Unaccounted for Gas (UAG) Report

National Grid
Gas Transmission

October 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 National Grid Gas Plc (NTS) Gas Transporter Licence 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 April 2015 to the 30th September 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 the 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

Contents

Contents **1**

Executive Summary **2**

1. National Transmission Unaccounted for Gas Trends **3**

1.1 Annual NTS Shrinkage **3**

1.2 Unaccounted for Gas **4**

1.2.1 Recent UAG Trend Analysis 5

1.2.2 Recent UAG Activities 8

1.3 UAG Management Activities **10**

1.3.1 Meter Witnessing 10

1.3.2 Meter Reconciliation 12

1.3.3 Future Initiatives 14

1.3.3.1 Meter Validation App - NGage 14

1.3.3.2 Baseline UAG Analysis 16

2. Summary **17**

Executive Summary

While the underlying UAG trend has seen a gradual decline over the last six months, July and August 2015 exhibited marked increases in UAG volumes. Despite the recent UAG behaviour and the early indications that UAG daily volumes are returning to pre July rates, overall UAG volumes continue to decline on an aggregated basis.

The cause of the recent increases in daily UAG are still being investigated but anomalous UAG behaviour highlights the need for a more formal structure as to how National Grid engages appropriately with all asset owners in these instances. It is proposed that National Grid will engage with all key stakeholders to formulate a framework that is compatible with the need to obtain timely information without undue overhead.

To further enhance UAG management, National Grid continues to undertake Network Innovation Allowance[10] (NIA) funded initiatives to assist meter validation and on going UAG analysis. The main thrust of these initiatives is the development of the fully featured, ‘free to all’, NGage meter validation tablet application that will enable asset owners across the NTS to easily provide detailed meter validation data with associated analysis. Further work with Manchester University is exploring new mathematical techniques that will help to provide further insight into UAG behaviour.

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

1. National Transmission Unaccounted for Gas Trends

1.1 Annual NTS Shrinkage

The annual NTS shrinkage trend since 2008 is presented in Figure 1.

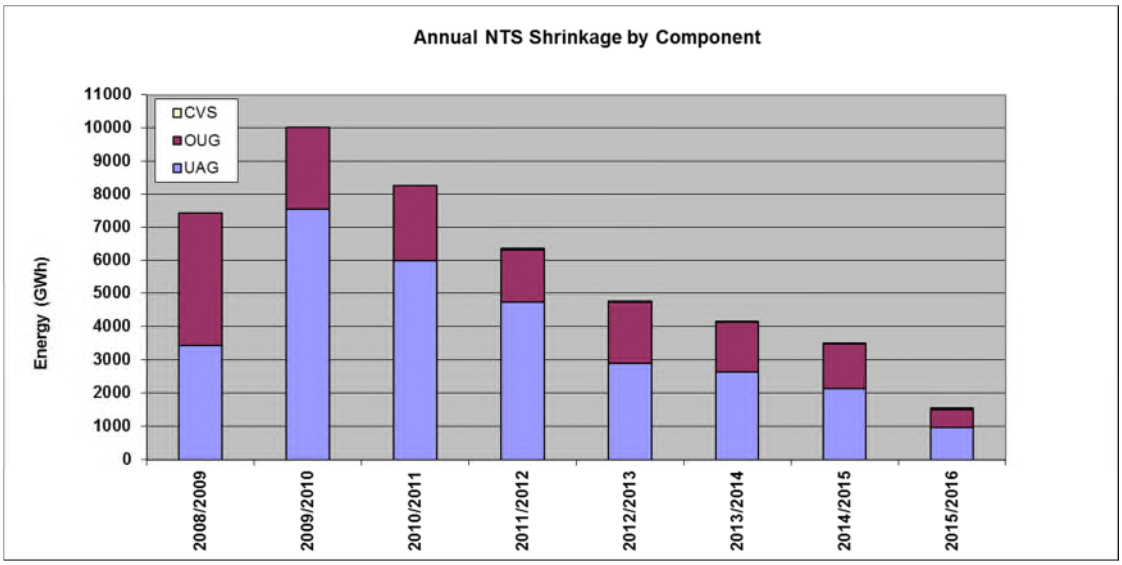

Figure 1: Annual NTS Shrinkage by component since 2008.

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 meter errors of significant magnitude.

[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 which has now been submitted to Ofgem for a decision.

