



SHRINKAGE LEAKAGE MODEL REVIEW

FINAL RESPONSE TO REPRESENTATIONS RECEIVED

GAS DISTRIBUTION NETWORKS REVIEW THE SHRINKAGE AND LEAKAGE MODEL ON AN ANNUAL BASIS AND CONSULT ON THE OUTCOME OF THAT REVIEW WITH OTHER GDN OPERATORS, GAS SHIPPERS AND INTERESTED PARTIES.

Joint Gas Distribution Network Submission
PUBLISHED | 31ST DECEMBER 2017

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1 Background

Shrinkage gas has reduced in recent years primarily through continued investment in pressure management and a targeted mains replacement programme. Gas Distribution Networks (GDNs) strive to ensure the calculation and reporting of Shrinkage gas is continually improved.

Each year, the GDNs publish a consultation driven by Shippers, GDNs and other interested parties. The purpose of this review is to detail the successes the industry has experienced as a result of continued development of the Shrinkage and Leakage model (SLM) and also detailed how the GDNs will continue to ensure shrinkage reporting accuracy and also that the model remains relevant and fit for purpose.

A joint Distribution Network report¹ was published on 12th November 2017 for industry consultation, and we are pleased to have received representations from Corona Energy² and ICoSS³.

As part of our ambition to increase stakeholder engagement and understanding of shrinkage related matters, we initially invited comment at the March and August Shrinkage Forums on areas that could be considered for inclusion in the initial review document.

We would like to take the opportunity to assure interested parties that whilst the SLM review process represents a positive opportunity for wider industry review and comment, we are also committed to understanding the views of our stakeholders via the Shrinkage Forum which meets on a quarterly basis throughout the year. We consider that the Shrinkage Forum presents a useful vehicle for interested parties to understand the elements of the shrinkage assessment process of most interest to them, and importantly, also provides an opportunity for our stakeholders to share their views with Distribution Network representatives.

As a result of stakeholder feedback represented through the August 2017 Shrinkage Forum, GDNs have tailored our commitments for the coming 12 months to focus on reporting elements which are of concern to the industry (See sections 8 and 10 of the SLM Consultation). Furthermore, GDNs have incorporated additional elements in to the SLM in order to supplement understanding, increase awareness, and to deliver on our stakeholder requests. A performance breakdown was included to demonstrate the main components of Shrinkage for each Local Distribution Zone (LDZ). The introduction of these performance measures is as a result of feedback received during the 2016/17 SLM review stakeholder consultation and August 2017 Shrinkage Forum (See Appendix A of the SLM Consultation).

2 Outcome of the Consultation

The consultation document set out the findings of the joint GDN review of the Shrinkage and Leakage Model and detailed our future commitments. The consultation process has raised specific areas for attention, identified below, to which we offer our response within this document. Please note, where similar points have been raised by both Corona Energy and ICoSS, these items have been grouped in order to avoid repetition.

2.1 Representations and Responses

This section presents the Corona Energy and ICoSS representations to the consultation and the joint GDN response. GDNs have captured the salient points from the representations for the purposes of this review paper; the full representations can be accessed on the Joint Office of Gas Transporters website.

¹ [2017 SLM Consultation](#)

² [Corona Energy Response](#)

³ [ICoSS Response](#)

- I. “transporters should seek to undertake a review of shrinkage to ensure that it is not contributing to Unidentified Gas and so prevent a repeat of the situation where the AUGE and the transporters disagree with each other over the level of shrinkage error present in Unidentified Gas” – **ICoSS**
- II. “transporters [to] undertake a thorough review of the current regime to ensure it is robust and equitable to restore confidence that the process provides an accurate view of shrinkage in the market and does not contribute towards Unidentified Gas (UIG). In our view this review should operate alongside the review currently being undertaken by shippers to improve Unidentified Gas (UIG)” – **Corona Energy**
- III. “One of the potential contributory factors to [UIG] volatility, along with daily read errors and deficiencies in the NDM calculation, would be any inaccuracies in the current shrinkage calculation (either positive or negative)” – **Corona Energy**

GDN Response

Whilst Shrinkage gas is an extremely small element of overall daily gas allocation in comparison to the other contributory factors (approximately 0.5%), as captured by XOSERVE at the November 2017 Shrinkage Forum; GDNs do acknowledge any Shrinkage calculation error would remain a part of UIG.

