



UAGCVS Report

November 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 April 2021 to 30th September 2021 inclusive, the period since the publication of the May 2021 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 RIIO 2 price control 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.

The total assessed UAG quantity for the April 2021 to September 2021 period is lower than the previous six-month period. Monthly assessed UAG is also less than the long-term average (April 2013 to September 2021) for 5 of the last 6 months, which is in line with throughput behaviour across summer and winter months.

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.

The increases in CVS that were observed during the 2020/21 period have curtailed during Formula Year 2021/22. This is mainly due to a reduction in CV capping experienced in the NO and NE LDZ's following increases in supply from St Fergus.

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.

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Unaccounted for Gas & Calorific Value Shrinkage Report – November 2021

Introduction

This report provides a review of National Grid's Unaccounted for Gas and Calorific Value Shrinkage 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 April to 30th September 2021 inclusive, the period since the publication of the May 2021 UAG report. It describes National Grid's 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 RIIO 2 price control 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 – requirement to undertake work to investigate the causes of UAG and CVS which is detailed in Appendix I of the report.

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 within 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 1st April 2021 to 30th September 2021.

Formula Years 2013/14 to 2021/22 (so far)

Figure 1 provides the annual assessed UAG, OUG and CVS quantities for Formula Years 2013/14 to 2021/22 (so far). A Formula Year refers to the period from 1st April to 31st March of the following year.

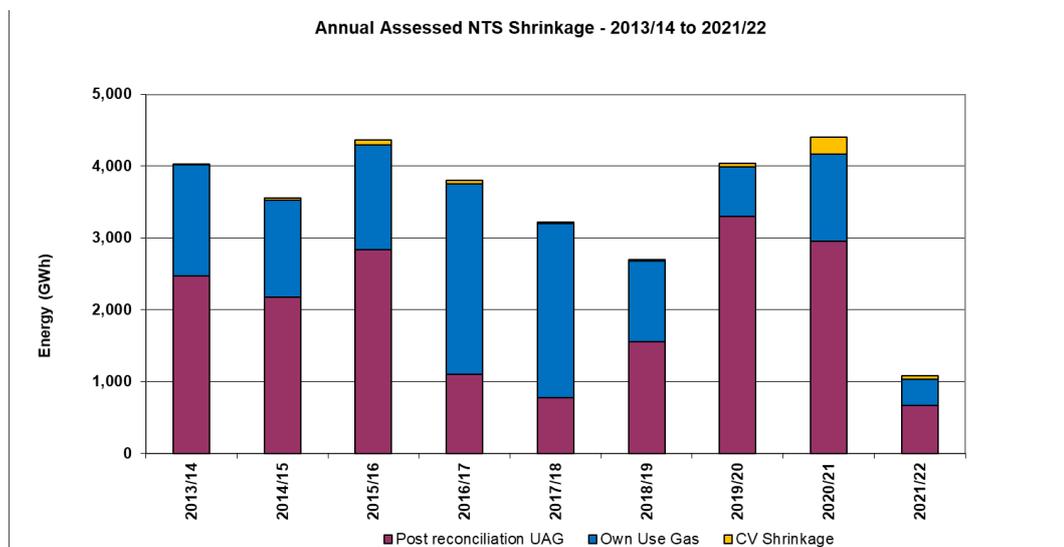


Figure 1: Annual assessed NTS Shrinkage – 2013/14 to 2021/22
 * 2021/22 includes months April 2021 to September 2021

Figure 1 demonstrates that for Formula Year 2021/22, so far, Shrinkage is low with UAG being the prominent component. UAG currently accounts for 62% of NTS Shrinkage with OUG accounting for 33% and CVS accounting for 5% which is a similar proportion to the last Formula Year.

Figure 2 provides a summer period assessed UAG, OUG and CVS including April to September data for each Formula Year.

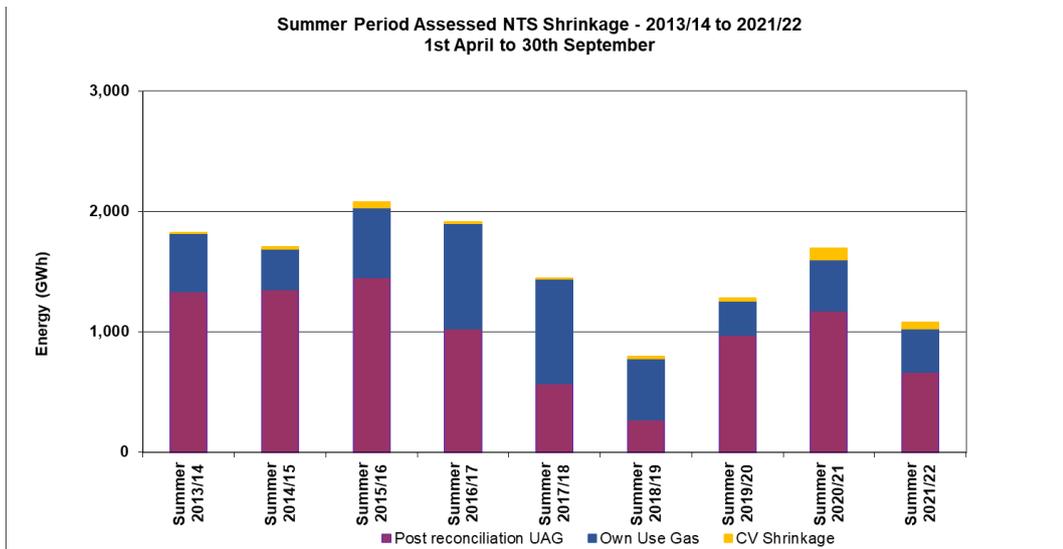


Figure 2: Summer Period Assessed NTS Shrinkage – 2013/14 to 2021/22

Figure 2 demonstrates that NTS Shrinkage throughout this summer period (April to September) has been lower than most other summer periods. Although each component as a proportion of total Shrinkage for this current period remains similar to the previous year's summer period, all three component values have decreased in comparison.

Post Reconciliation UAG is 43% lower than last year's summer period seeing 12 instances that exceeded ± 20 GWh and a slight increase in days where UAG was negative.

OUG values have also decreased in comparison to the previous year's summer period, a reduction of 16% has been observed. The decrease in OUG is largely due to a reduction in supply volumes from LNG terminals, therefore requiring less gas compression to move the gas across the NTS.

CVS is 45% lower than last year's summer period. Further information on CVS can be found in the CVS Statement further on in this report.

Figure 3 provides the annual assessed quantities of UAG for Formula Years 2013/14 to 2021/22.