Reducing UAG volumes since 2012 are largely considered to be more representative of typical NTS behaviour. Despite these reductions, UAG has consistently contributed over 50% of the total NTS Shrinkage budget since 2012 and National Grid continues to develop initiatives and activities (see Section 1.3.3) to further the understanding the behaviour of this volatile shrinkage component. These initiatives and activities will be discussed in further detail in the following sections of this report.

1.2 Unaccounted for Gas

As has been repeatedly reported, 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, it is the post 2012 UAG behaviour that is considered the most indicative of the impact of the wide ranging UAG management techniques being currently employed by all stakeholders.

A general set of UAG statistics since 2011 is presented in Table 1. The Table highlights the reduction in the annual UAG volumes, which is continuing into 2015/16. While the data conforms to a normal (Gaussian) distribution as indicated by the constancy of the standard deviations (spread) of the data across the period, the recent UAG behaviour in August 2015 is at significant variance to UAG trends in the previous months (see Figure 2). UAG in August 2015 contributed 46% of the year to date total volumes (energy) and while the daily average in September 2015 has reduced slightly, significant analysis is being undertaken to understand these current trends and the initial status of this analysis is presented in Section 1.2.1.

[3] Significant meter error is defined as a total reconcilable measurement error of greater than 50GWh.

UAG Statistics	2011/2012	2012/2013	2013/2014	2014/15	2015/16*
Assessed Annual Level (GWh)	4737	2894	2648	2121	957
Daily Average (GWh)	12.941	7.929	7.254	6.078	6.258
2σ (Std. Deviation) (GWh)	22.116	19.308	21.516	20.02	23.97
Percentage of NTS Throughput	0.45	0.29	0.29	0.25	0.29

* Data to end of August 2015 inclusive

Table 1: The statistical performance of UAG since 2011.

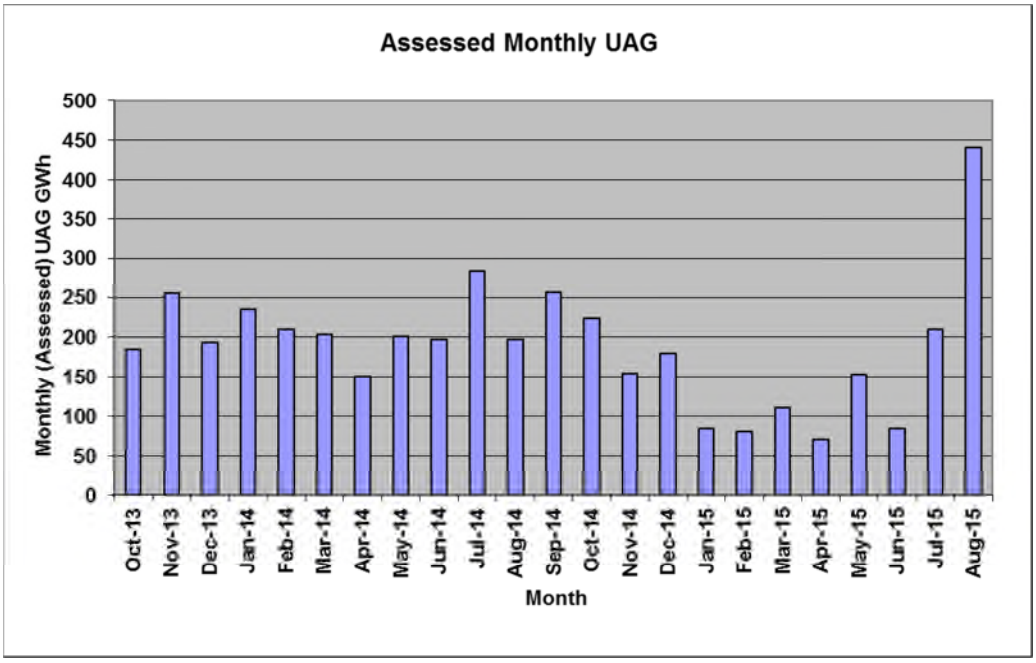

Figure 2: Monthly UAG since October 2013.

1.2.1 Recent UAG Trend Analysis

The latest UAG trend since March 2015 has been characterised by a series of consistently modest monthly volumes though to July 2015. Thereafter the daily averages began to increase culminating with the August monthly volumes being the highest single month since May 2011. Significant effort is now being expended within National Grid in an attempt to understand and interpret the July

and August 2015 UAG trend. The behavioural shift of UAG in these latter months is statistically presented in Table 2 below.