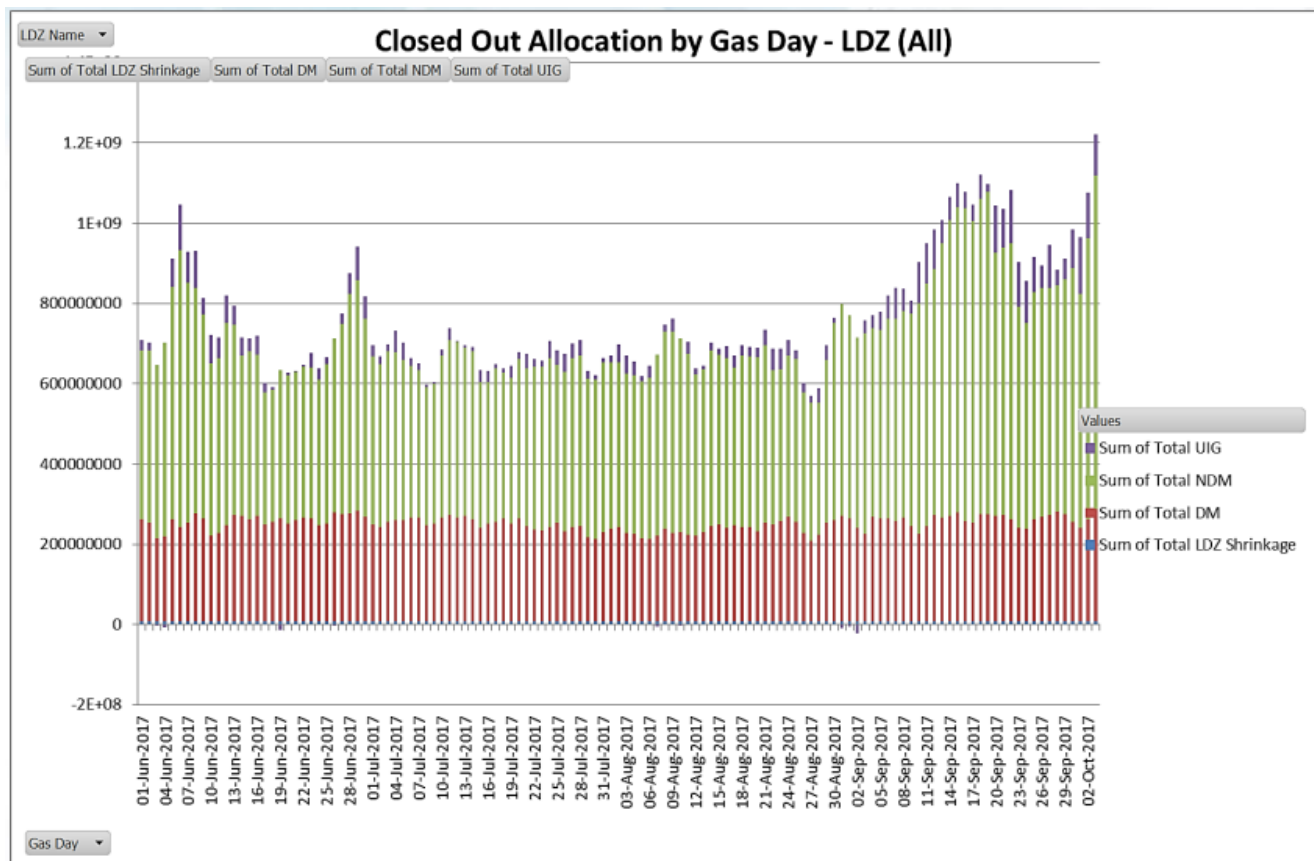


Figure 1 – Total Allocation by Gas Day⁴

To calculate Shrinkage, GDNs use many thousands or pieces of data relating to our assets and their operation. This data is refreshed annually to ensure the shrinkage calculations remain reflective of reality. The data goes

⁴ [Xoserve UIG Awareness Presentation to Nov 2017 Shrinkage Forum](#)

through meticulous checks and audits to ensure it is valid, accurate and free from any errors. GDNs have a License Condition to provide assurance around the data used for reporting purposes and therefore not only is the data examined to ensure validity, the model itself is also thoroughly reviewed to further reassure our output from the SLM reflects reality. Furthermore, the SLM is approved by OFGEM and was independently validated in 2013 when the latest model version was released.

We would like to reassure the industry that we will continue to seek opportunities to enhance the calculation and reporting process and comments are not only welcome but encouraged to help shape the strategy in developing the SLM.

As referenced by DNV GL⁵ in their role as the AUG Expert: *“UIG actually contains error due to the inaccuracy of the NDM algorithm. This error is the cause of the large magnitude and the volatility of the values that are being returned”*. GDNs are committed to ensuring the SLM calculates a realistic quantity of Shrinkage gas and as a result, this ensures the allocation of Shrinkage in the overall gas day allocation remains accurate. Commitments made by the GDNs for opportunities to improve the model as detailed in the SLMR further enhance the reporting of Shrinkage gas.

- IV. “It is.....vital that the shrinkage process is seen to be both robust and transparent, so that shippers can be confident that they are being allocated only those losses that are currently their responsibility” – **ICoSS**

- V. “it is appropriate that the transporters undertake a thorough and fully transparent review of the shrinkage and leakage model as soon as possible, providing its detailed findings to shippers to the level where they can gain confidence that the shrinkage process is robust” – **ICoSS**

GDN Response

As outlined in Section 4 of the SLM Consultation, GDNs go to great lengths to ensure that Shrinkage reporting is both robust and fully auditable. Large volumes of data are annually updated and processed in order to provide an accurate Shrinkage assessment. GDNs adhere to rigorous Data Assurance Guidelines (DAG) which are subject to strict internal approval processes (implemented annually by each GDN), in accordance with GDN’s Licence Conditions. The procurement, processing and validation of this large volume of data results in lead times of approximately 4 months (April-July) to produce the final Leakage and Shrinkage figures. These are subject to detailed internal governance procedures prior to being sent to Ofgem as part of the GDN’s Regulatory Reporting Pack (RRP). This data is used to compile the annual Assessment and Adjustment report⁶ published at the end of July and can be audited by the Regulator at any time.

GDNs, recognise that stakeholders have requested further understanding of the reporting process and are therefore investigating the viability of producing a ‘Shrinkage Briefing Pack’ to illustrate the above and an aggregated Shrinkage data template as an agreed action from the November 2017 Shrinkage Forum. Furthermore, GDNs will continue to raise awareness of Shrinkage reporting and it’s underpinnings through the Shrinkage Forums, with the aim of encouraging collaboration and dialogue with the industry.

⁵ [DNV GL UIG Assessment of the NDM Algorithm](#)

⁶ [LDZ Shrinkage Assessment and Adjustment](#)

- VI.** “The one area which is not being examined is shrinkage. It is therefore appropriate that a thorough review is undertaken now, looking at the fundamental underpinnings of the shrinkage process, the data used in the shrinkage and leakage model and also whether the current level of transparency in the process is appropriate.” – *Corona Energy*
- VII.** “The goal of this review is so that the whole market should be in a position to satisfy itself that the process undertaken is robust and even-handed, and going forward, the focus can move from this area of settlement to other areas that may be causing the volatility in the UIG process. To ensure that this confidence continues, we suggest that an annual review process is implemented, where an independent expert looks at the process to ensure it is accurate. This could be in the same manner as the Measurement Error Notification Guidelines (where an impartial expert is appointed), or through enhanced transparency of the current process by granting shipper access to the model.” – *Corona Energy*

