UAGCVS Report

May 2021

Executive Summary

This report provides a review of National Grid's Unaccounted for Gas (UAG) management since April 2013, the start of the RIIO-T1 price control, with particular emphasis on 1st September 2020 to 31st March 2021 inclusive, the period since the publication of the October 2020 UAG report. The report also contains a Calorific Value Shrinkage (CVS) statement with an overview of its possible causes. The publication of this report discharges National Grid Gas's obligations under the Gas Transporter Licence Part J of Special Condition 5.6 (System operator external incentives, revenues and costs) - to investigate the causes of UAG and CVS.

The total assessed UAG quantity for the September 2020 to March 2021 period is larger than the previous seven-month period. Monthly assessed UAG is also greater than the long-term average (April 2013 to March 2021) for 4 of the last 7 months, which is in line with throughput behaviour across summer and winter months.

Annual Assessed UAG for Formula Year 2020/21 is 11.7% lower than Formula Year 2019/20 but overall Shrinkage is higher than other years over the RIIO-T1 period.

National Grid continues to report post-reconciliation assessed UAG enabling a more accurate representation of UAG performance. National Grid has also continued to improve its understanding of the causes of UAG through the use of data visualisation tools, systematic data handling and data science.

National Grid has observed increases in CVS during Formula Year 2020/21 which has been mainly attributed to LDZ capping in the NO and NE LDZs. This has largely been caused by changes in supply pattern to the LDZs following a reduction in gas flows from St Fergus and an increase in supply from Teesside.

Continued support from meter owners has enabled National Grid to obtain and review meter validation information for NTS entry and exit facilities. This data is being used to support the identification of causes of UAG, to enhance National Grid's ability to detect meter error and to inform the preparation of future meter witnessing programmes.

Contents

Unaccounted for Gas (UAG) & Calorific Value Shrinkage (CVS) Report – May 2021

Introduction

This report provides a review of National Grid's Unaccounted for Gas (UAG) and Calorific Value Shrinkage (CVS) management.

The report provides information on assessed UAG quantities since April 2013, the start of the RIIO-T1 price control, with particular emphasis on 1st September to 31st March 2021 inclusive, the period since the publication of the October 2020 UAG report. It describes National Grids endeavours to undertake projects for the purposes of investigating the causes of UAG and CVS.

UAG, CVS and OUG (Own Use Gas) are the three components of NTS Shrinkage. Further information on the components of NTS Shrinkage can be found on the within the UAG page on the National Grid Gas website via the following link:

https://www.nationalgridgas.com/balancing/unaccounted-gas-uag.

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

- all previous UAG reports;
- daily data on the components of NTS Shrinkage

which are available on the National Grid website via the above link.

The publication of this report and associated backing data discharges National Grid Gas's obligations under the Gas Transporter Licence Part J of Special Condition 5.6 (System operator external incentives, revenues and costs) - Requirement to undertake work to investigate the causes of UAG and CVS. Part J of Special Licence Condition 5.6 which is detailed in Appendix I of the report. The relevant data used to produce the tables and graphs included in the report is provided or referenced in Appendix II.

If you have any feedback or questions on this document, please contact National Grid's Meter Assurance team via the following email address: meterassurance@nationalgrid.com. Meter Assurance, who are part of the Energy Balancing team National Grid Gas Transmission, are responsible for investigating the causes of and reporting upon UAG and CVS.

National Transmission System Unaccounted for Gas Trends

This section of the report provides information on assessed UAG quantities since April 2013, with particular emphasis on the period September 2020 to March 2021. It also provides a review of the assessed quantities of UAG observed for Formula Year 2020/21.

Formula Years 2013/14 to 2020/21

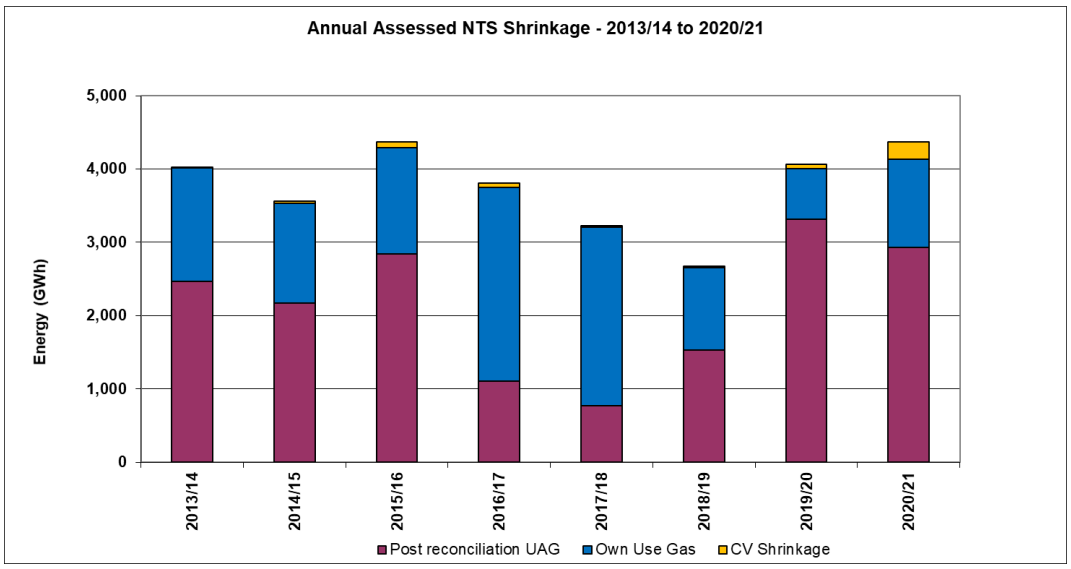

Figure 1: Annual assessed NTS Shrinkage – 2013/14 to 2020/21

Figure 1 provides the annual assessed UAG, OUG and CVS quantities for Formula Years 2013/14 to 2020/21. A Formula Year refers to the period from 1st April to 31st March of the following year.

Figure 1 demonstrates that for Formula Year 2020/21, NTS Shrinkage has been larger than other years throughout the RIIO-T1 period. UAG also continues to be the prominent component accounting for 67% of NTS Shrinkage although, this has reduced by 11.7% compared to Formula Year 2019/20.

CVS has also continued to increase throughout the last 12 months recording the highest amount throughout the RIIO-T1 period. The reasons behind the increase can be found in the CVS Statement further on in this report.

OUG has also increased in comparison to the previous Formula Year, where an increase of 75.7% has been observed and is similar to the values observed in Formula Year 2018/19. The increase in OUG is largely due to a reduction in supply volumes from LNG and an increase in supply from the Teesside Terminal which requires greater levels of compressor usage to transport the gas across the NTS.

Figure 2 provides the annual assessed quantities of UAG for Formula Years 2013/14 to 2020/21.

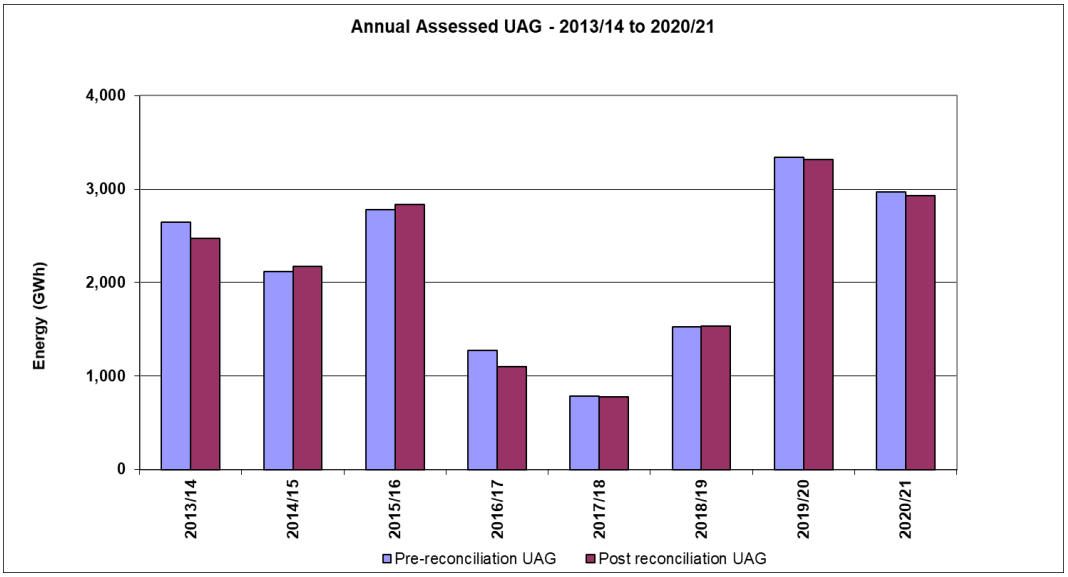

Figure 2: Annual assessed UAG – 2013/14 to 2020/21

Figure 2 represents both pre-reconciliation and post-reconciliation annual assessed UAG quantities. Pre-reconciliation UAG is calculated using the energy measurements reported in the Gemini commercial system at closeout for the NTS entry and exit points. If a meter or data error is identified following closeout for one of these points, the correct measurements are determined. Post-reconciliation UAG is then calculated using the corrected measurements. Further information on reconciliation is provided under section 'UAG Management Activities' of this report.

Assessed UAG since 2018/19 appears to have increased but UAG behaviour over the past seven months has been more similar to values witnessed in 2019/20 where UAG was predominantly positive with a trend of positive high UAG identified over the winter months. During 2016/17 to 2018/19 prolonged durations of negative UAG were observed which reduced the net total of UAG for those years. The increase in assessed UAG witnessed in 2019/20 and 2020/21 highlighted trends that have not been seen before, which are being investigated using data science.

Unless stated otherwise the remainder of this report will refer to post-reconciliation assessed UAG quantities.

Table 1 provides the annual and daily average assessed UAG quantities for Formula Years 2013/14 to 2020/21. The table also provides the annual assessed UAG quantities as a percentage of annual NTS Throughput.