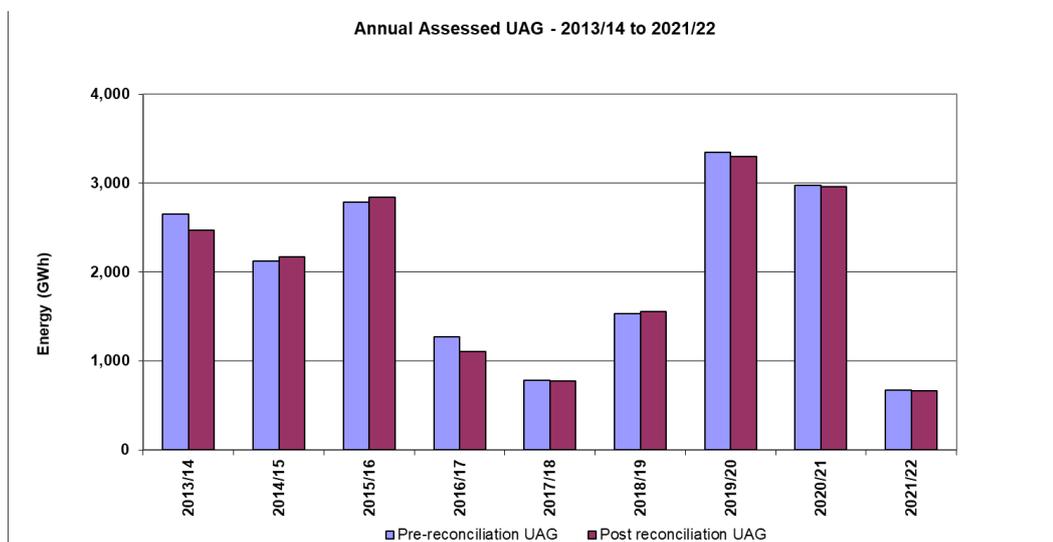


Figure 3: Annual assessed UAG – 2013/14 to 2021/22

* 2021/22 includes months April 2021 to September 2021

Figure 3 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 2017/18 has increased, although higher UAG over this year's winter may occur, trends in UAG behaviour over the past six months have not compared to the same months over the last 3 formula years with UAG values being lower.

During 2016/17 to 2018/19 Formula Years, durations of negative UAG were observed which reduced the net total of UAG for those years as seen in figure 4. However, the number of days that have exceeded -20 GWh has remained low across all Formula Years. Therefore, highlighting that the lower levels of annual assessed UAG observed in 2016/17 to 2018/19 were not as a result of large spikes of negative UAG.

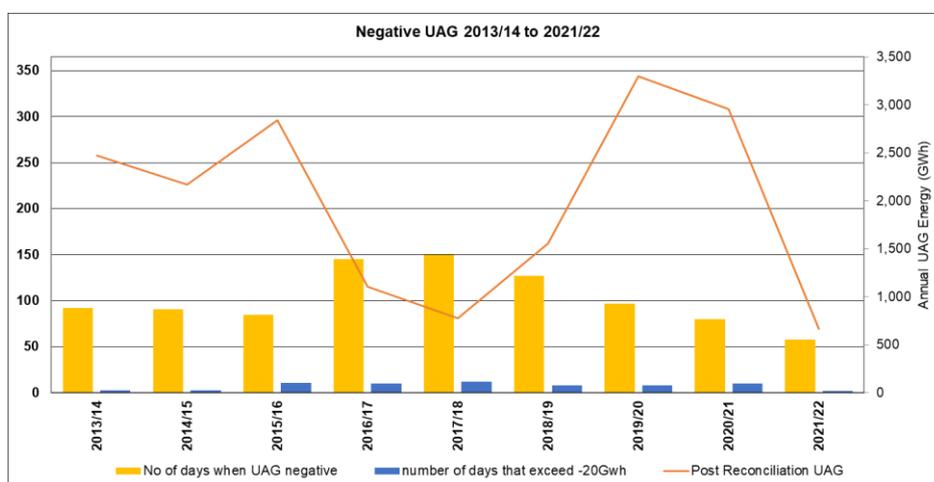


Figure 4: Negative UAG – 2013/14 to 2021/22
 *2021/22 includes months April 2021 to September 2021

The increase in assessed UAG witnessed in 2019/20 and 2020/21 highlighted trends that have not been seen before. These have been investigated using data science and will continue to be further analysed in the future.

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 2021/22. The table also provides the annual assessed Post Reconciliation 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	2021/22
Assessed Level (GWh)	2,472	2,173	2,838	1,103	776	1,555	3,299	2,958	668
Assessed Daily Average (GWh/d)	6.77	5.95	7.75	3.02	2.12	4.26	9.01	8.10	3.65
Percentage of NTS Throughput	0.28	0.24	0.31	0.12	0.08	0.17	0.36	0.32	0.19

Table 1: Statistical performance of UAG - 2013/14 to 2021/22
 *2021/22 includes months April 2021 to September 2021

The values provided in Table 1 for 2021/22 covers the 6 month period from 1st April 2021 to 30th September 2021 and indicates that annual assessed UAG, assessed daily average UAG and percentage of annual throughput for the year would be lower than the previous year if there is no change in the current trend.

The table highlights that UAG as a percentage of NTS Throughput follows Annual Assessed UAG and has been reducing since 2019/20 with UAG equating to 0.32% of NTS Throughput last year. For 2021/22 so far, UAG as a percentage of NTS Throughput is currently 0.19% and would be lower than the previous year if this year's winter UAG behaviours do not peak beyond the last two winters.

Figure 5 provides the total monthly assessed UAG from April 2013 to September 2021. It also provides the average monthly assessed UAG for this Formula Year (111.33 GWh) depicted as a dotted black line, together with the long-term average assessed UAG for the entire period (174.90 GWh) depicted as a dotted red line.

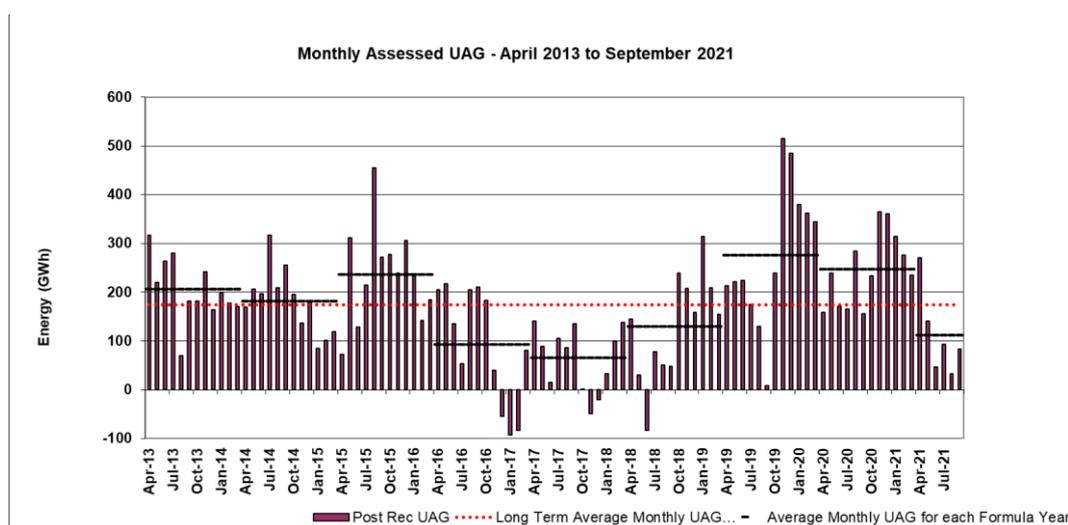


Figure 5: Monthly assessed UAG - April 2013 to September 2021

As Figure 5 indicates, since the start of Formula Year 2021/22, monthly assessed UAG for 5 out of 6 months has been below the long-term average.