GDN Response

GDNs examine Shrinkage through engagement with the industry on an ongoing basis via the Shrinkage forums, where stakeholders are encouraged to review the shrinkage process together with the transporters. Furthermore, GDNs review the fundamental underpinnings of the shrinkage process annually as part of the SLM Consultation which is a requirement of our Licence Condition (See section 4 of the SLM Consultation). As a result of stakeholder feedback represented through the August 2017 Shrinkage Forum, GDNs have tailored our commitments for the coming 12 months to focus on reporting elements which are of concern to the industry (See sections 8 and 10 of the SLM Consultation). As outlined above, GDNs are seeking to provide further transparency through the potential publication of a ‘Shrinkage Briefing Pack’ and aggregated Shrinkage data. As confirmed previously, GDNs adhere to rigorous Data Assurance Guidelines (DAG) and these are subject to detailed internal governance procedures, prior to being sent to Ofgem as part of the GDN’s Regulatory Reporting Pack (RRP). Those submissions are subject to both internal and external audit on a regular basis and this data is used to compile the annual Assessment and Adjustment report published at the end of July.

2.2 Summary of Consultation

The annual SLM review process is a formal opportunity for all interested parties to engage with the Distribution Networks on matters relating to shrinkage modelling. GDNs would like to thank Corona Energy and ICoSS for supporting the process with their representations. It is apparent through the recent Shrinkage Forums and the representations to this year’s consultation that Unidentified Gas, post-Nexus, is proving to be a challenging issue for the industry. GDNs recognise that any error in Shrinkage reporting has the potential to marginally impact the overall UIG figure and would therefore like to take this opportunity to reaffirm our joint commitment to:

- I. Continue to work with shippers and other interested parties through the Shrinkage Forum meetings to prioritise those elements of the SLM which will provide greatest benefit to the consumer.
- II. Continue to rigorously follow our Data Assurance Guidelines (DAG) procedures, which require strict internal approval processes.
- III. Continue to utilise the Shrinkage Forum meetings to increase industry awareness of our 2018 commitments and outline how these will improve the accuracy of the SLM.
- IV. Continue to listen to our stakeholders and encourage participation at future Shrinkage Forum meetings.

GDNs would like to take this opportunity to thank all those who have reviewed and inputted into the SLM review document. For information, attached below is the original Shrinkage and Leakage Model Review Consultation, which was published on the Joint Office of Gas Transporters website on 12th October 2017.

Appendix A - Shrinkage and Leakage Model Review Consultation



SHRINKAGE LEAKAGE MODEL REVIEW

INITIAL REPORT FOR CONSULTATION

GAS DISTRIBUTION NETWORKS REVIEW THE SHRINKAGE AND LEAKAGE MODEL ON AN ANNUAL BASIS AND CONSULT ON THE OUTCOME OF THAT REVIEW WITH OTHER GDN OPERATORS, GAS SHIPPERS AND INTERESTED PARTIES.

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1 Executive Summary

Gas Distribution Networks (GDNs) review the Shrinkage and Leakage Model (SLM) on an annual basis and consult on the outcome of that review with other GDN operators, gas shippers and other interested parties.

The outcome of this consultation will be submitted to the authority by 31 December 2017.

The purpose of the SLM Review is to assess how the SLM can better achieve the objective set out in Special Condition 1F Part E of the Licence. This requires the SLM to be designed to facilitate the accurate calculation and reporting of gas shrinkage and gas leakage in, or from each, GDN operated by a Licensee.

At the March 2017 and August 2017 Shrinkage Forums the GDN's representatives described the process of the SLM review and requested that the industry supply feedback of what they would like included. Although our licence obligation is to review the SLM to increase reporting accuracy, as a result of stakeholder feedback we have extended the publication to include a number of extra elements.

In response to specific feedback from Shippers at the August 2017 Shrinkage Forum, a breakdown of the variances between 2015/16 and 2016/17 Shrinkage performance has been included. This information is contained in Appendix A.

As a result of the joint GDN review and feedback from shippers concerning the level of 'Shrinkage error' within the model, it is proposed to focus on the following areas :-

Our Commitment	2018 Approach	Potential Impact on Shrinkage Modelling
Following discussions with Stakeholders GDNs will investigate the potential impacts of PE permeation.	GDNs will review the calculations within the model to determine whether PE permeation is inclusive within the current leakage rates. If this factor is found to be absent from the current rates, GDNs will engage with industry experts to review the impact of PE permeation on the Shrinkage and Leakage model.	If it is concluded that a separate PE permeation rate should be applied to the calculation of fugitive emissions from PE pipes, then this will result in an increase in total leakage although this is anticipated to be a relatively small amount due to the nature of this factor.
We will further investigate the accuracy of the existing MP Leakage calculation.	GDNs will engage with industry experts to determine the preferred approach for refreshing the MP Leakage calculation.	Feedback from the AUG expert suggests that pressure and leakage are proportional to one another, however, MP leaks are more likely to be rectified sooner. Any proposed change will target improvement to the MP leakage calculation.
We will continue to investigate the opportunity of reflecting the benefits of Remediated Pipes in the SLM.	GDNs are currently finalising the overall remediation capture process and ensuring all associated supporting evidence is available, with a view to developing an industry consultation on a modification to the SLM.	Remediation is a process for maintaining our pipe assets with minimal impact on our customers. If it is proven that remediation is effective in driving down leakage, future Shrinkage calculations may include a correction for remediated mains in order to improve the accuracy of the SLM.
We will review the suitability of the existing Own Use Gas calculation within the SLM.	We will continue to investigate the results of low carbon preheating trials and determine if they can be used as a basis for revising the Own Use Gas (OUG) calculation. We will also consult industry experts to understand if other methods of calculating OUG are available.	Whilst the results of the low carbon preheating trials have still to be fully reviewed, it is anticipated that the estimates of OUG will change.

Table 1 – Summary of 2018 Commitments

Further details of the 2018 commitments can be found in Section 10.

2 Background

Gas Distribution Networks (GDNs) have an obligation under Special Condition 1F Part E of the Licence to review the Shrinkage and Leakage Model (SLM) on an annual basis and to consult on the outcome of that review with other GDN operators, gas shippers and other interested parties.