UAG Statistics	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21
Annual Assessed Level (GWh)	2,472	2,173	2,838	1,103	775	1,532	3,318	2,929
Assessed Daily Average (GWh/d)	6.77	5.95	7.75	3.02	2.12	4.20	9.07	8.03
Percentage of NTS Throughput	0.28	0.24	0.31	0.12	0.08	0.17	0.36	0.31

Table 1: Statistical performance of UAG - 2013/14 to 2020/21

Table 1 highlights that Annual Assessed UAG has reduced for 2020/21 by 11.7% when compared to 2019/20. UAG equates to 0.31% of NTS throughput, which has also reduced when compared to last year, and is equal to that identified throughout the 2015/16 period.

Figure 3 provides the total monthly assessed UAG from April 2013 to March 2021. It also provides the average monthly assessed UAG for this Formula Year (244.11 GWh) depicted as a dotted black line, together with the long-term average assessed UAG for the entire period (178.53 GWh) depicted as a dotted red line.

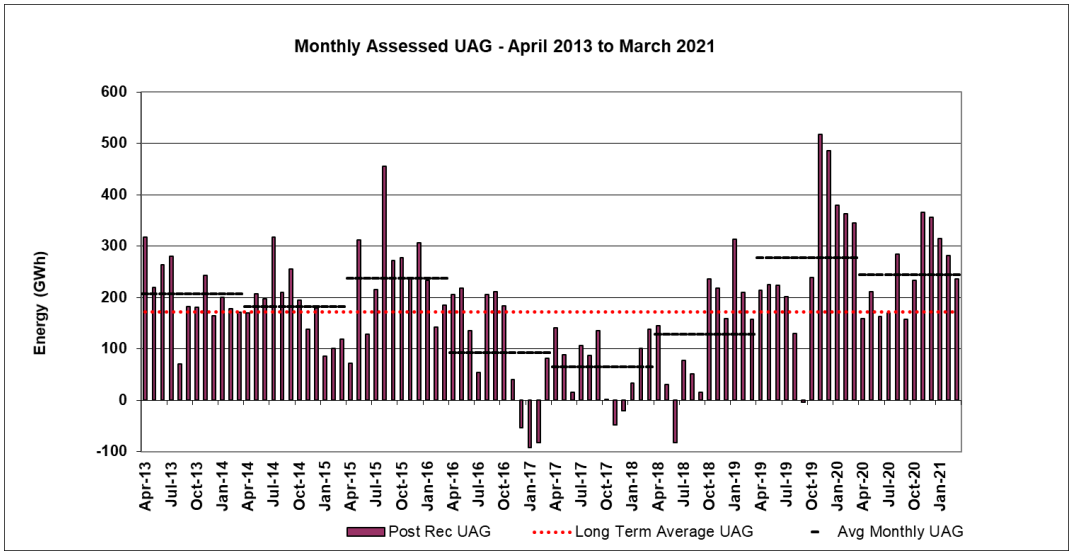

Figure 3: Monthly assessed UAG - April 2013 to March 2021

As Figure 3 indicates, since the start of Formula Year 2020/21, monthly assessed UAG for 8 out of 12 months has seen monthly assessed UAG being above the long-term average.

The period between November 2016 and September 2018 saw 23 consecutive months below the long-term monthly average, this is due to an increased amount of negative UAG throughout that period. This period along with the period between October 2019 and March 2020 where step changes in UAG behaviour were observed, are of interest to determine both trends and the source of the unusual UAG performance. Figure 3 also highlights a similar profile of UAG during the winter months for the 2019/20 and 2020/21 Formula Years.

Figure 4 provides the total monthly assessed UAG for September 2020 to March 2021, the period since the last UAG Report, compared with the equivalent months within 2019/20. This indicates a reduction of monthly assessed UAG for all months when compared to the previous Formula Year, except for September 2020, which saw an increased amount of negative UAG.

The higher levels of UAG witnessed between November 2019 and March 2020 are caused by consistent levels of positive high UAG over the 2019/20 winter months, which are referred to later in the report in Figure 11. A similar step change in UAG behaviour has also been observed from November 2020 – March2021. However, a greater magnitude of UAG was observed within the 2019/20 Formula Year. A Data Scientist has been investigating this UAG trend which is covered later in the report.

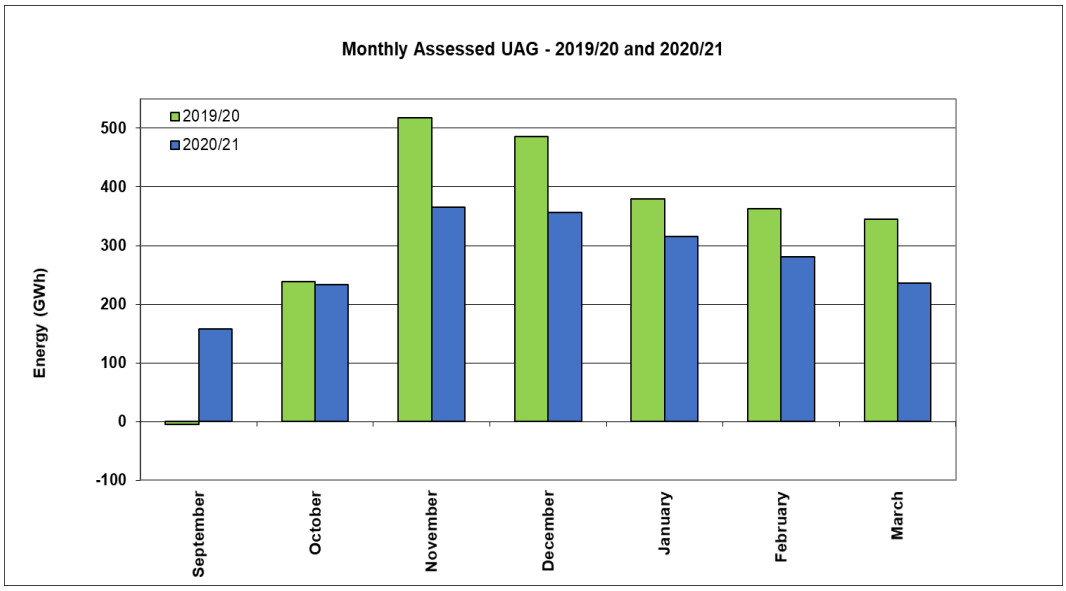

Figure 4: Monthly assessed UAG – September 2019 to March 2020 and September 2020 to March 2021

During the last seven-months, the total monthly assessed UAG varied from +157.38 GWh to +364.98 GWh, with a lower monthly average of 277.51 GWh when compared to the same months in the previous year. During the September 2019 to March 2020 period total monthly assessed UAG had a much greater swing, varying from -4.64 GWh to +517.29 GWh with a higher monthly average of 332.09 GWh.

Figure 5 provides total monthly assessed UAG quantities between formula year 2013/14 to 2020/21. The figure indicates the variance from one year to another, for example, the month of November has a UAG spread of +517.29 GWh and -48.41 GWh. This indicates that there has been no consistent seasonal UAG trend through the RIIO-T1 period, however, during the winter months of 2019/20 and 2020/21 increases in UAG and UAG behavioural trends have been observed, categorised by predominately positive high UAG.

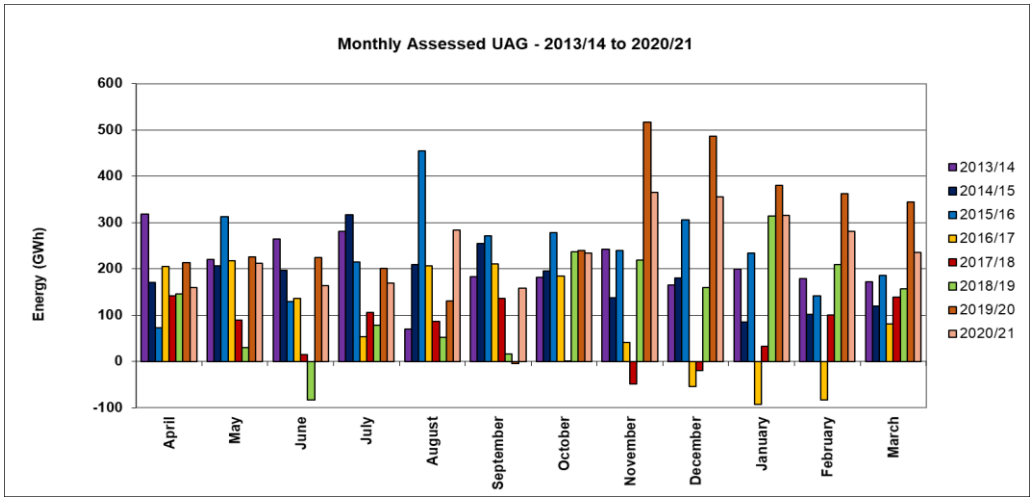

Figure 5: Monthly assessed UAG – 2013/14 to 2020/21

Figure 6 provides the daily assessed UAG values for the period between 1st September 2020 and March 2021 and indicates that UAG has been mostly within the ±20GWh limit since September. This is confirmed by the largely flat 30-day rolling average included in the figure (black line). As previously mentioned, a step change can be identified in the rolling average from November 2020 which remained throughout the rest of the period.