November 2016 and September 2018 saw 23 consecutive months below the long-term monthly average, as previously reported in Figure 4, this was due to an increased amount of negative UAG throughout that period. The current formula year has also witnessed a consecutive period with UAG being below the long-term average, this has occurred by lower daily UAG on a daily basis, fewer high spikes in UAG and with having fewer negative days than the previous instance. Analysis so far has not identified the reasons why step changes in UAG behaviour have been observed, but these periods of low and high trends are still of interest to determine the source of the UAG performance. Figure 5 also highlights a similar profile of UAG during the winter months for the 2019/20 and 2020/21 Formula Years, this is being closely monitored as we move into this winter.

Figure 6 provides the total monthly assessed UAG for April to September 2021, compared with the equivalent months within 2020. This indicates a reduction of monthly assessed UAG for all months when compared to the previous Formula Year, except for April 2021, which includes the high UAG trend period witnessed last winter.

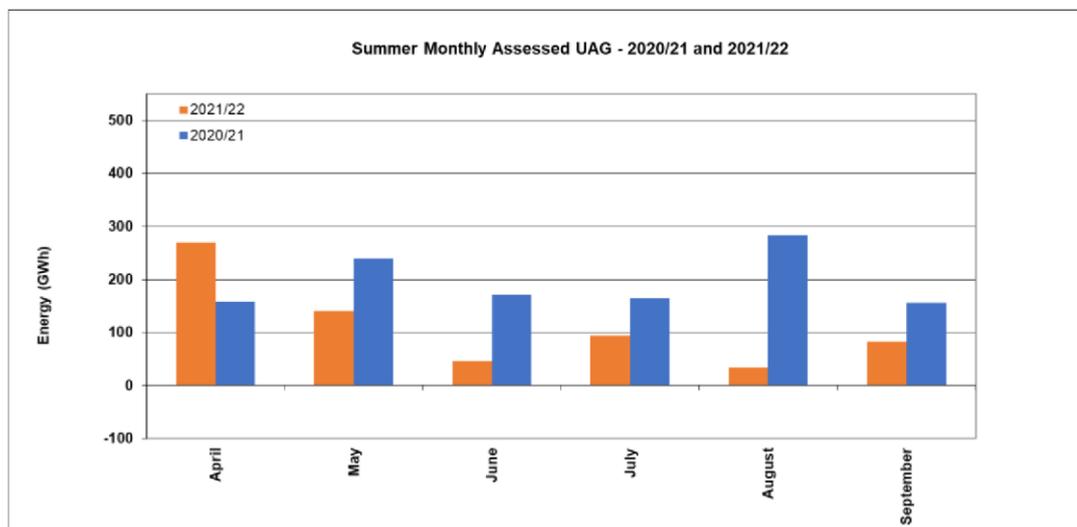


Figure 6: Summer Monthly Assessed UAG – April 2020 to September 2020 and April 2021 to September 2021

As seen in Figure 6, during the last six months the total monthly assessed UAG varied from +33.48 GWh to +270.11 GWh, with a monthly average of 111.33 GWh. These values are lower when compared to the same months in the previous year. During April 2020 to September 2020, total monthly assessed UAG varied from +156.14 GWh to +283.79 GWh with a higher monthly average of 195.63 GWh.

Figure 7 provides the daily assessed UAG values for the period between 1st April 2021 and September 2021 and indicates that UAG has been mostly within the ± 20 GWh limit since April. This is confirmed by the largely flat 30-day rolling average included in the figure (black line). As previously mentioned, April was picking up the tail end of the high UAG trend last winter, a step change can be identified in June 2021 which centred at around 2 GWh average throughout the remainder of the period.

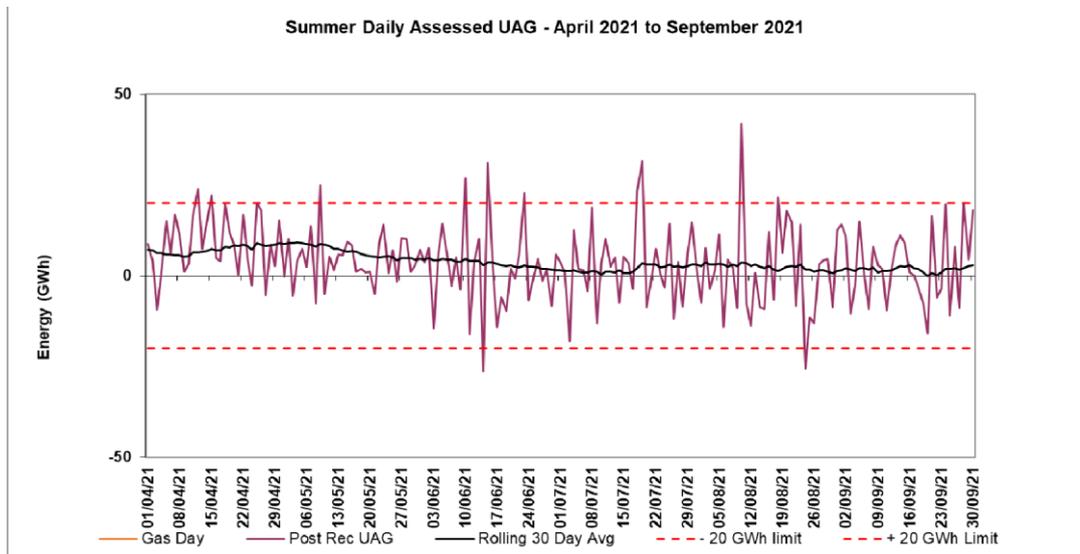


Figure 7: Summer Daily assessed UAG – April 2021 to September 2021

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 April 2021 to September 2021 there were 12 days when daily assessed UAG exceeded ± 20 GWh. This is a 45% reduction in high UAG days when compared to the same period in 2020/21 where 22 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 have been explored via a separate UAG investigation project. The period between April 2021 and September 2021 has not witnessed any UAG trend.