The outcome of this consultation will be submitted to the authority by 31 December 2017.

The purpose of the SLM Review is to assess how the SLM can better achieve the objective set out in Special Condition 1F.13 of the Licence. This requires the SLM to be designed to facilitate the accurate calculation and reporting of gas shrinkage and gas leakage from each GDN operated by a Licensee.

We value all feedback and representations; responses to this document are encouraged and should be received no later than 9th November 2017. Communication should be directed to Peter Morgan or via the Joint Office (contact details below).

Contact: Peter Morgan, Network Support Officer

SGN

Email: peter.morgan@sgn.co.uk

Telephone: 0131 469 1854

Write to: Peter Morgan, SGN

Axis House, 5 Loanhead Drive, Newbridge, Edinburgh EH28 8TG

Alternatively

Joint Office: enquiries@gasgovernance.co.uk

We are specifically interested to understand the following:

1. What is the area(s) of shrinkage that is of particular interest to you and that you feel requires review or mention as part of this annual review process that isn't sufficiently captured within this document?
2. The GDNs are committed to continuously improve the value of the SLM, with this in mind, is there any feedback you would like to share regarding this or previous Shrinkage Leakage Model Review documents?

3 Overview of Shrinkage

Shrinkage refers to the gas which is lost from the transportation network. Under the Uniform Network Code (UNC), GDNs are responsible for purchasing gas to replace the gas lost through Shrinkage.

GDNs estimate Shrinkage using an industry approved methodology and engineering model. The model applies pre-determined leakage rates but is updated annually for a number of activity based factors. The methodology used to determine Shrinkage quantities continues to evolve; this document details the GDN's collective thoughts of how we can continue to improve the methodology and accuracy of the calculations. As part of this consultation, and throughout the annual lifecycle of the Shrinkage process, GDNs are always interested in understanding where shippers and other interested parties believe elements of the methodology can be improved and would welcome this feedback.

Shrinkage is comprised of three elements (leakage, theft of gas and own use gas), of which leakage contributes around 95% of the total quantity. Detail of how each element is calculated is found later in this document.

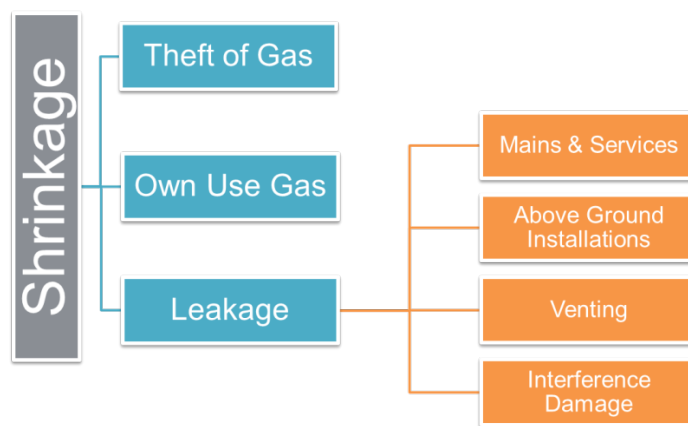


Figure 1: Breakdown of shrinkage also demonstrating the component parts of leakage

The Joint Office of Gas Transporters regularly host Shrinkage Forums throughout the year, the forum is open to all interested parties and attendance is strongly encouraged for those persons with an interest in gas distribution shrinkage. The Shrinkage Forum is an opportunity to connect with colleagues from the gas distribution and shipper community and share opinions, ideas and increase understanding.

Further information relating to the Shrinkage Forum can be found at: www.gasgovernance.co.uk/Shrinkage

4 Overview of the Shrinkage and Leakage Model

Our stakeholders told us that there was a knowledge gap in the industry of the methods used to determine shrinkage volumes. This section details each of the components of shrinkage which includes leakage assumptions, % influence of each component on the total volume, the calculation methods and our commitments to increasing accuracy in each area.

Table 2 provides a high level indication of the volume of data GDNs process annually* in order to provide an accurate Shrinkage assessment for the purposes of Shrinkage purchase and incentive calculation.

No. of Networks	Length of Pipes (LP & MP)	No. of Above Ground Installations (AGIs)	No. of Services
2,346	254,500 km	108,600	19,126,000

Table 2 – Summary of the volumes of key data used to calculate shrinkage

**The figures in Table 2 are taken from the 2016/17 leakage calculations*

Table 2 demonstrates the large volume of data GDNs process in order to provide an accurate Shrinkage assessment. As well as processing large volumes of data, GDNs adhere to rigorous Data Assurance Guidelines (DAG) procedures which require strict internal approval processes. The procurement, processing and validation of this large volume of data results in lead times of approximately 4 months (April-July) to produce the final Leakage and Shrinkage figures. These are subject to detailed internal scrutiny and formal approval processes prior to being sent to Ofgem as part of the GDN's Regulatory Reporting Pack (RRP) and is used to compile the annual Assessment and Adjustment report¹ published at the end of July.

4.1 Low Pressure Mains & Service Leakage

Weighting: circa 78% of leakage.

Background: Leakage from low pressure mains is estimated by applying the leakage rates determined from the National Leakage Tests (NLT) programme to the mains asset records. Leakage from low pressure services is estimated by applying the leakage rates determined from the NLT, which provided an average leakage rate for each service classification.

LP Mains Calculation method: Asset length (km) x annual leakage rate x average system pressure correction² x Monoethylene Glycol³ correction (where applicable).

LP Mains Rates: 11 rates from 25 categories based on materials and diameters

LP Service Calculation method: No. of services by category x annual leakage rate x average system pressure correction

LP Service Rates: 4 rates/categories (steel and PE service connections to PE or metallic mains)

Figure 3 (see Section 7) demonstrates that the NLT, commissioned by the UK GDNs, remains world leading in both scale and accuracy. The tests involved sampling 849 Low Pressure pipes and 6,054 services. There is no evidence to suggest that the resulting leakage rates have materially changed since these tests. Continuous

¹ <https://www.gasgovernance.co.uk/Shrinkage/Assessment-and-Adjustment>

² Leakage rates were determined at 30mbarg pressure so require correction if pressures are greater or lower than this amount. The lower the average system pressure the less an asset will leak.