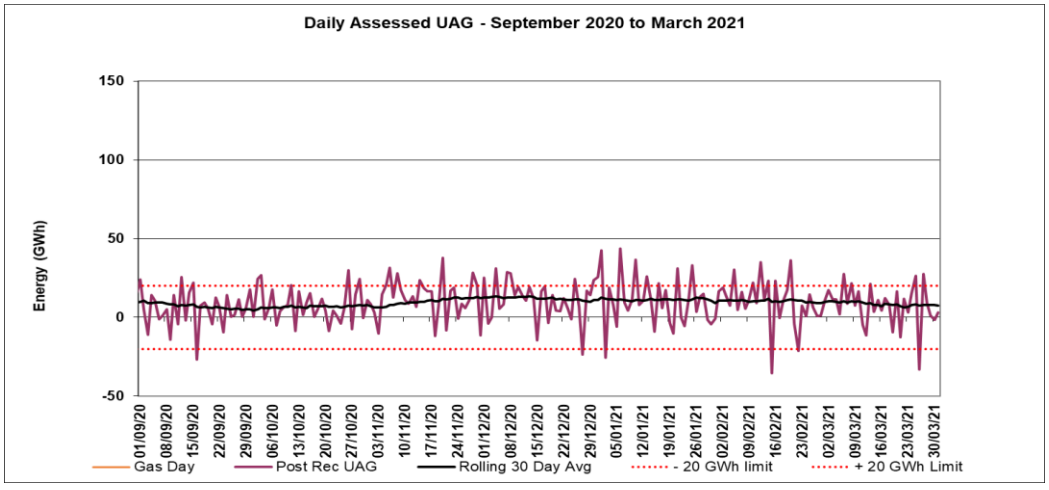

Figure 6: Daily assessed UAG – October 2020 to March 2021

National Grid reviews and investigates the assessed UAG values on a daily basis paying particular attention to any values that exceed ±20 GWh. These baseline UAG quantities are provided as red dotted lines in the above figure. During the period of September 2020 to March 2021 there were 46 days when daily assessed UAG exceeded ±20 GWh. This is a 29% reduction in high UAG days when compared to the same period in 2019/20 where 65 days exceeded ±20 GWh.

National Grid has investigated all days with high levels of positive or negative UAG that have not been categorised as UAG trends. All trends are investigated via a separate UAG project investigation process. The period between November 2020 to March 2021 has been categorised as a UAG trend due to the presence of consistently high positive UAG days and as a result will be investigated via the UAG project investigation process. Out of the 46 days that have exceeded ±20 GWh, 32 are included in the UAG trend analysis and will be covered in future UAG Reports. The gas days that were categorised as a trend within 2019/20 have been reviewed via data science and so far, whilst no causes of UAG has been identified from that analysis, several causes have been eliminated.

Of the 14 days that exceed ±20 GWh National Grid have investigated and identified 20.09 GWh of UAG.

Figure 7 outlines the demand breakdown with UAG overlaid for the period between April 2018 to March 2021 and does not display any noticeable behavioural changes over this period. LDZ Offtakes display a seasonal pattern throughout, as does Interconnector Export, whereas Industrial and Power Station demand demonstrates a more consistent annual offtake.

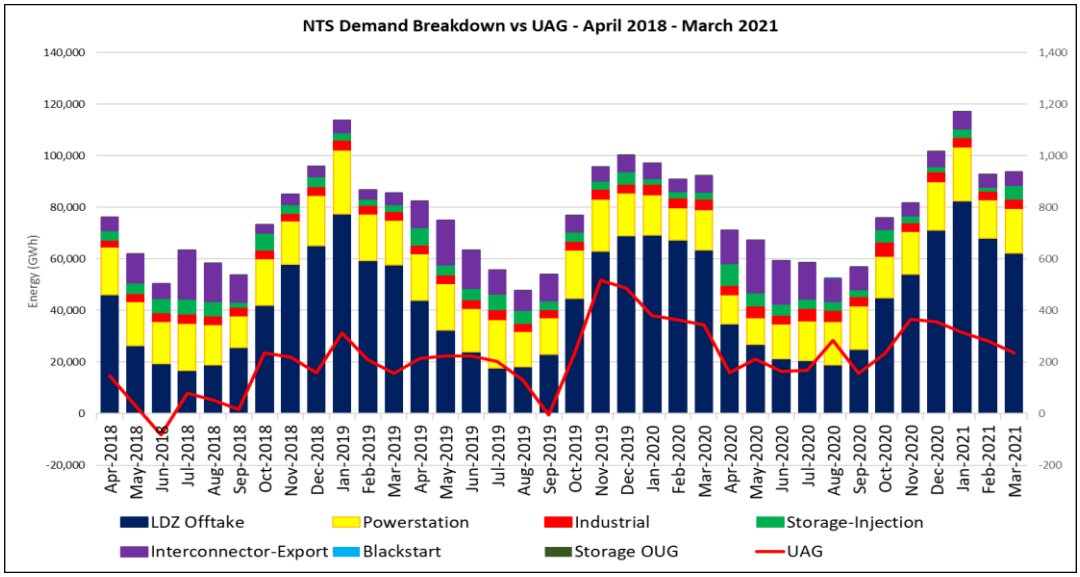

Figure 7: NTS demand breakdown – April 2018 to March 21

LDZ Offtakes are the largest component of NTS Demand during the winter months which coincides with the increase in assessed UAG that has been observed in the last two Formula Years. The Offtakes have been individually and collectively assessed against daily UAG to establish if there are any relationships in behaviour. So far, no correlation has been identified, further information on this analysis can be found in the report under section 'UAG Investigation Project'.

Figure 8 provides an overview of the Supply patterns between April 2018 to March 2021 and demonstrates a seasonal Supply pattern that has been observed in previous UAG Reports. Over the last seven months, Terminal, LNG and Interconnector Imports have all increased in line with seasonal Demand.

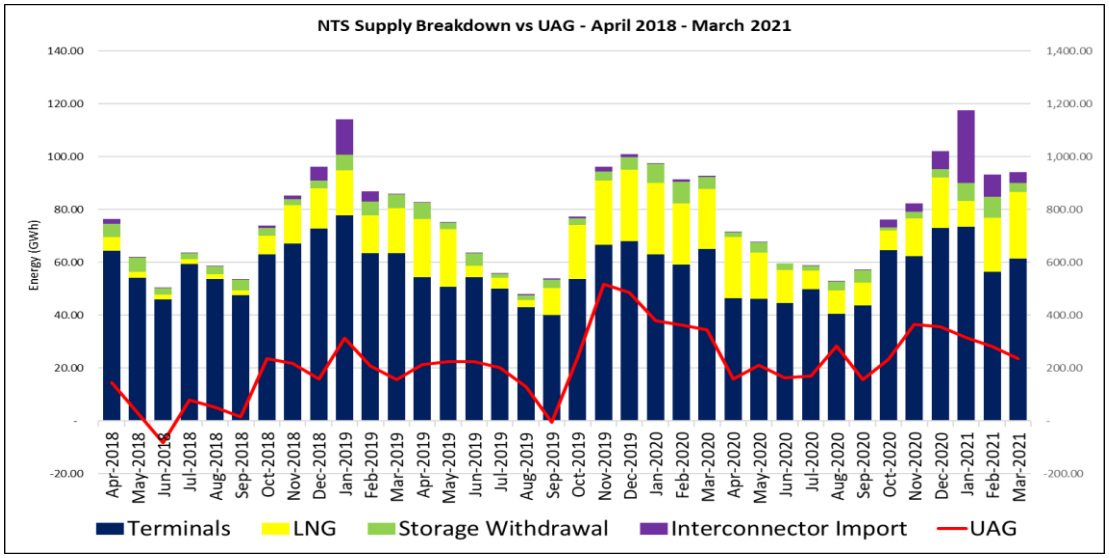

Figure 8: NTS supply breakdown – April 2018 to March 2021

Changes in LNG supply pattern were observed during the 2018/19 winter period with greater LNG imports when compared to previous years. A further rise in LNG was witnessed over the 2019/20 winter period and remained high until May. Similar increases have been observed during 2020/21 with rises in total LNG supply from November 2020 which continued to increase for the rest of the Formula Year, except for January 2021 where a reduction was observed.

Figure 9 below provides the total LNG Imports since April 2018 and highlights the change in patterns that have been observed over the last 2 years. The increase in LNG Import has occurred during the same periods where trends of high positive UAG has been witnessed during the same two Formula Years. The relationship between UAG and LNG has been analysed and so-far, no correlation has been identified. The detail of this analysis is within section 'UAG Investigation Project' of the Report.

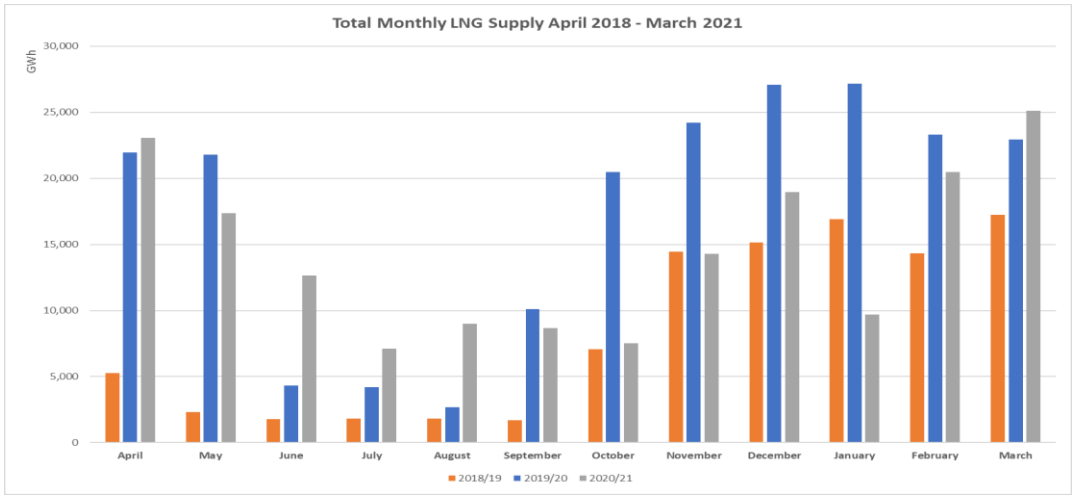

Figure 9: LNG Supply – April 2018 to March 2020

Figure 10 displays the monthly net Interconnector position (Interconnector exports minus imports) over the period between April 2016 and March 2021. UAG does not follow any pattern to net Interconnector activity.