Of the 12 days that exceed ± 20 GWh, National Grid have investigated and have not identified the cause of the UAG.

Figure 8 outlines the demand breakdown with UAG overlaid for the period between April 2018 to September 2021 and does not display any noticeable behavioural changes for most site types over this period apart from a reduction in Interconnector Export volumes and a slight increase in Storage Injection. LDZ Offtakes display a seasonal pattern throughout, as does Interconnector Export, whereas Industrial and Power Station demand demonstrates a more consistent annual offtake.

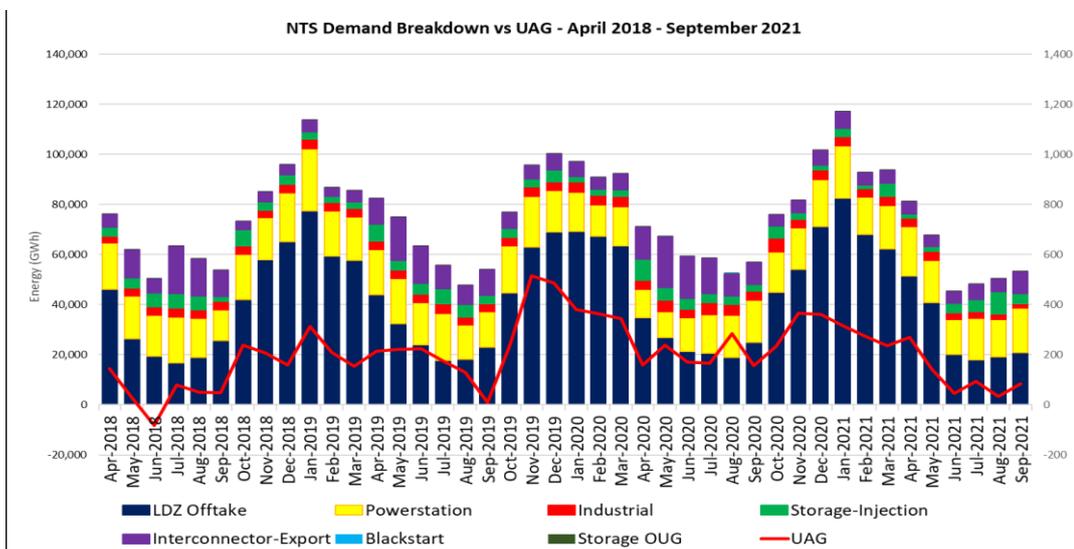


Figure 8: NTS demand breakdown – April 2018 to September 2021

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 significant correlation has been identified, further information on this analysis can be found in the report under section ‘UAG Investigation Project’.

Figure 9 provides an overview of the Supply patterns between April 2018 to September 2021 and demonstrates a seasonal Supply pattern that has been observed in previous UAG Reports. Over the last six months, Terminal and Interconnector Imports have all decreased in line with seasonal Demand. LNG imports at Isle of Grain and Milford Haven ASEPs have featured less this summer.

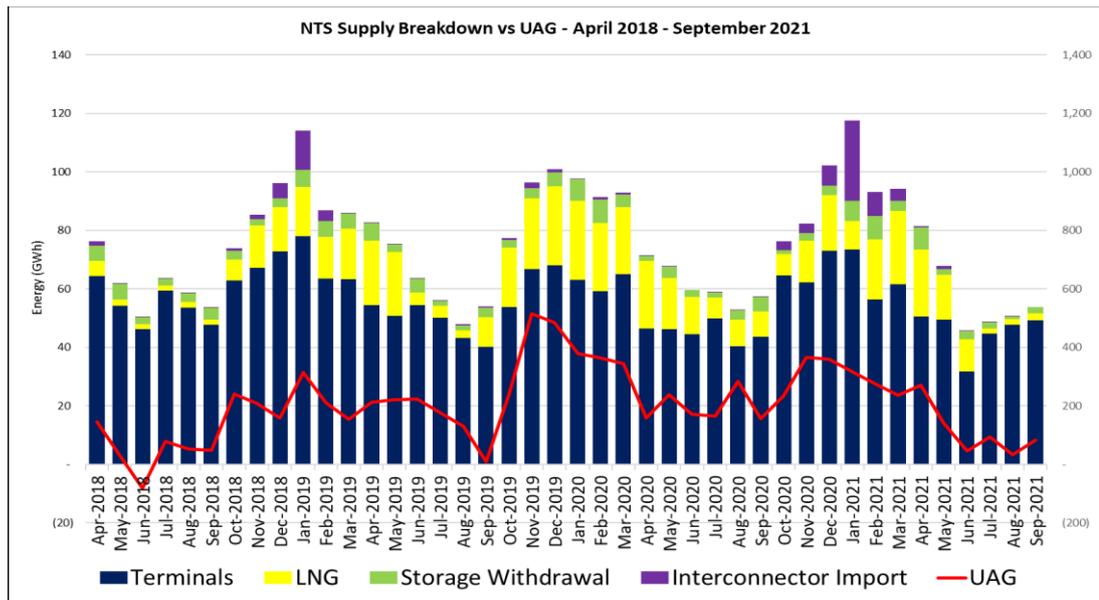


Figure 9: NTS supply breakdown – April 2018 to September 2021

Figure 10 provides the total LNG breakdown including South Hook and Dragon from Milford Haven and both Isle of Grain Terminals in the South East.