³ Lead yarn joints leak less if Monoethylene Glycol is saturated in the gas, MEG treatment only impacts spun cast and pit cast assets. The higher the MEG saturation the greater the leakage reduction.

investment by GDNs, which has prioritised replacing the pipework most at risk from degradation and leaks, is likely to mean that the current population of pipework has lower average leakage rates than previously. This was demonstrated by the minor differences between the 1992 and 2002/3 NLTs, where several leakage rates were revised down. As such, the significant investment and disruption required to repeat the NLT, would represent poor value for money for the customer.

Following the analysis of the Allocation of Unidentified Gas (AUG) Methodology undertaken by DNV GL⁴ and subsequent feedback from shippers at the August 2017 Shrinkage Forum, we have included a commitment for the coming year to investigate the permeation of natural gas through the wall thickness of PE pipes (see Section 10 for details).

4.2 Medium Pressure Mains Leakage

Weighting: circa 8% of leakage.

Background: Medium pressure (MP) leakage is estimated by applying the LP leakage rates at 30mbarg to the MP mains asset profile. The rationale for this is that the number of public reported escapes per km of MP main is of a similar order to that of the LP system. Therefore, it is inferred that the mains must be leaking at a similar rate. Systems operating at higher pressures are constructed and tested to an appropriately higher level of integrity.

Unlike Low Pressure mains the calculation method for Medium Pressure mains takes no cognisance of the actual average operating pressures of the respective grids. To improve the accuracy of the calculation, a pressure related calculation of leakage may be more appropriate, which would also facilitate a mechanism for achieving and reflecting leakage reduction through effective pressure management. To achieve this it would be necessary to establish MP specific leakage rates; however, isolating sections of the MP system to undertake pressure decay tests is difficult due to the strategic importance of these mains to security or supply, even under low demand periods. Cadent Gas raised a NIA project which confirmed a correlation between MP leakage and system pressures.

In our commitments for the coming year we describe our intentions to commence further investigatory work in this area of leakage modelling (see Section 10 for details). It is our intention to review the current process and engage with industry experts to understand if there is a better and more concise methodology to report Medium Pressure leakage. This will consider the suitability of methods to validate the current rate assumptions used within the SLM and determine whether the implementation of a pressure correction factor will increase accuracy. This review coincides with feedback received from DNV GL as part of the AUG Expert review that considered MP Leakage may be an area of potential underestimation within the SLM.

Calculation method: Asset length (km) x annual leakage rate.

Rates: 6 rates from 25 categories based on materials and diameters

4.3 Above Ground Installation Leakage

Weighting: circa 8% of leakage.

Background: Leakage for AGI's is estimated by multiplying the number of AGI's by the pre-determined leakage rate for the type of AGI. The five types of AGI's are;

1. Holder Station (Largely phased out)
2. NTS Offtake (Reduce pressure from above 70 bar to Local Transmission)
3. Local Transmission (Reduce pressures from up to 69 bar to lower pressure tiers)

⁴ <https://www.gasgovernance.co.uk/sites/default/files/ggf/page/2017-06/Final%20Factor%20Table%20Letter%2030%20June%202017.pdf>

4. District Governor (Supply gas to lower pressure tiers. Outlet pressure 25-75 mbar)
5. Service Governor (Commonly feed individual premises)

The leakage rates for AGIs were determined by Advantica in 2003 and are documented in the Above Ground Installation Shrinkage report. The programme established average leakage rates for the five types of AGI's. Table 3 below provides a summary of findings.

Asset Type	Leakage m ³ /year/site	Number surveyed
Holder station	7,692	24
NTS offtake	31,075	67
Local Transmission	6,485	145
District Governor	407	246
Service Governor	8	54

Table 3 – AGI Leakage Rates and Sites Surveyed

The AGI sample plan included a total of 536 sites across the UK and utilised 2 leakage measurements techniques, Fugitive Measurement Device (FMD) and Area Survey Vehicle (ASV), the latter was only used for holder stations.

To ensure that the AGI Shrinkage report 2003 was valid (a similar test had not been previously carried out), the University of Nottingham were engaged to carry out an independent validation of the technique involved and concluded that the FMD is a valid, practical method for making measures of fugitive emissions from the Gas Distribution System. The University of Newcastle were also engaged to validate the statistical analysis carried out within the report and concluded there is no evidence of any bias and the data had been correctly analysed.

The cost of completing the extensive study into AGI Shrinkage was in the region of £1m⁵. The conclusions which were drawn are still considered valid due to similar network operating procedures that are still in use today. The AGI's which are in service today are of similar nature compared to what was in use in 2003.

Calculation method: Asset quantity x annual leakage rate.

Rates: 5 leakage rates (Holder Stations, NTS offtakes, Local Transmission Stations, District Governors, Service Governors)

4.4 Above Ground Installation Venting

Weighting: circa 5.5% of leakage.

Background: AGI Venting rates were determined as part of a 1994 Watt Committee Report, the derivation of this value is unknown and is a single fixed value for each LDZ.

GDN's initiated site surveys (which are now complete) in support of a project raised by Cadent to review venting rates of the most commonly used pneumatic control equipment. The next steps for implementing a change to the leakage model to better reflect the AGI venting emissions is to form a systemised mechanism for annual data population that is consistent across all GDNs. This will allow a consultation to be released, which if accepted by the industry, would allow the venting estimation to move to an activity based calculation.

Calculation method: Fixed annual leakage volume per LDZ.

Rates: Fixed annual leakage volume per LDZ.

⁵<https://www.gasgovernance.co.uk/sites/default/files/ggf/Shrinkage%20and%20Leakage%20Model%20Review%20No%201%20WWU.pdf>

4.5 Interference Damage

Weighting: circa 0.5% of leakage.

Background: Interference damage is the gas escaping into the atmosphere as part of an unplanned escape usually caused by third party damage. Interference damage is split into two categories, above and below 500kg of gas released and is calculated using assumed leakage rates per incident together with an average response and repair time (for below 500kg incidents).