The positive values on the graph show the net value being predominantly gas imports and the negative values are when the interconnector facilities are predominantly exporting gas. The period from September 2020 is more in line with export activities seen in previous years, with 2019/20 being the exception. January 2021 saw the lowest net position over the whole 5-year period due to greater export activities.

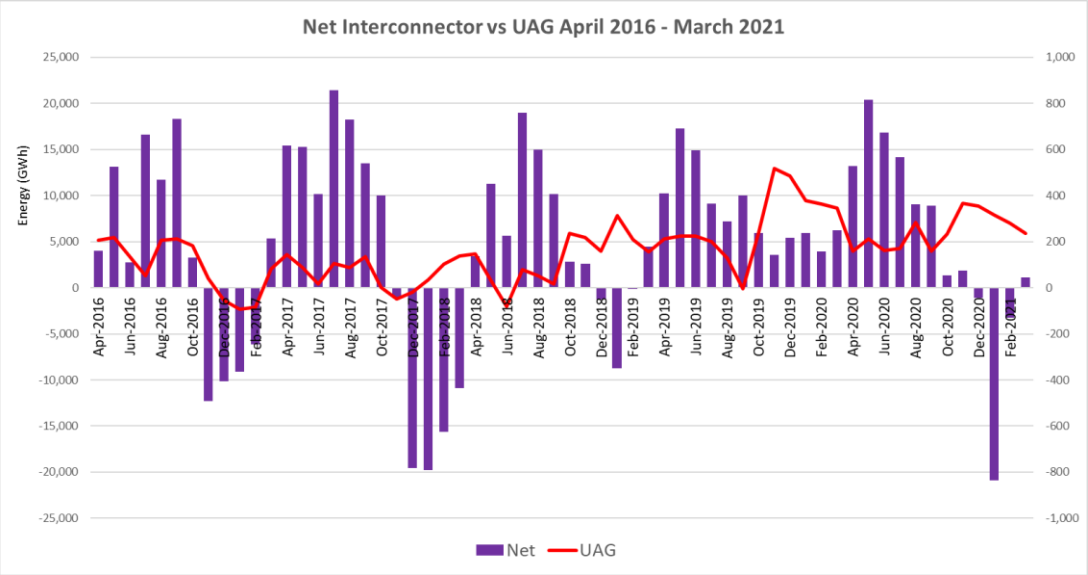

Figure 10: Net Interconnector – April 2016 to March 2021.

Formula Year 2020/21

This section of the report provides data on assessed UAG levels for the April 2020 to March 2021 period. Following a change in the publication dates of the UAG Report this is the first opportunity for National Grid to report on the entire 2020/21 Formula Year.

2020/21	UAG	OUG	CVS	Total
Actual Annual Levels (GWh)	2,929	1,208	236	4,374
Percentage of Total NTS Shrinkage	67.0	27.6	5.4	100.0

Table 2: Actual Assessed Levels for UAG, OUG and CVS – 2020/21

Table 2 provides the actual assessed levels for UAG, OUG and CVS for the 2020/21 Formula Year. The table indicates that UAG was the predominant element of NTS Shrinkage.

Assessed UAG during 2020/21 has reduced from the previous Formula Year by 11.7%.

The decrease in observed levels of UAG is mainly due to the reduction in the magnitude of high UAG even though a positive trend has been observed over the winter months of both Formula Years and despite fewer occurrences of negative UAG when compared to the previous year."

National Grid have also witnessed an increase in annual OUG and CVS by 75.7% and 311.9% respectively.

Figure 11 provides the total monthly assessed UAG for April 2020 to March 2021 compared to the equivalent months of 2019/20. During 2020/21, the total monthly assessed UAG varied from +157.38 GWh to +364.98 GWh with a monthly average of 244.11 GWh. 2019/20 had a higher monthly average of 276.51 GWh.

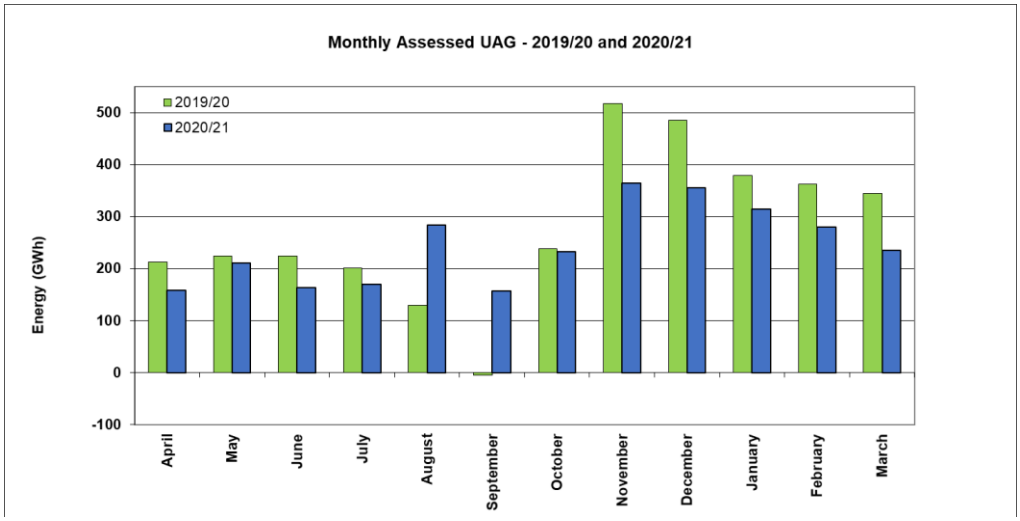

Figure 11: Monthly Assessed UAG – 2019/20 and 2020/21

Figure 11 confirms the total monthly assessed UAG for Formula Year 2020/21 closely follows the monthly profile of UAG from 2019/20, although with a lower magnitude, except for August and September where the total monthly assessed UAG is greater than the previous year.

Figure 12 provides the daily assessed UAG values for 1st April 2020 to 31st March 2021. Large day to day variability in the daily assessed UAG values has continued with daily UAG varying from -35.38 GWh to +43.68 GWh with a daily average of 8.03 GWh.

The black line in the centre illustrates a 30-day rolling average and Baseline UAG quantities are provided as red dotted lines.

A positive UAG trend has been identified during the winter months of 2020/21 which is demonstrated by the slight increase in the Rolling 30 Day Average at the start of November, which is present until the end of March 2021.

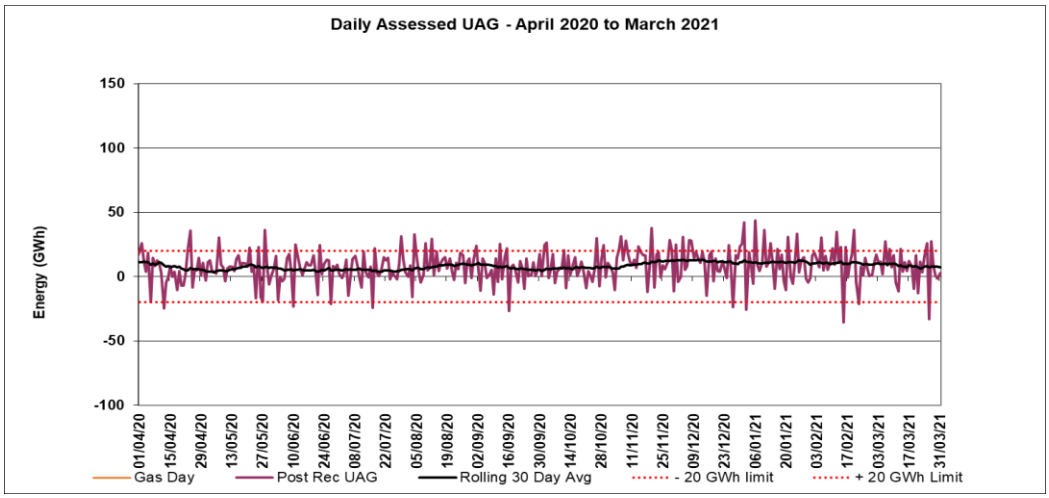

Figure 12: Daily Assessed UAG – April 2020 to March 2021

During 2020/21 there were 65 days when daily assessed UAG exceeded ±20 GWh (27.8% of occasions). This has decreased by 19 occasions from the previous year where84 days exceeding ±20 GWh were observed.

Negative UAG was observed on 81 days (22.2% of occasions) during 2020/21. A reduction to the previous year's 98 negative UAG days.

As described previously in this report, National Grid reviews and investigates the assessed UAG on a daily basis, paying particular attention to any values that exceed ±20 GWh. A dedicated project team have been set up to build tools to investigate UAG trends. UAG trends are a series of consistent patterns of UAG and will be investigated using Data Science and Correlation Analysis.

To date, the UAG Project has investigated the high UAG trend from November 2019 – March 2020 via Correlation Analysis. Further details of this can be found in section 'UAG Investigation Project' later in the report. The high UAG trend that has been identified between November 2020 – February 2021 is currently being investigated within the project and updates will be provided in further UAGCVS Reports.

Conventional High UAG checks have been conducted for gas days falling outside of the trend and have identified UAG on 5 gas days. A total of 37.1 GWh has been identified via the conventional UAG checking process for 2020/21.

A meter error notification has been submitted to the Joint Office by Cadent to notify the industry of a significant meter error that has been identified at Alrewas EM NTS to LDZ Offtake between gas days May 2019 to February 2021. Once the Meter Error Report (MER) is publicly available, National Grid will authorise and submit the corrected measurements to Xoserve to be processed on a subsequent invoice run.

The UAG investigation project enables an end to end review and improvement of current process and systems, automated system validation checks, data automation, data visualisation with enhancements to current and new tools for more accurate analysis.

The UAG, OUG and CVS data provided in this section of the report is the data National Grid included in its Regulatory Reporting Pack (RRP) submission to Ofgem for 2020/21.