UAG Statistics	2015/16*	2015/16 April to June inc.	2015/16 July – August inc.	2015/16 September**
Assessed UAG level in period (GWh)	957	308	649	201
Daily Average (GWh)	5.803	3.390	10.465	8.392
2σ (Std. Deviation) (GWh)	23.97	22.37	23.56	24.38
Percentage of NTS Throughput	0.29	0.15	0.51	0.40

* Data to end of August 2015 inclusive

** Data to 24th of September 2015 inclusive

Table 2: The statistical performance of UAG for 2015/16 to date.

In general terms the increase in UAG in July and August 2015 was not accompanied by an increase in volatility as confirmed by the reasonably consistent standard deviations during the period. Hence the increase in daily UAG averages point to the existence of a relatively consistent positive bias overlaying the underlying behaviour. This is very possibly due to an individual or multiple data/meter error(s) of similar daily (total) magnitude. The September 2015 figures are presented for comparison and appear to indicate that the UAG behaviour is beginning to returning to the pre July/August 2015 levels. While this is not absolutely conclusive evidence, it does provide some indication that the July/August and early September 2015 behaviour can be regarded as a distinct and unique period which will assist further analysis.

To confirm this hypothesis, the quondam 'magnitude by order' bar chart presented in the previous report[4], when updated to a line chart (see Figure 3) provides a clearer indication of the UAG behaviour in July/August 2015. Since, as the overall magnitude of the daily UAG volumes increased on a day by day

[4] Unaccounted for Gas (UAG) Report April 2015. To be found at www2.nationalgrid.com/uk/industry-information/gas-transmission-system-operations/balancing/unaccounted-for-gas

basis, as evidenced by the gradual separation of the July (blue) and August (orange) trends, the overall shape of the respective curves for each month remained largely similar[5].

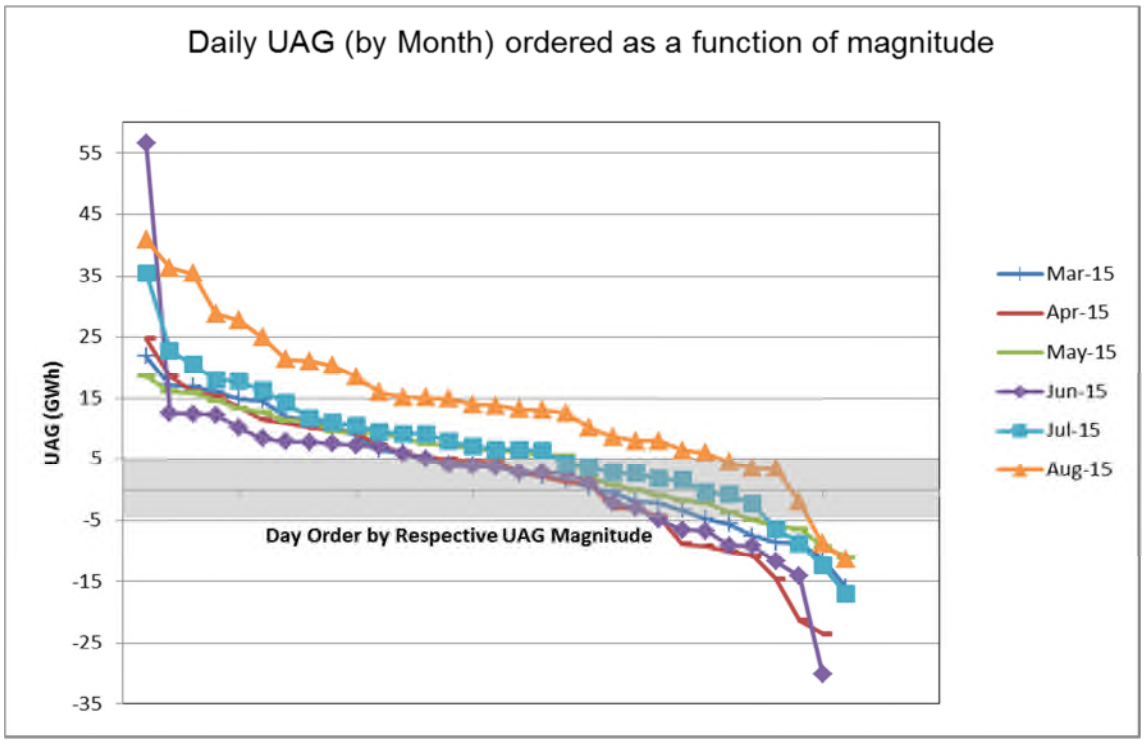

Figure 3: Daily UAG sorted by magnitude per month

Taking the data in Figure 3 and continuing to use the symmetrical +/- 5GWh Dead-band around the zero UAG baseline (presented as the grey shaded area in Table 3), continues to emphasise the consistency of the UAG behaviour between March and June 2015. July and May 2015 also exhibit consistent UAG Stability Metrics[6] although these were the second and third highest totalling months in the period. This further highlights the continued need to use a range of techniques to analyse underlying UAG trends.