GDNs have a licence obligation to attend at least 97% of uncontrolled gas escapes within 1 hour and 97% of controlled gas escape within 2 hours (where the risk to the customer is deemed lower). These targets have been consistently outperformed in recent years and include incidents of interference damage. For interference damage, the source of the leak is generally more obvious due to the nature of the incidents and so can be made safe more quickly.

Therefore, GDNs have concluded that the current assumptions regarding interference damage remain valid and it would be better to prioritise other elements of the model to improve accuracy, given its minimal impact.

Calculation method: Multiple scenarios

>500kg interference damages: An assessment is made of each >500kg incident and included in the model.

<500kg interference damages (Mains): Number of incidents split 95:5 between low pressure and medium pressure incidents. Different leakage rate and response time for low pressure and medium pressure.

<500kg interference damages (Services): Number of incidents split 50:50 between severed and punctured services. Different leakage rate and response time for severed and punctured services.

Number of incidents x leakage rate x predetermined response/fix time

4.6 Theft of Gas

Weighting: circa 4% of shrinkage.

Background: Shrinkage includes the element of Theft of Gas (ToG) deemed 'transporter responsible'. This is currently estimated by applying a fixed 0.02% factor to throughput. However, the absolute level of theft, by its nature, is impossible to establish and the current assumption can be considered conservative and likely to overestimate the total quantity of transporter responsible gas. GDN data from 2010 on detected ToG cases, provided to the Shrinkage Forums in August⁶ and September⁷ 2011, indicated that levels were several times lower than the current throughput factor suggests. However, GDNs have no statistically robust basis to suggest that the current assumed level of transporter responsible theft is any higher or lower than the current assumption as a % of throughput.

Furthermore, during 2016/17, a specific LDZ experienced an uncontrolled increase in demand as a result of a large industrial connection which inflated the value of the ToG. GDNs believe that this particular circumstance could affect the accuracy of the SLM and as a consequence we may consider suggestions to avoid such situations occurring in the future (see Section 7 for details).

Calculation method: 0.02% of throughput

⁶ <https://www.gasgovernance.co.uk/sf/100811>

⁷ <https://www.gasgovernance.co.uk/SF/280911>

4.7 Own Use Gas

Weighting: circa 2% of shrinkage.

Background: Own Use Gas (OUG) refers to gas used by the transporter for operational purposes, primarily pre-heating, but which does not pass through a meter. This is currently estimated by applying a fixed 0.0113% factor to throughput.

In our commitments for the coming year we describe our intentions to continue investigatory work in this area of leakage modelling (see Section 10 for details). We will continue to investigate the results of low carbon preheating trials and determine if they can be used as a basis for revising the OUG calculation. We will also consult industry experts to understand if other methods of calculating OUG are available.

Calculation method: 0.0113% of throughput.

5 Shrinkage Components Timeline

The timeline below demonstrates the continued evolution of shrinkage methodology and our commitments to address each of the elements.

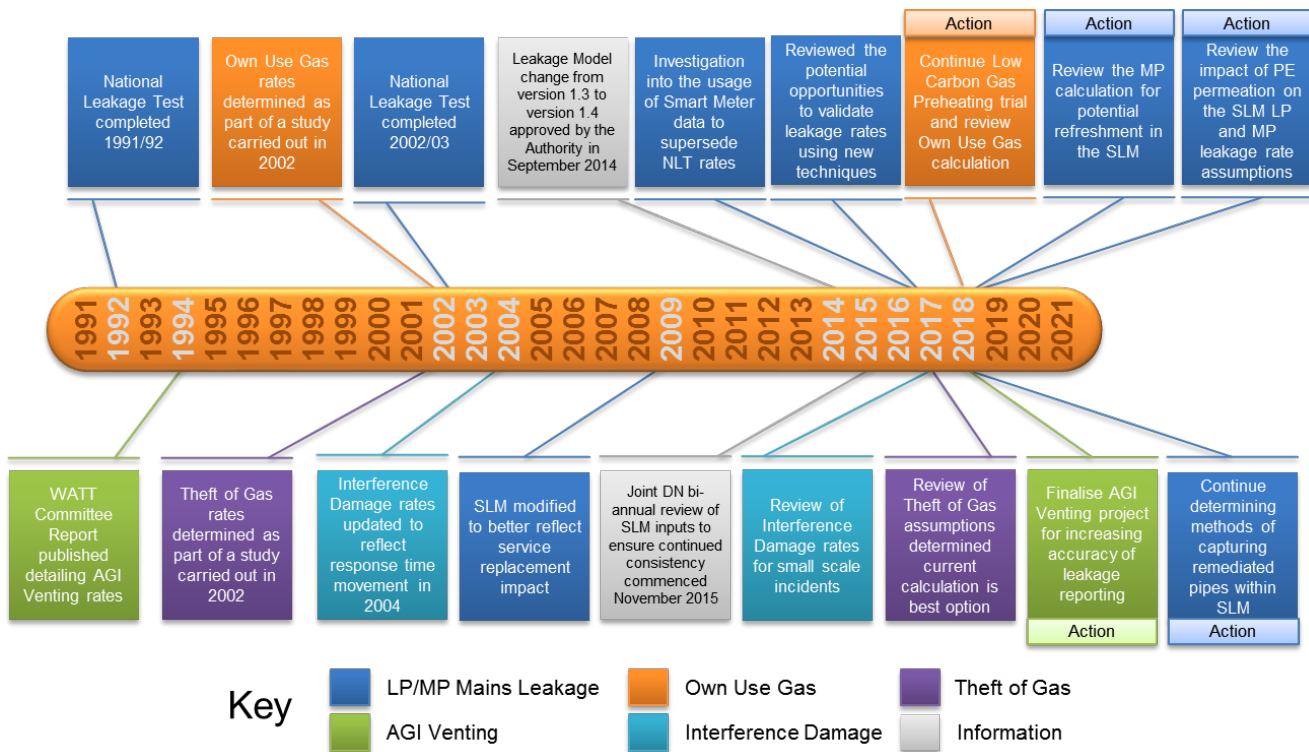


Figure 2 – Shrinkage Component Timeline

6 Shrinkage Reduction Successes

Shrinkage forms the majority of a gas distribution network companies' business carbon footprint and accounts for around 1% of Great Britain's total greenhouse gas emissions. As such, reducing losses aligns with achieving the UK government's emissions target and contributes to reducing customer bills.