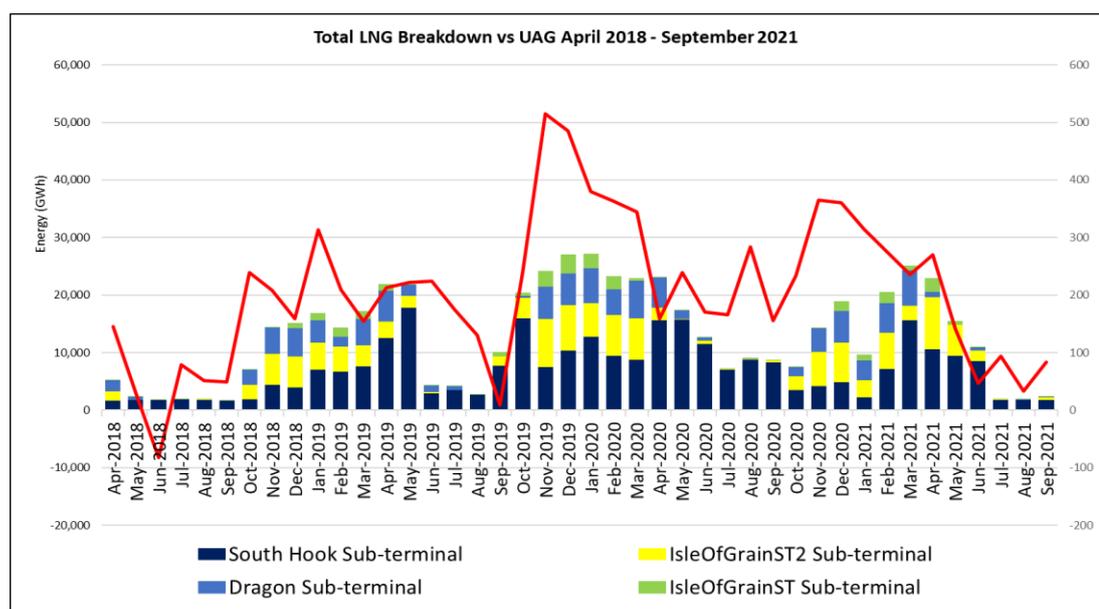


Figure 10: Total LNG breakdown – April 2018 to September 2021

As previously reported, UAG does appear to increase and decrease with LNG flows but so far, there has been no evidence that LNG has been the cause of UAG behaviour.

Figure 11 below compares the total monthly LNG Imports since April 2018 and highlights the change in patterns that have been observed.

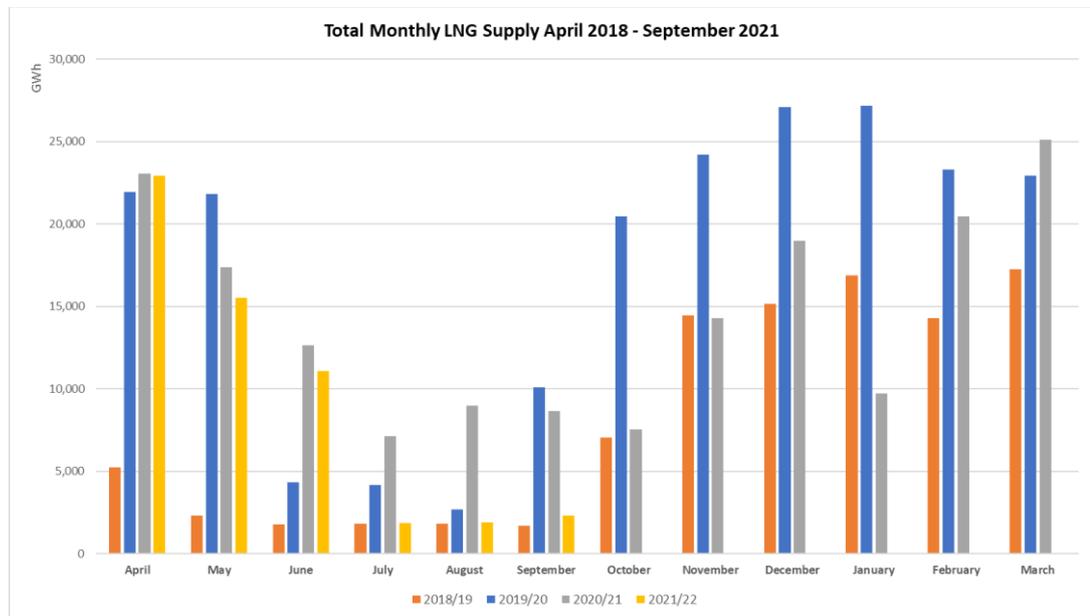


Figure 11: LNG Supply – September 2018 to September 2021

The increase in LNG Import over the winter periods has occurred during the same periods where trends of high positive UAG has been witnessed during the same two Formula Years. This too will be monitored over the coming winter.

The relationship between UAG and LNG has previously been analysed and no significant correlation has been identified so far. National Grid has started to investigate if there is a relationship between UAG and the temperature of gas being imported onto the NTS to understand how this may impact NTS volumes, further information on this investigation will be shared in future UAGCVS Reports. Details of previous analysis is within section ‘UAG Investigation Project’ of the Report.

Figure 12 displays the monthly net Interconnector position (Interconnector exports minus imports) over the period between April 2016 and September 2021.

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. This graph demonstrates that UAG does not follow any pattern to net Interconnector activity.

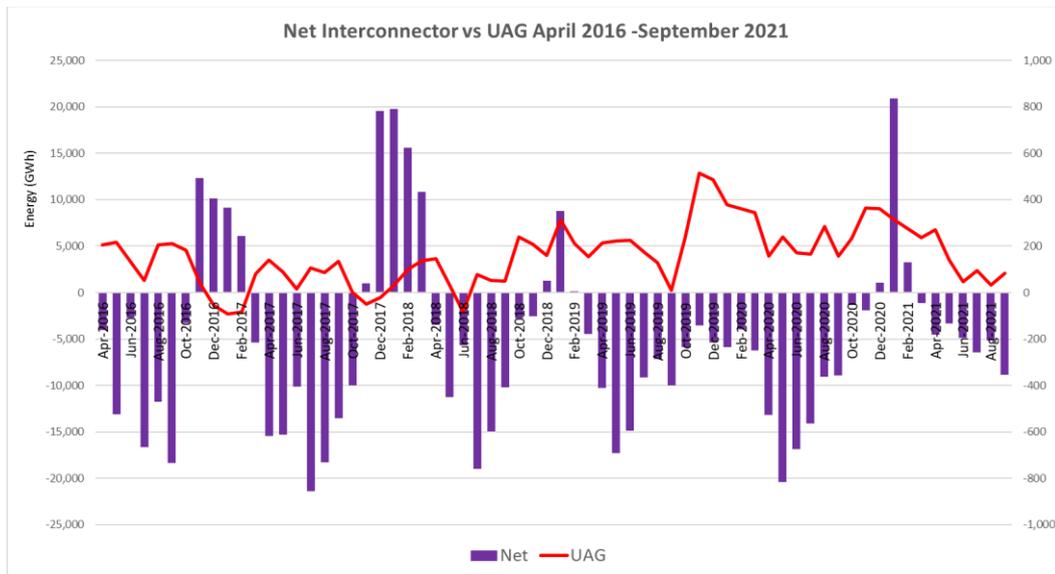


Figure 12: Net Interconnector – April 2016 to September 2021

National Grid are looking into the possibilities of correlation between UAG and net steering difference at Interconnectors. Interconnector measurements are determined as ‘Allocate as Nominate’ meaning that the Interconnector values used within the UAG calculation are commercial values rather than what was physically measured. The Steering Difference is the difference between the net commercial billed and net physical metered measurements on each day for each Interconnected Point and the OBA (Operational Balancing Account), is based on the cumulative difference. The OBA is managed by the Interconnector Operators.

Further analysis into the impacts of what daily Steering Difference and the cumulative OBA has on UAG is currently being investigated and will feature in a future report.