UAG Management Activities

This section of the UAG report describes the various activities and initiatives that National Grid has been undertaking or is planning to undertake to investigate the causes of UAG.

Meter Validation Report Reviews

Meter owners are obliged to undertake meter validations for each of their metering installations on at least an annual basis to confirm that the metering equipment is measuring correctly. The results of these tests should be documented within a meter validation report and provided to National Grid as soon as possible after the completion of the validation.

The validation reports provide essential information that allows National Grid to assess the asset health and accuracy of the metering connected to its network. This enables a better understanding of the impact that meter error will have on assessed UAG.

For Formula Year 2020/21 National Grid has so far received meter validation reports for 219 NTS entry and exit facilities (94% of all NTS connected sites and 99.5% of volume based on 2019/20 total throughout). These reports are for validations that have taken place between April 2020 and March 2021.

The Meter Assurance team has reviewed all of the 219 Meter validation reports received so far. National Grid have raised queries, where necessary with all relevant meter owners, to confirm if any instruments that tested outside of tolerance would have introduced measurement error, thus impacting assessed UAG levels. So far, none have been deemed to have caused end of day measurement error.

The Meter Assurance team will continue to request and review the remaining 2020/21 meter validation reports and use the data provided to assist with the identification of causes of UAG and to inform the preparation of future meter witnessing programmes.

During meter validations, the meter installation equipment is interfered with by the personnel undertaking the testing. This may include making modifications to the metering system in order to simulate and record values which entails disconnecting physical instruments, wires and software. There is a risk that meter error could be introduced through these activities. National Grid is continuing to investigate the potential to identify assessed UAG when meter validations are known to be taking place.

National Grid is focussing on validation tests that have the potential to cause significant measurement error, to gain a better understanding of different calibration equipment and different tolerances. The asset owners are assisting with our queries associated to these tests.

Meter Witnessing

Witnessing involves National Grid personnel attending metering installations throughout the UK during meter validations to observe and document the testing taking place. Due to COVID-19 restrictions and social distancing, National Grid was unable to directly witness any annual meter validations throughout 2020/21.

The purpose of witnessing the validations is to gain assurance that the measurement equipment within the metering installation continues to measure the gas delivered to or taken from the NTS without bias and within the agreed measurement uncertainties.

The witnessing programme for Formula Year 2021/22 is under development and is hopeful that witnessing will be able to restart. National Grid will be contacting the specific asset owners in due course to discuss witnessing. The metering installations will be selected based upon National Grid's assessment of the previous validation report or if the site has current measurement issues or are of interest or concern.

Out of the 10 meter witnessing visits that were planned for Formula Year 2020/21, none have been completed due to COVID-19 restrictions, although engagement with asset owners has continued.

Reconciliation

National Grid has an obligation to reconcile NTS related meter and data errors on behalf of the shipping community.

In the last seven months since the publication of the October 2020 UAG Report National Grid has adjusted 180.51 GWh in absolute energy terms via the reconciliation process. This comprises 22 instances of reconciliation at individual NTS entry and exit facilities, each instance comprising of one or more days of reconciliation for a total of 856 gas days. The majority of these reconciliations concern days in Formula Year 2020/21, however, reconciliations have also been processed for 2017/18, 2018/19 and 2019/20.

Figure 13 provides the annual reconciliation quantities, in absolute energy terms, for 2013/14 to 2020/21. The orange coloured bars indicate the reconciliation quantities processed since the publication of the October 2020 UAG report.

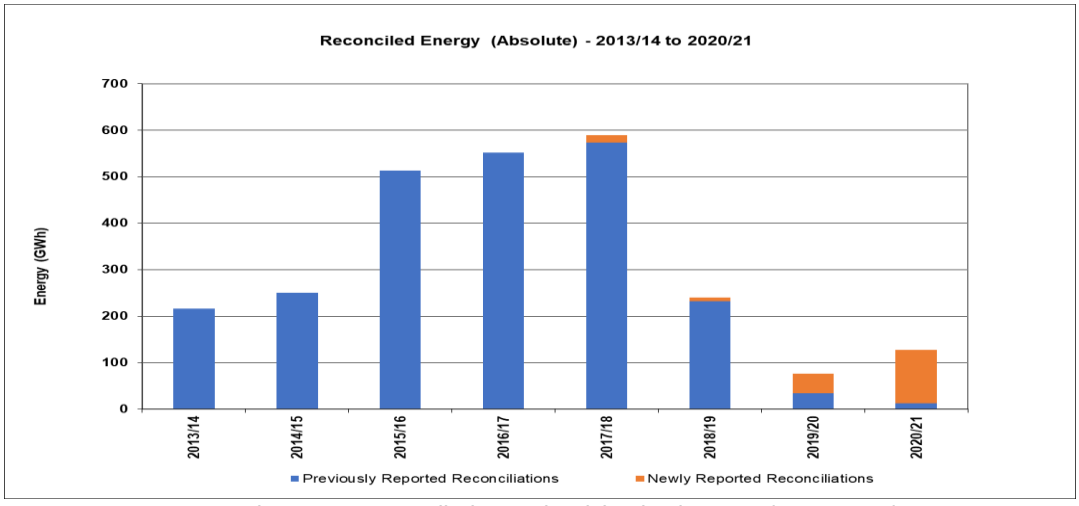

Figure 13: Reconciled energies (absolute) – 2013/14 to 2020/21

Of the 22 instances of reconciliation processed, consisting six related to meter error (27% of instances) and 16 related to data error (73% of instances).

National Grid is continuing to improve its validation of end of day measurements to help address data quality challenges experienced during the pre-closeout period. One initiative that has been offered to the Sub Terminals is the automated handling of their data which loads directly into the GCS system, reducing the opportunity for manual input errors to occur. Other initiatives have been embedded to improve the monitoring of reconciliations including SLA's and improved customer visibility following an end to end customer journey mapping exercise. National Grid hopes that this can be rolled out to NTS Storage sites in the future.

National Grid is continuing to process meter or data error reconciliations which will be included in future Unaccounted for Gas reports.

UAG Investigation Project

National Grid manage projects to investigate the causes of UAG, particular interest has been the increase of assessed UAG that has been observed since October 2019. The projects also include historical and future UAG patterns or trends.

The current project is managed in sprints to try and maximise the output from the allocated resource. The projects ambition is to better understand end to end data flows to identify and mitigate systematic data error, to automate and validate all data points and build the tools to identify the causation of UAG.

Since the publication of the October 2020 UAG Report the project has carried out the following:

Review of the after the day settlements processes. This included data flow analysis across several gas days with differing levels of UAG which supported the hypothesis that the after the day settlements process is working correctly and the best available data is used, however, there were some levels of uncertainty between different telemetry points which are now under investigation.

Correlation detection using site data compared to UAG behaviours. The project data scientist identified no meaningful UAG correlation between the individual sites or collective site types for the 3 years that were analysed. All sites within the following categories have been assessed for UAG correlation; Interconnector, Sub Terminal, Storage Withdrawal, DN Offtake, Power Station, Industrial and Storage Injection.

UAG correlation was also conducted for each site type as a percentage of throughput and again, there was no evidence of correlation.

UAG calculated in volumetric terms. Following enhancements to the Gemini system, National Grid are now able to view site types and calculate UAG in volumetric terms more efficiently and accurately.

New data model development. Enabling the team to enhance their ability to validate daily Measurements by having access to more data points within the data visualisation system Tableau allowing for more advanced measurement checking within entry and exit closeout periods.

High UAG investigations for the periods where a UAG trends have not been observed.

Table 3 provides an overview of the UAG projects / initiatives National Grid have planned over the next 12 months (Formula Year 2021/22). The table identifies if the project / initiative was in the previous reporting period, this reporting period or the wider 12 month reporting period.

Project / Initiative	Target Completion Date	UAG / CVS
Full Assessment of mathematical models in the National Grid Analysis Tool	This 6-month reporting period	UAG
Enhancements to UAG Causality detection models	This 12-month reporting period	UAG
Periodic review of UAG Trends (if applicable)	Wider 12 month reporting period	UAG
Review of current Linepack Model	This 6-month reporting period	UAG
Linepack calculation improvements (if applicable)	Wider 12 month reporting period	UAG
Continuous improvement / process improvement to the Settlements Process and ability to validate site Measurements within Entry and Exit Closeout	Wider 12 month reporting period	UAG
Embed the new data models and build dashboards to reduce erroneous measurements being settled	This 6-month reporting period	UAG
Enhancements to Tableau dashboards to improve high UAG checks and better detection of the cause of High UAG	This 6-month reporting period	UAG

Table 3: Project initiatives for Formula Year 2021/22

National Grid continues to manage the UAG project and develop tools to better identify the causes of UAG and UAG trends.

Data Science / Correlation Analysis

National Grid is committed to improving the analytics surrounding UAG and as a result has been working in conjunction with Data Scientists to conduct more complex mathematical investigations into different aspects and variables that could be a contributing factor to UAG. This section of the report provides a sample of the analysis that has been conducted.

Correlation analysis is a statistical method used to evaluate the strength of relationship between two, numerically measured, continuous variables/datasets. This type of analysis is useful when trying to establish if there are possible connections between variables. It is often misunderstood that correlation analysis determines cause and effect; however, this is not the case because other variables that are not present in the study may have impacted on the results.

If correlation is found between two variables it means that when there is a systematic change in one variable, there is also a systematic change in the other; the variables alter together over a certain period of time. So, in correlated data, the change in the magnitude

of 1 variable is associated with a change in the magnitude of another variable, either in the same (positive correlation) or in the opposite (negative correlation) direction.

- Positive correlation exists if one variable increases simultaneously with the other, i.e. the high numerical values of one variable relate to the high numerical values of the other.

- Negative correlation exists if one variable decreases when the other increases, i.e. the high numerical values of one variable relate to the low numerical values of the other.

Correlation Coefficient values can range from +1 to -1, where +1 indicates a perfect positive relationship, -1 indicates a perfect negative relationship, and a 0 indicates no relationship exists.