Each GDN continues to see incremental improvements in shrinkage reduction; we have made progress in a number of areas which have seen a positive impact in reducing Shrinkage:

- The main contributory factor to Shrinkage reduction is our mains replacement programme. Since the start of RIIO GD1, GDNs have replaced over 15,000km of metallic mains with PE.
- Implementation of pressure profiling systems that automatically manage low pressure governor settings in line with customer requirements. This ensures networks run at the optimum levels to minimise lost gas, while at the same time achieving security of supply. Furthermore, continuous review of established profiling systems is carried out to ensure they remain relevant to other changes taking place on the LP network. As highlighted in Appendix B, apart from our mains replacement programme, the greatest influence on Shrinkage is the average system pressure. GDNs recognise this and have therefore invested heavily in pressure management systems over a number of years. This is demonstrated by network length covered by self-learn profiling. Approximately 70% of the GDNs network length is on profile control.
- Continued investment in a range of innovative projects looking to develop cost effective solutions which offer opportunities for improved pressure management and resultant reductions in shrinkage
- Installation of new, and the replacement of any obsolete clocking systems to allow differential within day pressure settings on those networks where it may not be economically justified to install profile control.
- Pro-active management of network pressures through adjusting district governor settings seasonally.
- Reinforced governance around the management of temporary modifications to pressure settings for operational works.
- Focused approach to improving levels of mono-ethylene glycol saturations with the associated impact of reduction in Leakage from impacted material joint types. This includes reviewing end to end processes, replacement of aging equipment to maximise saturation potentials and relocating equipment to areas with greater proportions of iron mains.
- Introduction of more sophisticated management information to help support the management of networks, and allow early identification of underperforming areas and actions to resolve any issues.
- Optimisation of pressures on all-PE networks.
- Joint GDN workshops have been held during 2016/17 to improve best practice, progress any SLM modifications and prepare material for Shrinkage Forum meetings.

7 Previous Commitments Review

The information within this section provides an update on commitments the GDNs gave in the 2016 SLM.

Project Name: Methods of Leakage Measurement

Project Lead: All GDNs

Shrinkage Component: Leakage Rates

Our 2016 Commitment: We will review the methods of Leakage Measurement and explore opportunities for any improvements

In 2002/03 a National Leakage Test (NLT) project was commissioned to repeat the leakage tests undertaken in 1992; these rates are used to determine leakage from low pressure mains and services and medium pressure mains. The leakage rates were determined using the pressure decay method, which was chosen as the leakage is deduced from an accurately measured drop in pressure. The project involved sampling 849 pipes and 536 Above Ground Installation (AGI); the results showed that in most cases the leakage rate for particular groups of mains were lower than found in 1992, principally in polyethylene, spun cast and pit cast iron material types.

Part of the Energy UK Gas Retail Group Shrinkage Study⁸ published in October 2015, reviewed alternative studies into leakage rates and has provided the GDNs with a valuable insight into the techniques used for leakage rate determination in other countries. In particular, this study detailed the methods adopted in Netherlands⁹, US (EPA)¹⁰ and Spain¹¹.

The Netherlands and US (EPA) approach involved attempting to derive leakage rates for different pipe materials from actual gas leaks using the suction method in the Netherlands and the bagging method in the US (EPA). As well as inherent uncertainty regarding these techniques, this approach also relies on finding a statistically valid sample of actual escapes for each material/diameter band.

The Spanish approach involved using the Pressure Variation method which works on the principle that the leakage flow rate will be proportional to the pressure of the gas network whereas consumer consumption is not related to the pressure in the main. However, this method is reliant on the assumption that actual consumer consumption remains constant throughout the test period which the Spanish report concedes is more applicable to countries in Southern rather than Northern Europe.

Figure 3 provides a summary of these three studies in comparison to the NLT and whilst it is acknowledged that they are less expensive to conduct, they are also less accurate.

The Energy UK Gas Retail Group Shrinkage Study also makes reference to a number of studies that have attempted to actually sample local atmospheric concentrations of methane in order to directly measure leakage from the gas network.

GDNs consulted with National Grid's US operations who were directly involved in trialling some of these methods. The devices used in the US trials identified issues with accuracy, in that nearly every airborne methane molecule was being found. For accuracy, devices are required that could differentiate between fossil based natural gas and biogenic natural gas (for example, livestock, farms, sewers and landfills). Identification of leaks using this method could lead to unnecessary investigations and disruption to customers as field operatives search for the source of leaks that turn out to not be natural gas related.

⁸ <https://www.gasgovernance.co.uk/Shrinkage/Retail-Study>

⁹ <http://members.igu.org/html/wgc2006/pdf/paper/add10963.pdf>

¹⁰ https://www.epa.gov/sites/production/files/2016-08/documents/9_underground.pdf

¹¹ <http://members.igu.org/html/wgc2006/pdf/paper/add9930.pdf>

Consequently, as a result of the scope and scale of the NLT undertaken in 2002/03 compared to equivalent tests undertaken elsewhere, GDNs are confident that the results, using the Pressure Decay technique, remain valid.