The definition of the +/- 5GWh Dead-band (shown in Figure 3) is arbitrary and a more robust determination of these tolerances will be one of the main themes of the independent Baseline study being undertaken at Manchester University

[5] The large positive and negative days in June 2015 (purple) were the consequence of a linepack anomaly on two consecutive days.
[6] The UAG Stability Metric is defined as the ratio of days within the Dead Band to days in the respective month.

(See Section 1.3.3.2). In the meantime, the current levels are considered appropriate in the absence of other information.

Days	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15
>5 GWh	12	14	19	13	18	25
Within +/- 5GWh Dead band	13	9	8	10	9	4
< -5 GWh	6	7	4	7	4	2
UAG Stability Metric[6]	0.42	0.29	0.26	0.32	0.29	0.13

Table 3: Summary of the UAG Dead-band Analysis.

1.2.2 Recent UAG Activities

National Grid has already conducted a series of in-house UAG analysis in an attempt to isolate any underlying causes to the current trends. The early results of this analysis are still being evaluated but the findings and resultant actions will be communicated in subsequent UAG reports.

As UAG is strongly influenced by measurement, the recent lowering of UAG volumes are a 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. These relationships enable close and trusted cooperation between all stakeholders.

For example, to support the current UAG analysis, National Grid has approached all distribution asset owners with the outcome of the initial UAG trend analysis to clarify some of the off-take flow patterns observed. All have responded with information and this is helping to define the next stages of investigation.

While the recent transients in the UAG behaviour can be attributed to system biases, it has highlighted the need to provide consistent, timely and focused communication with all asset owners. This is to ensure effective UAG analysis can be undertaken while ensuring an appropriate level of overhead for respective asset owners. Thus National Grid is proposing to introduce a two tiered information request framework for asset owners to assist with on-going UAG analysis. This information request (IR) framework is to provide clarity around near term UAG management and engage key stakeholders drawing on their respective and highly valued expertise. The proposed tier structure is:

TIER 1

Tier 1 data requests will initially be targeted directly to individual asset owners and by supported by in house analysis.

TIER 2

Tier 2 requests will be targeted at a wider asset owner base across the NTS. Again this request will be supported by the findings of the current in house analysis.

These proposals will be further developed and discussed with all stakeholders to ensure that the framework and frequency of IRs is consistent and appropriate. National Grid's close and transparent relationships with all meter asset owners and validation agencies offers the platform to develop this communication and information exchange capability. To date, previous ad-hoc nature of information requests to asset owners has always elicited a positive and timely response. However, there is a need to provide a more formal structure to the process to ensure that only reasonable demands are being placed on asset owners.

A general review of all 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 three main categories:

1. Meter Witnessing
2. Meter Reconciliation
3. 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 4.

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
2015/2016	4	3	4	11

Table 4: National Grid's Meter witnessing record.

For 2015/16 the witnessing campaign has been aligned to the financial (regulatory) year and its scope and current status is presented in more detail in Table 5.

Site Type	Planned	Completed
Terminals	5	1
Storage	4	3
Interconnectors	2	2
VLDMC		
Third Party	3	0
NGGT	3	2
DNO		
NGGD	3	1
WWU	2	0
SGN	3	2
NGN	2	0
Total	**27**	**11**

Table 5: Summary of National Grid's 2015/16 Meter Witnessing 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 meter validation documentation supplied by the respective asset owners. Again the standard of validation information and test results were

high and there were very few instances where additional information was required.

The level of observed validations has been, 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[7] 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.

It is proposed to revisit the scheduling of an industry wide 'ME2 Review' during the next series of liaison meetings with the distribution networks and other key stakeholders over the next few months. Consideration of timeframes necessitates this review as the advances in the collection of validation data with the advent of the National Grid 'NGage' tablet App (see Section 1.3.3.1) significantly opens up the debate about the complete efficacy of the current processes in all instances.