Meter Error is still deemed to be the main cause of UAG. As previously reported this year, a significant meter error notification was submitted to the Joint Office by Cadent to the industry because a meter error had been identified at Alrewas EM NTS to LDZ Offtake between gas days May 2019 to February 2021. Once the Meter Error Report (MER) has been made publicly available, National Grid will submit the corrected measurements to Correla on behalf of Xoserve to be issued on a subsequent invoice.

The UAG investigation project has enabled an end to end review and improvement of current process and systems, automated system validation checks, data automation, data visualisation with a scope to enhance our 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 are 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 2021/22 National Grid has so far received meter validation reports for 29 NTS entry and exit facilities, these reports are for validations that have taken place between April 2021 to September 2021.

The Meter Assurance team has reviewed all of the 29 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. To date, none have been deemed to have caused end of day measurement error.

The Meter Assurance team will continue to request and review the remaining 2021/22 meter validation reports as they are provided throughout the rest of the Formula Year 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

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.

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, social distancing, and number of people safe to be on site, National

Grid has not planned to witness any annual meter validations throughout this period but will reassess the remainder of the year now restrictions have eased.

Relationships with asset owners has still been maintained throughout the pandemic via telephone and email.

Reconciliation

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

In the last six months since the publication of the April 2021 UAG Report, National Grid has adjusted 164.87 GWh in absolute energy terms via the reconciliation process. This comprises 42 instances of reconciliation at individual NTS entry and exit facilities, each instance comprising of one or more days of reconciliation for a total of 96 gas days. The majority of these reconciliations have corrected days in Formula Year 2019/20; however, reconciliations have also been processed for 2018/19 and 2021/22.

Figure 13 provides the annual reconciliation quantities, in absolute energy terms, for 2013/14 to 2021/22. The orange coloured bars indicate the reconciliation quantities processed since the publication of the May 2021 UAG report.

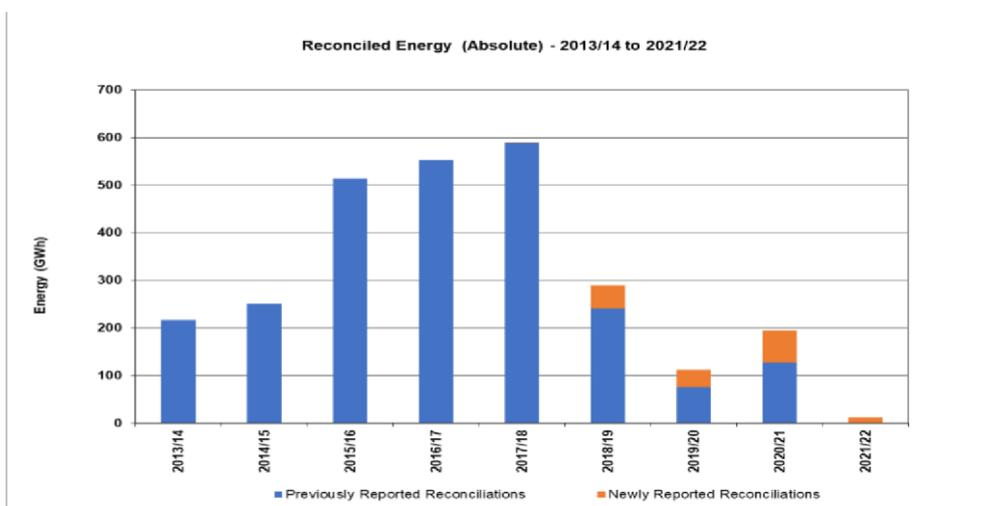


Figure 13: Reconciled energies (absolute) – 2013/14 to 2021/22

Of the 42 instances of reconciliation processed, 12 related to meter error (29% of instances) and 30 related to data error (71% 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. National Grid hopes that this can be rolled out to NTS Storage sites in the future. 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 is continuing to process meter and data error reconciliations which will be included in future 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 an Agile methodology utilising sprints to 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 sources of UAG.

Since the publication of the May 2021 UAG Report the project has carried out the following:

Further correlation detection using different variables compared to UAG behaviours has been completed. Linepack Drift was one of the variables analysed, which is the difference between Predicted Closing Linepack (PCLP) and Actual Linepack. Moderate to high correlation was detected which has instigated further analysis to be carried out this Formula Year. The detail of the correlation analysis is below within the Data Science section of this report.

A new data model has been delivered and a suite of new dashboards have been developed to enhance National Grids ability to visualise and validate daily Measurements. The dashboards allow access to more data points such as raw telemetry data via National Grids Gas National Control Centre's SCADA system within Tableau permitting for more advanced measurement checking within entry and exit closeout periods. The dashboards have been tested and are embedded within the team's processes.

A review of an analytical tool and its mathematical models has been completed by our data scientist. This has allowed a deeper understanding of its potential and will help to scope the next phase of its development enabling causation of UAG at site level.

A review of the current linepack calculation model has been carried out alongside historical and new linepack analytical and theoretical papers. A theory that involves introducing ground temperatures was tested within the linepack model which has given some suggestion that it could reduce linepack bias. Only a small sample of data was taken for this study, therefore a further study has been scoped to investigate this theory further.

Table 2 provides an overview of the UAG projects and initiatives National Grid have planned over this Formula Year (2021/22). The table confirms if the project or initiative was in the previous reporting period (April 2021 to September 2021), this reporting period (October 2021 to March 2022) or was scheduled over the wider 12-month reporting period (2021/22).

Project / Initiative	Target Completion Date	UAG CVS /	OUTCOME
Full Assessment of mathematical models in the National Grid Analysis Tool	April 21 to September 21 reporting period	UAG	The Analysis tool has been reviewed by a data scientist and in its current format, is not capable of identifying the causation of UAG. Further modelling and data validation is required.
Enhancements to UAG Causality detection models	Wider 2021/22 reporting period	UAG	N/A for this report
Periodic review of UAG Trends (if applicable)	Wider 2021/22 reporting period	UAG	Work is ongoing, outcome N/A for this report
Review of current Linepack Model	April 21 to September 21 reporting period	UAG	A review of the current linepack model has been carried out to determine any potential bias to linepack caused by parameters such as fixed temperature. Our findings suggest potential improvement could be made to the current linepack model if current fixed temperatures are replaced with ground temperatures for specific regions. Further analysis is required with larger data sets to determine the financial magnitude of the current model.
Linepack calculation improvements	Wider 2021/22 reporting period	UAG	N/A for this report
Continuous improvement / process improvement to the Settlements Process and ability to validate site Measurements within Entry and Exit Closeout	Wider 2021/22 reporting period	UAG	Work is ongoing, outcome N/A for this report
Embed the new data models and build dashboards to reduce erroneous measurements being settled	April 21 to September 21 reporting period	UAG	New dashboards have been embedded within the daily processes which enables validation from multiple data sources to identify measurement error before close out
Enhancements to Tableau dashboards to improve high UAG checks and better detection of the cause of High UAG	April 21 to September 21 reporting period	UAG	Improvements have been made to introduce checks for Offtake metering and further analysis is ongoing to understand the potential impact of linepack and Interconnector OBA
Linepack Analysis using ground temperature	October 21 to March 22 reporting period	UAG	Work is ongoing, outcome N/A for this report
Telemetry Triage to improve the handling and faster response of telemetry queries	April 21 to September 21 reporting period	UAG	This work is complete and embedded within the process
Investigate the causes of Interconnector OBA on UAG and improve the process	October 21 to March 22 reporting period	UAG	Work is ongoing, outcome N/A for this report

Table 2: 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

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.