Strong correlation: If the coefficient value lies between ± 0.50 and ± 1, then it is said to be a strong correlation.

Moderate correlation: If the value lies between ± 0.30 and ± 0.49, then it is said to be a medium correlation.

Weak correlation: If the value lies between ± 0.29 and 0, then it is said to be a weak correlation.

Figure 14 below is a review of the different factors such as UAG and Demand, that could have a relationship with LNG Imports, LNG has been of particular interest in previous reports due to high UAG when there is larger LNG flows. The data in this analysis covers the period from 01/01/2018 to 31/01/2021. The greatest correlation between UAG and the individual LNG Terminals is at Isle of Grain 2 (LNGIOG2) with a correlation of 0.29 although this is not deemed to be significant.

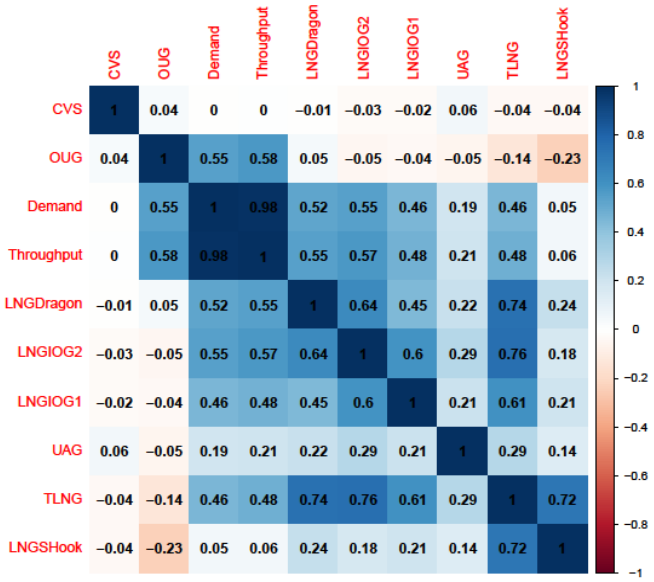

Figure 14: LNG Correlation Analysis 01/01/2018 – 31/01/2021

National Grid has additionally used a Predictive Power Score which can detect linear or non-linear relations between two variables. In this instance Total LNG and UAG have been used and no meaningful correlation between the two was established during the last three years.

Figure 15 below looks specifically at the winter period when the trend of high UAG occurred during the 2019/20 Formula Year. Again, the strongest correlation between UAG and an LNG Terminal is Isle of Grain 2 with a value of 0.29, which is not deemed to be significant.

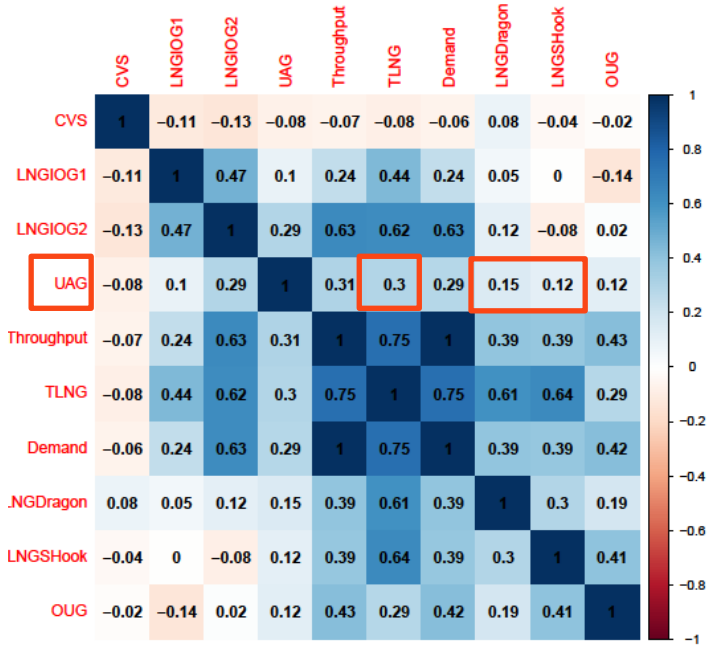

Figure 15: LNG Correlation Analysis 01/11/2019 – 28/02/2020

National Grid has also analysed UAG correlation with Interconnector import and export activities. Figure 16 below highlights that between 01/01/2018 and 31/01/2021 there is no significant correlation between the sites and UAG. The greatest of correlation for UAG was 0.24 for Moffat Export.

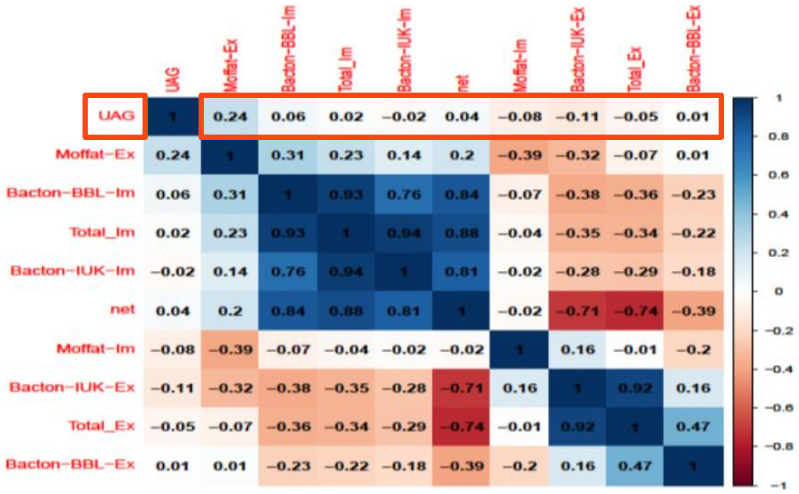

Figure 16: Interconnector Correlation Analysis 01/01/2018 – 31/01/2021

Data science has also been utilised to determine if there is a relationship between UAG the Local Distribution Zones (LDZ) and their Offtakes between October 2019 and January 2021. The LDZs with the strongest correlation to UAG is SE and WS both scoring 0.28. Neither of these scores are deemed to be significant. The data was also reviewed at individual Offtake level where Ross SW had the greatest correlation with a score of 0.29 again, is not deemed to be significant.

As previously mentioned, Data Science and correlation analysis has been conducted on all site measurements and the measurement as a percentage of NTS throughput. On all occasions, no significant correlation has been identified between UAG and site measurements or site measurements as a percentage of NTS throughput and UAG.

Tableau Analysis

National Grid has been utilising Tableau software for some time now to visualise and analyse its data. Current Tableau dashboards are enabling to us to identify and minimise data errors within the closeout period. These are being enhanced as new and improved data models become available.

National Grid has been focusing on developing tools to support the validation of site measurements within closeout to minimise the likelihood of erroneous measurements being used for invoicing.

Over the next 6 months National Grid plans to further develop the Tableau dashboards and visualisation tools available following the implementation of new and improved data models.

CVS Statement & Investigation

Calorific Value Shrinkage (CVS) is gas which cannot be billed due to the application of Gas (Calculation of Thermal Energy) Regulations 1996 (amended 1997) and is the Local Distribution Zone (LDZ) Energy difference between measured and billed Calorific Value (CV).

The regulations outline that the daily CV average for a given charging area / LDZ is calculated by summing the product of the CV and volume for all the inputs and dividing by the total volume of gas entering the LDZ.

The maximum daily CV average for the LDZ, permitted by the regulations, is equal to 1.0 MJ/m³ above the lowest measured daily CV of the inputs. Meaning, if for any given day an input into an LDZ has a CV outside of this range, a capped CV (lowest input CV + 1 MJ/m³) will be applied to the whole region for billing purposes. This is in order to protect customers who may live near this supply of lower quality gas and prevent over-payment for the gas they are receiving.

To calculate CVS, National Grid calculate the energy difference based on the value that was used to bill downstream shippers (based on the principles detailed above), and the measured quantity leaving the NTS by OFGEM approved equipment.

CVS occurs every day for all LDZ's with more than one input into the region. These are only very small quantities if no capping occurs and is caused by the LDZ CV being rounded to one decimal place following its calculation. With CV capping being the major contributing factor to CVS, UNC Offtake Arrangement Document Section F 2.2 details that all parties cooperate with the view to avoiding or minimising the amount of CVS each day.

With that in mind, if capping is caused by an NTS to LDZ offtake, National Grid will investigate to establish the feasibility of avoiding future occurrences of such capping and therefore, where appropriate to do so, provide guidance to the Distribution Network Operator (DNO) and/or National Grid Control Centre, to either alter patterns of flow through the offtakes or modify flows within the NTS to increase the blending of gases where safe and prudent to do so. If the capping is caused by non-NTS inputs into the LDZ, the DNO's will investigate the source and where appropriate liaise with the relevant asset owner with an aim of avoiding future instances.