1.3.2 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

[7] 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)

(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 in Table 5 for the financial years since 2009.

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 only **two** on-going joint office notified meter errors still being reconciled. There are **no** MERs for sites (Unique Sites/ VLDMC[8]) which are outside the joint office notification process.

Year	Annual No of Reported Meter Errors	Assessed UAG (GWh)	Net Energy Reconciled (GWh)[9]	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	2121	25	2055
2015/2016	22	957	22	979

Table 6: Meter Reconciliation Statistics inclusive of UAG Net of Meter Error.

[8] Unique Site & VLDMC (Very Large Daily Metered Consumer) refer to directly connected sites to the National Transmission System (NTS) whose reconciliations are conducted by National Grid.
[9] Net Energy Reconciled represents the balance of gas costs to the community (negative) and from the community (positive).

1.3.3 Future Initiatives

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

1.3.3.1 Meter Validation App - NGage

NGage is the National Grid 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 in accordance with the respective internal standards (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).

A gas property and flow calculator, again in accordance with the international standards ISO 6976, AGA8, AGA10 (gas properties), ISO 5167-1991, 2003 (flow) standards, will be offered as a standalone package ($NGage^{Calc}$) 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 NIA[10] funding for NGage Validation App was secured in November 2014 and the programme commenced in January 2015. The key progress can be summarised as:

- The basic functional aspects of the table App for both iOS and Android platforms has been established.
- The calculation and data handling and core functionality have been developed.
- Additional user input features (keyboard) and functionality have been scoped and funding approved for their inclusion in the initial product release.
- Full Cloud Hosting features have been developed and the Administration Site is available in the test environment.
- The NGage[Calc] and gas property Excel add-in have been modified to incorporate the meter specific GS(M)R[11] parameters of Wobbe, Incomplete Combustion Factor (ICF) and Sooting Index (SI).

The NGage suite of products (see generic icon below) are scheduled to be released in the late autumn of 2015 and with a fully supported roll out in the following months.

Figure 4:- National Grid's NGage Brand Icon.

[10] NIA :- Network Innovation Allowance is the RIIO mechanism that allows National Grid (Gas & Electricity) to spend 0.7% of its turnover on Innovation. The Network Innovation Allowance encourages wide collaboration with all project learning being shared across the gas community.
[11] GS(M)R Gas Safety (Management) Regulations 1996.

1.3.3.2 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.

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

Status:

The iCASE[12] funding has been approved for this mathematical based study and will enable a full time PhD student to be employed to undertake the programme. Initial discussions with Manchester University have been conducted to outline the initial scope direction of the programme. The recent UAG trends provide ample opportunity for the methods to be reviewed and refined with topic data and this will assist the ongoing analysis of UAG over the past few months. The Manchester team will also be using a range of historical data, where discovered meter errors were subsequently found, to assess and calibrate the effectiveness of the techniques and approaches being developed.

The appointment of the student and the initial analysis will commence in January 2016 and the results will be articulated via the NIA portal[13] and subsequent UAG reports.

[12] Industrial Cooperative Awards in Science & Technology (CASE) provides funding for PhD studentships where businesses take the lead in arranging projects with an academic partner of their choice
[13] http://www2.nationalgrid.com/UK/Our-company/Innovation/Gas-transmission-innovation/NIA-Projects/

2. Summary

While the underlying UAG trend has seen a gradual decline over the last six months, July and August 2015 exhibited marked increases in UAG volumes. Despite this recent UAG behaviour and the early indications that UAG daily volumes are returning to pre July rates, overall UAG volumes continue to decline on an aggregated basis.

The cause of the recent transients is still being investigated but anomalous UAG behaviour highlights the need for a more formal structure as to how National Grid engages appropriately with all asset owners in these instances. It is proposed that National Grid will engage with all key stakeholders to formulate a framework that is compatible with the need to obtain timely information without undue overhead.

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.

A review and potential 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.

To further enhance UAG management, National Grid continues to undertake NIA funded initiatives to assist meter validation and on going UAG analysis. The main thrust of these initiatives is the development of a fully featured ‘free to all’ NGage meter validation tablet application that will enable asset owners across the NTS to easily provide detailed meter validation data with associated analysis. Further work with Manchester University will be exploring new mathematical techniques that may provide further insight into UAG behaviour.

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[14] related to its UAG management.

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