As shown in Table 3, correlation analysis has been carried out on various site type variables to determine whether there are any relationships to UAG behaviours.

SITE TYPE / VARIABLE	OUTPUT / RESULT
LNG	To date, no significant correlation has been identified with the site types and variables to UAG.
Power Stations	
Industrial Sites	
Sub Terminals	
Storage	
Interconnectors	
LDZ Offtakes	
Compressors	
LDZ Composite Weather Variable (CWV)	
UIG (LDZ)	
NTS Throughput	
Alrewas EM (Over Meter Error period)	
UAG V Linepack Drift	Conclusive that there is some evidence of inverse correlation between UAG and Linepack drift. The next stage is to determine the causation of that inverse correlation.

Table 3: Correlation Analysis per Site Type / Variable

This correlation analysis was carried out over periods of unusual UAG trends for a range of dates between 2018 and 2021. All tests were inconclusive apart from when UAG was analysed with Linepack Drift, which does demonstrate an inverse correlation between them. Details of the majority of the tests listed in table 3 can be found in the May 2021 UAG Report. Although the results have so far been inconclusive, correlation analysis will be revisited with findings detailed in future reports.

Figure 14 displays the inverse correlation between UAG and Linepack Drift from July 2020 to July 2021, which gave a range of data spanning from high and low UAG periods. This shows that when UAG is high, Drift is low and visa-versa. The data used were 7-day

averages of each variable which better displays the data without the fluctuation of daily UAG.

UAG and Drift data July 2019 – July 2021

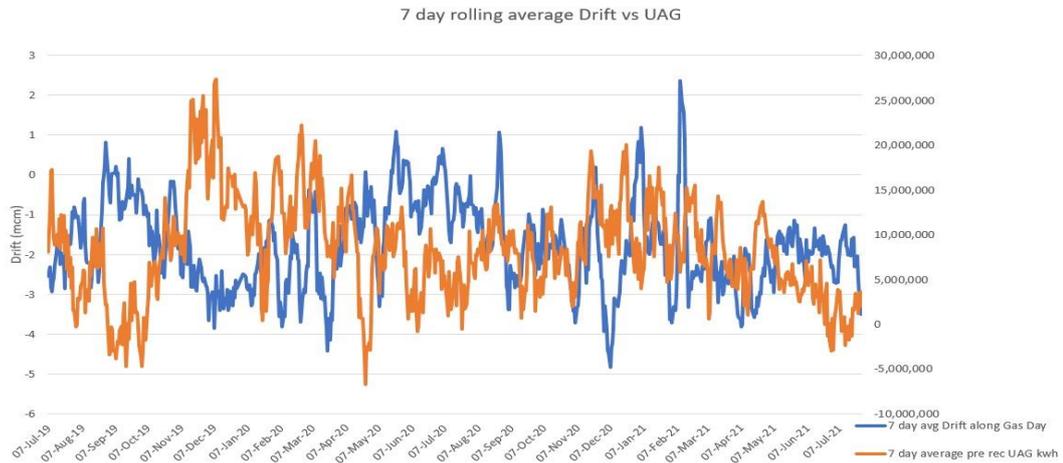


Figure 14: UAG and Linepack Drift data July 2019 to July 2021

The previous correlation analysis that was carried out within table 3 showed minimal correlation of up to 0.25, with ± 1 equating to a complete correlation. The data in Figure 14 however showed moderate to high correlation coefficient measuring the linear relationships of two variables of up to -0.73 between August 2019 and January 2020. Further work is being carried out to understand the reason there is a relationship between the two variables and if one can influence the other.

An app built using RStudio and hosted on the Shiny platform, was developed for National Grid by a Mathematics PhD student to identify the causation of UAG using various analytical models. This app has undertaken a comprehensive review to understand its methodology with an aim to improve its capability. During this review, the app did not identify any tangible or consistent flags to a particular site that may have caused UAG on a particular gas day. It was deduced that the app requires further levels of data and validation which will be the next phase of its development. The app was also analysed over days where known error had been identified through the reconciliation process and it failed to identify or flag most of those sites.

Tableau Analysis

National Grid utilises Tableau software to visualise and analyse its data. Current Tableau dashboards are enabling 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 developed a dashboard to support the validation of pre close-out measurements and Shipper allocations allowing the team to identify error by comparing settled data to instantaneous telemetered data. This has been made possible due to an improved data model which National Grid continues to develop to allow further visualisation tools to be built.

As further developments are made, National Grid will provide updates in future reports.

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 is calculated by summing the product of the CV and volume for all supply inputs and dividing by the total volume of gas entering the charging area.

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

To calculate CVS, National Grid deduct the value that is used to bill downstream shippers based on the principles detailed above, from what was measured leaving the NTS by OFGEM approved equipment.

CVS occurs every day for all charging areas with more than one supply input into the region, this usually only equates to very small quantities if capping hasn't occurred, and is a result of the charging area 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 avoid or minimise the amount of CVS each day.

With that in mind, if capping is caused by an NTS/LDZ offtake, National Grid will investigate and where possible to minimise or avoid capping, will provide guidance to the Distribution Network Operator (DNO) to alter patterns of flow through the offtakes or alternatively look at solutions to alter flows within the NTS to improve blending of gases. If the capping is caused by a non-NTS connected asset that inputs gas into the LDZ, the DNO's will investigate the source and liaise with the relevant asset owner to avoid future instances.