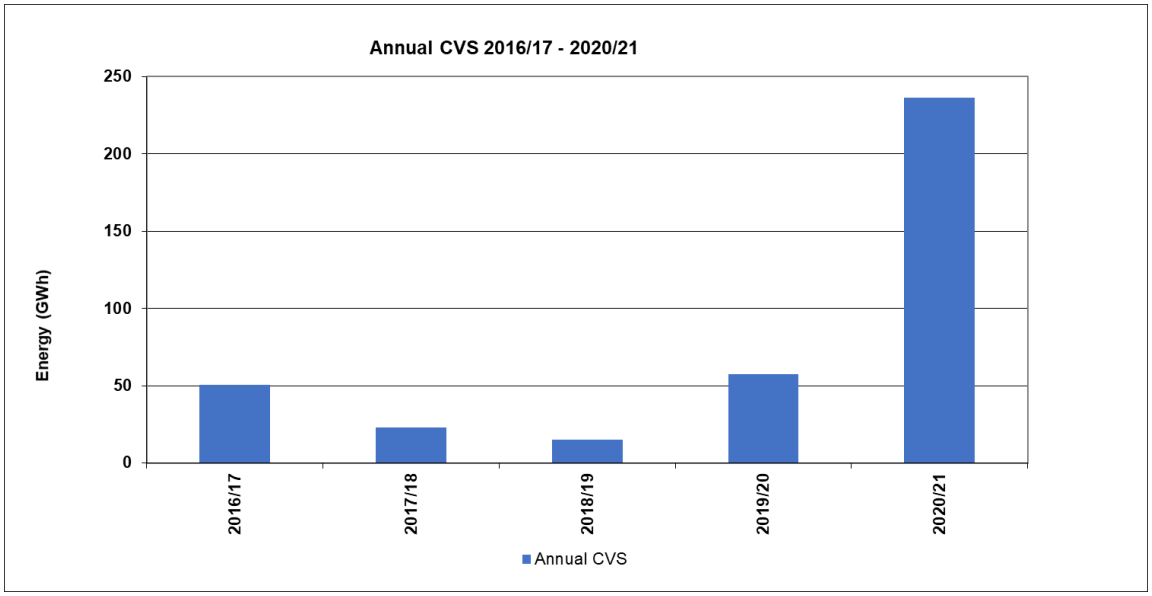

Figure 17: Annual CVS April 2016 – March 2021

Figure 17 provides total yearly CVS for the last 5 years. The figure indicates that there is no obvious trend year on year for CVS, however a clear step increase can be observed for Formula Year 2020/21 which is explained below. As shown in Figure 1 CVS is the smallest component of NTS shrinkage, even with the increase witnessed over the previous year it accounts for less than 5% of overall NTS shrinkage.

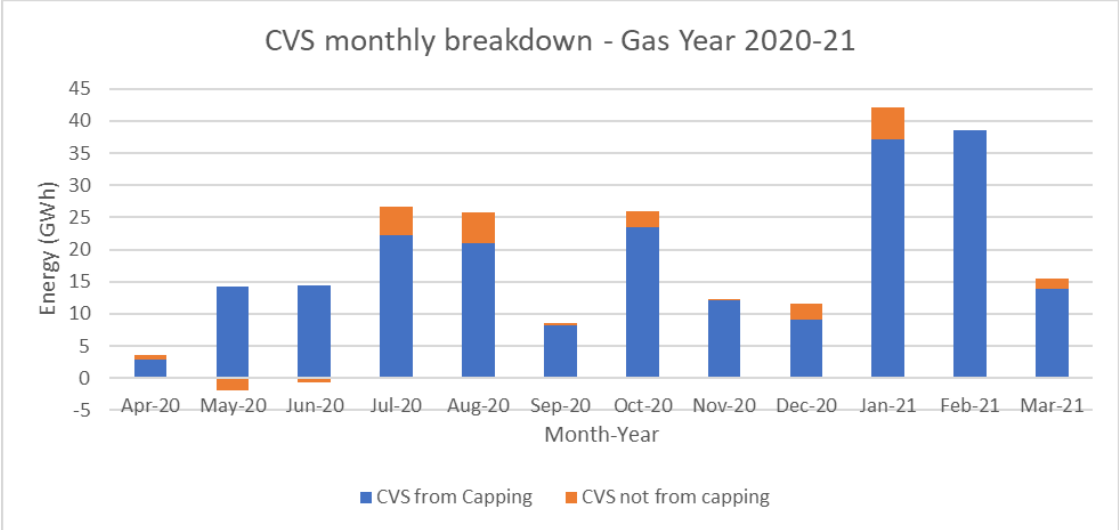

Figure 18: Monthly CVS Breakdown April 2020 – March 2021

Figure 18 provides a monthly breakdown of CVS for Formula Year 2020/21, outlining the large proportion created by CV capping. CVS can be either positive or negative when not caused by CV capping, this is due to the rounding of the LDZ CV's to 1 decimal place, as previously mentioned.

Throughout Formula Year 2020/21, the NTS has experienced a considerable amount of days where CV has capped in both the Northern (NO) and North East (NE) LDZ's, which has been the contributing factor to the increased levels of CVS observed this year in comparison to previous years, detailed in Figure 17. This is due to the network

configuration and how gas is blended in these regions from the different supply points on the NTS.

In previous years the NO region has seen gas predominantly supplied from St. Fergus terminals, with a lower CV. However, over the last 12 months, supply flow profiles in the north have changed. NO LDZ has received a lower proportion of gas from St Fergus with an increased supply entering the region from the Teesside terminal to the East, which has a higher CV of gas supplied.

With most NTS to LDZ offtakes within the NO LDZ experiencing higher proportions of gas from Teesside, this has increased the overall daily average CV for the LDZ. NTS to LDZ Offtake CV's situated to the north of this region however, have not been impacted as they are solely supplied gas from St Fergus terminals and therefore the whole of the LDZ is subject to capping.

This increase in gas supplies from the Teesside Terminal is also having a similar impact on the NE LDZ. Although most of the region is supplied gas from Teesside, some of the offtakes within the NE LDZ receive gas exclusively from the Easington terminals to the South of that region, with a lower CV of gas supplied than at Teesside. Due to the NTS configuration in that area, blending of the different terminal gasses cannot be achieved, therefore there is a disparity in CV's entering the LDZ, which leads to capping.

National Grid have investigated potential options to reduce capping in the NE and NO regions over the last year, along with conversations with the DNO affected, but unfortunately so far, there hasn't been a safe, reliable and cost-effective solution to reduce or avoid this from reoccurring. National Grid monitor all instances of capping and continue to investigate ways it can be reduced.

Conclusion

The total assessed UAG quantity for the September 2020 to March 2021 period is larger than the previous seven-month period. Monthly assessed UAG is also greater than the long-term average (April 2013 to March 2021) for 4 of the last 7 months.

The total annual assessed UAG for Formula Year 2020/21 was less than the total observed in 2019/20 but larger than all other years within the RIIO-T1 Price Control Period and the high UAG Trend observed during 2019/20 was also present during 2020/21.

National Grid continues to report post-reconciliation assessed UAG enabling a more accurate representation of UAG performance. National Grid has also continued to improve its understanding of the causes of UAG through the use of data visualisation tools, systematic data handling and Data Science.

Continued support from meter owners has enabled National Grid to obtain and review meter validation information for NTS entry and exit facilities. This data is being used to support the identification of causes of UAG, to enhance National Grid's ability to detect meter error and to inform the preparation of future meter witnessing programmes.

No meaningful correlation has been identified between any site type and UAG to date. Analysis will continue and further updates will be provided in future UAG Reports.

National Grid has observed increases in CVS during Formula Year 2020/21 which has been mainly attributed to LDZ capping in the NO and NE LDZs. This has largely been caused by changes in supply pattern to the LDZs following a reduction in gas flows from St Fergus and an increase in supply from Teesside.

Appendix I - National Grid Gas Plc (NTS) Gas Transporter Licence Special Condition Part J 5.6

Part J: Requirement to undertake work to investigate the causes of UAG and CVS

5.6.53 The licensee must use reasonable endeavours to undertake UAG Projects and compile a CVS Statement for the purposes of investigating the causes of UAG and CVS for each Regulatory Year.

5.6.54 The licensee must, unless the Authority otherwise directs, publish the UAGCVS Reports and provide a copy to the Authority by 1 May and 1 November in each Regulatory Year for the preceding six month period ending on 31 March and 30 September respectively.

5.6.55 The licensee must outline in the UAGCVS Report:

(a) the UAG Projects the licensee has undertaken in the previous period;

(b) the UAG Projects the licensee proposes to undertake in the next period and its views on whether, and if so how, the findings of the UAG Projects may be taken forward in order to reduce the volume of UAG;

(c) the reasons why any UAG Projects that the licensee proposed to undertake have not been undertaken during the Regulatory Year;

(d) a CVS Statement outlining the work conducted during the previous period to investigate CVS, and explaining the licensee's understanding of the causes of CVS;

(e) any additional activities and inspections undertaken by the licensee to improve metering calibration and accuracy;

(f) a summary of any relevant discussions concerning UAG or CVS at industry fora and with interested parties on a one-to-one basis; and

(g) any data or information related to UAG or CVS that the Authority may reasonably request.

5.6.56 During the period of 28 days beginning with the date of publication of a UAGCVS Report the licensee must, unless the Authority otherwise consents, publish on its website all the relevant data referred to in the UAGCVS Report.

Interpretation and definitions

UAG

is unaccounted for gas and means the amount of gas (GWh) that remains unaccounted for after the Entry Close-out Date following the assessment of NTS Shrinkage performed in accordance with the Uniform Network Code.

UAG Projects

means the projects currently undertaken by the licensee including:

(a) the witnessing by the licensee of the validation of Measurement Equipment at NTS System Entry Points or Supply Meter Installations at NTS Exit Points; and

(b) investigation and analysis of data in order to seek to identify causes of UAG.

UAGCVS Report

means a report required under Part J of Special Condition 5.6 (System operator external incentives, revenues and costs).

Appendix II - Relevant data referred to in May 2021 UAGCVS Report

This appendix provides the relevant data used to prepare the figures and tables provided in the report. The assessed UAG, OUG and CVS values used in the figures and tables are calculated from daily assessed values published on the National Grid website.

