter validation and UAG analysis. The Meter Validation and Analysis App has been sanctioned through the Network Innovation Allowance (NIA) and is well advanced with the gas property and gas flow calculation engine already at a beta testing stage. This unique offering will enable asset owners across the NTS to easily provide consistent ME2 meter validation data with associated analysis. This will not only provide unequivocal evidence of meter management performance but also provide indicators for potential areas for future investment. The App offers a future proof offering as software updates will be readily available from a controlled online repository.

The healthy relationship between National Grid and the meter asset owners will enable a distribution network request to review the ME2 procedure to be undertaken in a positive climate of cooperation.
The development of ME2 offers all asset owners the opportunity to refine meter validation activities and National Grid is suitably positioned to facilitate such an undertaking. This review has enormous potential to harness the widespread technical metering expertise across the community to develop a robust, flexible and enduring validation regime.

National Grid continues to broaden its engagement with all asset owners and will further enhance this activity by providing more opportunities and would always welcome any feedback[6] related to UAG management.

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