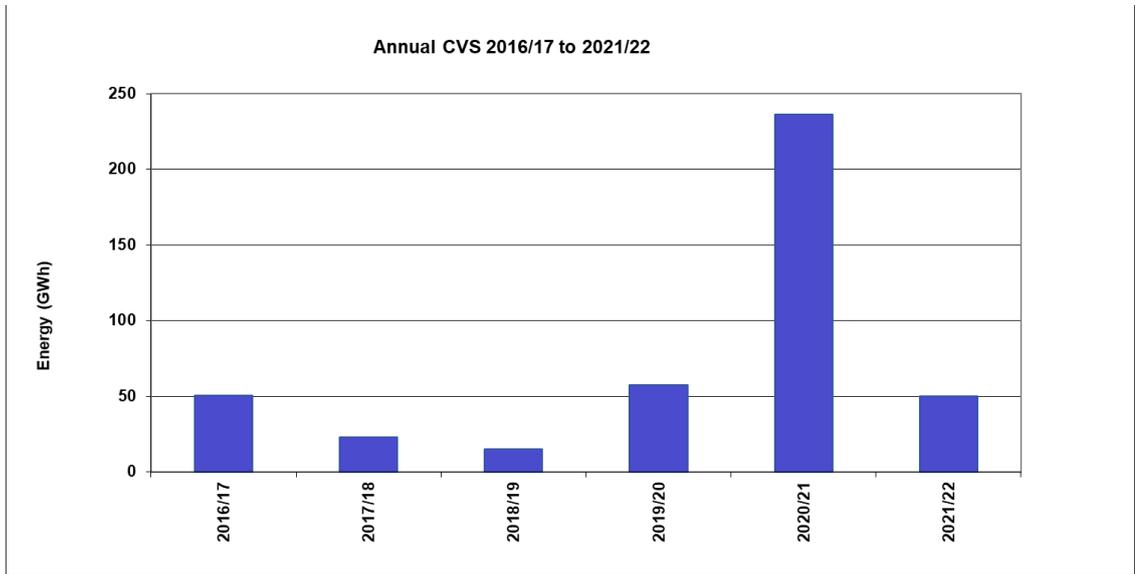


Figure 15 - Annual CVS 2016/17 to 2021/22

Figure 15 provides total annual CVS for Formula Years 2016/17 to 2021/22. The figure indicates there has been no obvious trend year on year for CVS. Formula Year 2020/21 witnessed an increase of 312% from the previous year, although for 2021/22 so far, is not experiencing similar CVS values. Therefore, based on current CVS volumes, 2021/22 is expected to be lower than 2020/21.

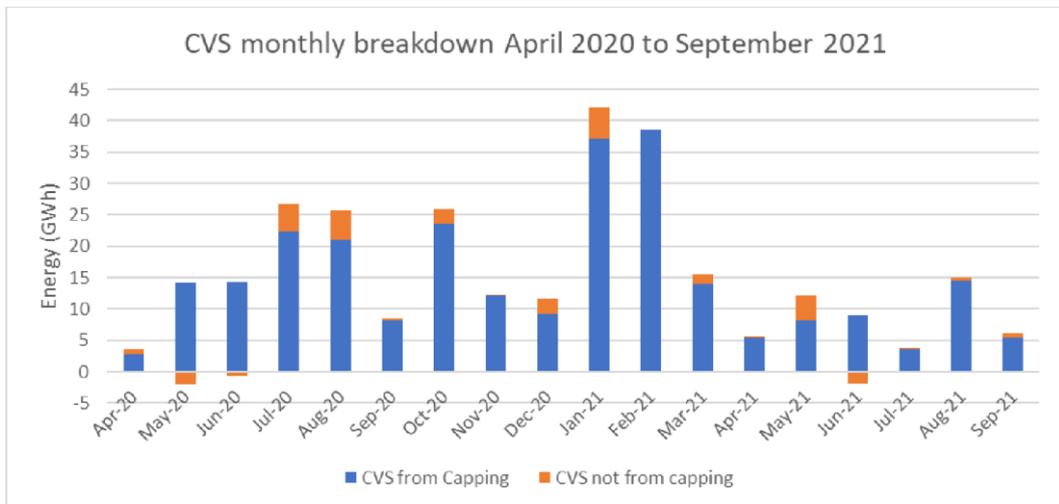


Figure 16 - CVS Monthly Breakdown 2020/21 to 2021/22

Figure 16 provides a monthly breakdown of CVS for Formula Years 2020/21 and 2021/22 (so far), outlining the proportion detailed in blue that represents CVS due to 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 the last six months, CV capping has equated to 46.33 GWh with capping occurring in 9 of the 13 LDZs, which is lower than the previous six months where a total of 134.34 GWh had been observed.

Although CV capping is still most prevalent in the North East (NE) and Northern (NO) regions, the values have decreased. NE has seen a reduction of 82% and NO has reduced by 48% when compared to the previous 6 month period, reduced capping has also occurred in NW and SC. CV capping has been observed in EA, EM, NT, SO and WM regions over the last 6 months as seen in Table 4.

Month	CVS caused by Capping (GWh)													Total
	EA	EM	NE	NO	NT	NW	SC	SE	SO	SW	WM	WN	WS	
Oct-20	0.00	0.00	7.57	15.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.48
Nov-20	0.00	0.00	11.04	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.07
Dec-20	0.00	0.00	6.83	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.14
Jan-21	0.00	0.00	31.66	5.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.19
Feb-21	0.00	0.00	22.90	15.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.52
Mar-21	0.00	0.00	7.94	3.75	0.00	1.32	0.92	0.00	0.00	0.00	0.00	0.00	0.00	13.93
Apr-21	0.81	0.00	3.15	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.55
May-21	0.00	0.00	8.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.18
Jun-21	0.34	2.44	3.29	1.71	0.00	1.12	0.14	0.00	0.00	0.00	0.00	0.00	0.00	9.04
Jul-21	1.25	0.00	0.69	0.96	0.26	0.00	0.00	0.00	0.00	0.00	0.45	0.00	0.00	3.60
Aug-21	0.00	0.00	0.14	14.11	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	14.56
Sep-21	0.00	0.72	0.00	4.59	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	5.40
Totals	2.41	3.16	103.38	67.10	0.26	2.43	1.06	0.00	0.10	0.00	0.76	0.00	0.00	180.67

Table 4: CVS Caused by Capping (GWh)

The majority of CV capping over the last 6 months has been witnessed in NO and NE regions due to greater supplies of gas entering the region from the Teesside terminal (North East), which has a higher CV to the smaller volumes of gas entering the region from St Fergus terminal (North Scotland). Due to the NTS configuration in that area, blending of the different terminal gasses cannot be achieved has not occurred, therefore there is a disparity in CV's entering the LDZ, which leads to capping

Conclusion

The total assessed UAG quantity for the April 2021 to September 2021 period is lower than the previous six-month period. Monthly assessed UAG is also less than the long-term average (April 2013 to September 2021) for 5 of the last 6 months, which is in line with throughput behaviour across summer and winter months.

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.

The increases in CVS that were observed during the 2020/21 period have curtailed during Formula Year 2021/22. This is mainly due to a reduction in CV capping experienced in the NO and NE LDZ's following increases in supply from St Fergus.

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.

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).

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