Figure 1:

Formula Year	Annual post-reconciliation assessed Unaccounted for Gas (GWh)	Annual assessed Own Use Gas (GWh)	Annual assessed CV Shrinkage (GWh)
2013/14	2,472	1,548	6
2014/15	2,173	1,358	27
2015/16	2,838	1,458	71
2016/17	1,103	2,650	51
2017/18	775	2,427	23
2018/19	1,532	1,127	15
2019/20	3,318	687	57
2020/21	2,929	1,208	236

Figure 2:

Formula Year	Annual pre-reconciliation assessed Unaccounted for Gas (GWh)	Annual post-reconciliation assessed Unaccounted for Gas (GWh)
2013/14	2,648	2,472
2014/15	2,121	2,173
2015/16	2,782	2,838
2016/17	1,272	1,103
2017/18	783	775
2018/19	1,528	1,532
2019/20	3,342	3,318
2020/21	2,972	2,929

Figure 3:

Month	Monthly post-Reconciliation assessed Unaccounted for Gas (GWh)	Long-term average monthly post-reconciliation assessed Unaccounted for Gas (GWh)	Average monthly post-reconciliation assessed Unaccounted for Gas for Formula Year (GWh)
Apr-13	317.44	178.53	205.96
May-13	219.73	178.53	205.96
Jun-13	263.95	178.53	205.96
Jul-13	280.72	178.53	205.96
Aug-13	70.32	178.53	205.96
Sep-13	182.42	178.53	205.96
Oct-13	181.28	178.53	205.96
Nov-13	242.19	178.53	205.96
Dec-13	164.73	178.53	205.96
Jan-14	199.55	178.53	205.96
Feb-14	178.06	178.53	205.96
Mar-14	171.13	178.53	205.96
Apr-14	170.10	178.53	181.05
May-14	206.87	178.53	181.05
Jun-14	196.66	178.53	181.05
Jul-14	316.85	178.53	181.05
Aug-14	209.14	178.53	181.05
Sep-14	255.07	178.53	181.05
Oct-14	195.17	178.53	181.05
Nov-14	137.43	178.53	181.05
Dec-14	180.02	178.53	181.05
Jan-15	85.04	178.53	181.05
Feb-15	101.03	178.53	181.05
Mar-15	119.23	178.53	181.05
Apr-15	72.17	178.53	236.48
May-15	312.16	178.53	236.48
Jun-15	128.85	178.53	236.48
Jul-15	214.60	178.53	236.48

Aug-15	455.12	178.53	236.48
Sep-15	271.54	178.53	236.48
Oct-15	277.74	178.53	236.48
Nov-15	238.92	178.53	236.48
Dec-15	306.21	178.53	236.48
Jan-16	233.55	178.53	236.48
Feb-16	141.95	178.53	236.48
Mar-16	184.97	178.53	236.48
Apr-16	205.08	178.53	91.89
May-16	217.46	178.53	91.89
Jun-16	135.27	178.53	91.89
Jul-16	53.27	178.53	91.89
Aug-16	205.62	178.53	91.89
Sep-16	210.84	178.53	91.89
Oct-16	183.72	178.53	91.89
Nov-16	40.17	178.53	91.89
Dec-16	-54.23	178.53	91.89
Jan-17	-92.83	178.53	91.89
Feb-17	-83.14	178.53	91.89
Mar-17	81.41	178.53	91.89
Apr-17	141.25	178.53	64.62
May-17	88.64	178.53	64.62
Jun-17	14.68	178.53	64.62
Jul-17	105.72	178.53	64.62
Aug-17	86.80	178.53	64.62
Sep-17	135.25	178.53	64.62
Oct-17	0.15	178.53	64.62
Nov-17	-48.25	178.53	64.62
Dec-17	-20.10	178.53	64.62
Jan-18	32.59	178.53	64.62
Feb-18	100.31	178.53	64.62
Mar-18	138.44	178.53	64.62
Apr-18	145.25	178.53	127.64

May-18	30.21	178.53	127.64
Jun-18	-82.80	178.53	127.64
Jul-18	77.92	178.53	127.64
Aug-18	51.14	178.53	127.64
Sep-18	15.84	178.53	127.64
Oct-18	236.27	178.53	127.64
Nov-18	218.61	178.53	127.64
Dec-18	158.94	178.53	127.64
Jan-19	313.79	178.53	127.64
Feb-19	209.72	178.53	127.64
Mar-19	156.83	178.53	127.64
Apr-19	213.20	178.53	276.51
May-19	225.00	178.53	276.51
Jun-19	223.99	178.53	276.51
Jul-19	201.31	178.53	276.51
Aug-19	130.08	178.53	276.51
Sep-19	-4.64	178.53	276.51
Oct-19	239.09	178.53	276.51
Nov-19	517.29	178.53	276.51
Dec-19	486.04	178.53	276.51
Jan-20	379.70	178.53	276.51
Feb-20	362.66	178.53	276.51
Mar-20	344.46	178.53	276.51
Apr-20	158.69	178.53	244.11
May-20	211.42	178.53	244.11
Jun-20	163.19	178.53	244.11
Jul-20	169.64	178.53	244.11
Aug-20	283.79	178.53	244.11
Sep-20	157.38	178.53	244.11
Oct-20	233.18	178.53	244.11
Nov-20	364.98	178.53	244.11
Dec-20	355.91	178.53	244.11
Jan-21	314.78	178.53	244.11

Feb-21	280.77	178.53	244.11
Mar-21	235.56	178.53	244.11

Figure 4:

Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)	Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)
Sep-19	-4.64	Sep-20	157.38
Oct-19	239.09	Oct-20	233.18
Nov-19	517.29	Nov-20	364.98
Dec-19	486.04	Dec-20	355.91
Jan-20	379.70	Jan-21	314.78
Feb-20	362.66	Feb-21	280.77
Mar-20	344.46	Mar-21	235.56

Figure 5:

Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)	Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)
Apr-13	317.44	Apr-17	141.25
May-13	219.73	May-17	88.64
Jun-13	263.95	Jun-17	14.68
Jul-13	280.72	Jul-17	105.72
Aug-13	70.32	Aug-17	86.80
Sep-13	182.42	Sep-17	135.25
Oct-13	181.28	Oct-17	0.15
Nov-13	242.19	Nov-17	-48.25
Dec-13	164.73	Dec-17	-20.10
Jan-14	199.55	Jan-18	32.59
Feb-14	178.06	Feb-18	100.31
Mar-14	171.13	Mar-18	138.44
Apr-14	170.10	Apr-18	145.25
May-14	206.87	May-18	30.21

Jun-14	196.66	Jun-18	-82.80
Jul-14	316.85	Jul-18	77.92
Aug-14	209.14	Aug-18	51.14
Sep-14	255.07	Sep-18	15.84
Oct-14	195.17	Oct-18	236.27
Nov-14	137.43	Nov-18	218.61
Dec-14	180.02	Dec-18	158.94
Jan-15	85.04	Jan-19	313.79
Feb-15	101.03	Feb-19	209.72
Mar-15	119.23	Mar-19	156.83
Apr-15	72.17	Apr-19	213.20
May-15	312.16	May-19	225.00
Jun-15	128.85	Jun-19	223.99
Jul-15	214.60	Jul-19	201.31
Aug-15	455.12	Aug-19	130.08
Sep-15	271.54	Sep-19	-4.64
Oct-15	277.74	Oct-19	239.09
Nov-15	238.92	Nov-19	517.29
Dec-15	306.21	Dec-19	486.04
Jan-16	233.55	Jan-20	379.70
Feb-16	141.95	Feb-20	362.66
Mar-16	184.97	Mar-20	344.46
Apr-16	205.08	Apr-20	158.69
May-16	217.46	May-20	211.42
Jun-16	135.27	Jun-20	163.19
Jul-16	53.27	Jul-20	169.64
Aug-16	205.62	Aug-20	283.79
Sep-16	210.84	Sep-20	157.38
Oct-16	183.72	Oct-20	233.18
Nov-16	40.17	Nov-20	364.98
Dec-16	-54.23	Dec-20	355.91
Jan-17	-92.83	Jan-21	314.78
Feb-17	-83.14	Feb-21	280.77

Mar-17	81.41	Mar-21	235.56

Figure 6 & 12:

Daily assessed UAG values are published on the National Grid website via the following link: https://www.nationalgridgas.com/balancing/unaccounted-gas-uag. The upper and lower baseline UAG quantities provided in Figure 5 are respectively -20 GWh and +20 GWh.

Figures 7 – 10 & 14 - 16:

Daily actual energy values for the NTS entry and exit points are published on the National Grid website via the following link: https://www.nationalgridgas.com/data-and-operations/transmission-operational-data.

Figure 11:

Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)	Month	Monthly post-reconciliation assessed Unaccounted for Gas (GWh)
Apr-19	213.20	Apr-20	158.69
May-19	225.00	May-20	211.42
Jun-19	223.99	Jun-20	163.19
Jul-19	201.31	Jul-20	169.64
Aug-19	130.08	Aug-20	283.79
Sep-19	-4.64	Sep-20	157.38
Oct-19	239.09	Oct-20	233.18
Nov-19	517.29	Nov-20	364.98
Dec-19	486.04	Dec-20	355.91
Jan-20	379.70	Jan-21	314.78
Feb-20	362.66	Feb-21	280.77
Mar-20	344.46	Mar-21	235.56

Figure 13:

Formula Year	Number of instances of reconciliation published in October 2020 UAG report	Reconciled energy (absolute) published in October 2020 UAG report (GWh)	Number of instances of reconciliation processed since publication of October 2020 UAG report	Reconciled energy (absolute) processed since publication of October 2020 UAG Report (GWh)
2013/14	45	216.49	0	0
2014/15	47	250.71	0	0
2015/16	63	513.72	0	0
2016/17	127	552.32	0	0
2017/18	61	573.78	5	15.31
2018/19	36	232.48	4	8.12
2020/21	10	34.38	3	41.18
2020/21	2	12.01	14	115.90

*some reconciliations cross multiple Formula Years

Figure 17:

Formula Year	Annual CVS (GWh)
2016/17	51
2017/18	23
2018/19	15
2019/20	57
2020/21	236

Figure 18:

Month	Monthly Total CVS Caused by Capping (GWh)	Month	Monthly Total CVS Caused by Capping (GWh)
Apr-20	2.82	Oct-20	23.48
May-20	14.17	Nov-20	12.07
Jun-20	14.37	Dec-20	9.14
Jul-20	22.31	Jan-21	37.19

Aug-20	20.96	Feb-21	38.52
Sep-20	8.14	Mar-21	13.93

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom
Registered in England and Wales
No. 4031152

nationalgrid.com