Test	Cast Iron	Spun Iron	Ductile Iron	Steel	PE	Mains Total	Services	Confidence
2002/3 NLT	445	139	111	62	92	849	6054	90% confidence interval as a percentage of total value: ±19.4%
Netherlands 2005	7		3	3 LP 4 HP	0 LP 3 MP	13	0	"not intended to obtain a full statistically reliable leakage data"
US EPA Tests 1996	21			17	6 (described as 'plastic')	44	33	±65%
Spanish Tests 2005	0				21 (34 test 13 dis-counted)	21	Unspecified	90% confidence level as a percentage of total value: ±47.8%

Figure 3: International Leakage test statistics¹²

Project Name: Capture of Remediated Mains in the Model

Project Lead: SGN

Shrinkage Component: Low Pressure Mains Leakage Calculation

Our 2016 Commitment: We will investigate the opportunity of reflecting the benefits of Remediated Pipes in the model

Leakage from low pressure mains is estimated by applying the leakage rates determined from the NLT programme to the mains asset records. Currently mains leakage is calculated as:

$$\text{Asset length (km)} \times \text{annual leakage rate} \times \text{average system pressure correction} \times \text{Monoethylene Glycol correction (where applicable)}$$

In recent years, innovation within the industry has led increasingly to the use of robotics to remediate large diameter metallic mains, rather than replacing the asset. The use of robotics to anaerobically seal joints of large diameter metallic mains will reduce leakage from the asset. In order to improve the accuracy of the SLM, SGN will seek to develop proposals to better reflect the benefits of mains remediation.

SGN are investigating the viability of applying a 'correction factor' to the existing leakage rates of individual mains assets within the model, based on a detailed remediation capture report currently being developed by DNV GL. This will provide a standardised, auditable framework to capture treated mains within our asset repository.

The proposal is to adjust the mains calculation to include a 'remediation correction factor' as outlined below:

¹²https://www.gasgovernance.co.uk/sites/default/files/ggf/Joint%20GDN%20Response%20to%20Energy%20UK%20GRC%20Shrinkage%20Study_0.pdf

Asset length (km) x annual leakage rate x average system pressure correction Monoethylene Glycol correction (where applicable) x remediation correction (where applicable)

As part of our 2017 Commitments (see Section 10), SGN will finalise the overall remediation capture process and ensure all associated supporting evidence (required for the above change) is available, with a view to developing an industry consultation on a modification to the SLM.

Project Name: Calculation of Medium Pressure Leakage

Project Lead: Cadent

Shrinkage Component: Medium Pressure Leakage Calculation

Our 2016 Commitment: We will continue to investigate the calculations of Medium Pressure leakage in the model

The GDNs identified the Medium Pressure calculation as an opportunity for review. This has since been corroborated by the DNV GL review identifying the Medium Pressure calculation as an area of interest and was discussed at the Shrinkage Forum on 30th August 2017.

A NIA project identified a correlation between pressure and leakage in medium pressure assets. We have continued to explore the results of this NIA project and the potential impact on Leakage modelling.

As part of our 2017 Commitments (see Section 10) we will continue to investigate the calculations of Medium Pressure leakage in the SLM.

Project Name: Calculation of Own Use Gas (OUG)

Project Lead: Northern Gas Networks & SGN

Shrinkage Component: Own Use Gas Calculation

Our 2016 Commitment: We will continue to investigate the results of low carbon preheating trials on the Own Use Gas calculations in the model

Own Use Gas is driven by consumer gas demand, and by being a factor of throughput cannot be targeted for reduction by gas distribution networks. As technology evolves and more efficient equipment becomes available, it was proposed to review this calculation and determine if an activity based calculation would be more appropriate. Furthermore, GDNs currently experience windfall gains and losses as a result of fluctuating throughput.

Northern Gas Networks are in the process of investigating Low Carbon Gas Preheating¹³. This involves installing and monitoring the operational efficiency of a representative sample of preheating technologies. All 12 sites will be commissioned by winter 2017/18, with the majority installed already. To determine a robust data sample we would need to operate each of the 12 sites through a full heating season, with expected timescales for initial data analysis to be early 2018 and the final report and analysis due in June 2018.

SGN have also conducted a field trial to contrast two different preheat technologies; a new installation using ProHeat's 99kW Immersion Tube Preheater, contrasted against an existing 100 kW single phase water bath heater installed in 1976. Both units were extensively tested and monitored over a period of continuous operation to measure thermal efficiency and system fuel efficiency. The differences in performance between both preheaters was significant with Immersion Tube technology out-performing bath type heaters in all areas, giving significantly better thermal efficiencies, lower CO2 emissions and lower fuel consumption than traditional

¹³ <https://www.northerngasnetworks.co.uk/ngn-you/the-future/preheating/>

water bath technology. ProHeat has now been adopted by SGN as an approved technology, with the first full ProHeat site (Lochmaben) coming on line in 2018.

As part of our 2017 Commitments (see Section 10) we will continue to investigate the results of low carbon preheating trials on the Own Use Gas calculations in the model. We will consider the outputs of both the NGN trial study and the SGN Innovation project into alternative pre-heating technology and determine if there are any implications to the accuracy of the Own Use Gas calculation in the leakage model.

Project Name: Calculation of <500kg Interference Damage

Project Lead: All GDNs

Shrinkage Component: <500kg Interference Damage Calculation

Our 2016 Commitment: We will review the calculations of <500kg Interference damage in the model

GDNs have a licence obligation to attend at least 97% of uncontrolled gas escapes within 1 hour and 97% of controlled gas escape within 2 hours (where the risk to the customer is deemed lower). These targets have been consistently outperformed in recent years and include incidents of interference damage. For interference damage, the source of the leak is generally more obvious due to the nature of the incidents and so can be made safe more quickly.

Therefore, GDNs have concluded that the current assumptions regarding <500kg interference damage remain valid and it would be better to prioritise other elements of the model to improve accuracy, given its minimal impact.

Project Name: Calculation of Theft of Gas (ToG)

Project Lead: All GDNs

Shrinkage Component: Theft of Gas (ToG) Calculation

Our 2016 Commitment: We will review the calculation of Theft of Gas in the model

Shrinkage includes an element of theft deemed 'transporter responsible'. This is currently estimated by applying a fixed 0.02% factor to throughput. However, the absolute level of theft, by its nature, is impossible to establish and the current assumption can be considered conservative and likely to overestimate the total quantity of transporter responsible gas. GDN data from 2010 on detected ToG cases, provided to the Shrinkage Forums in August and September 2011, indicated that levels were several times lower than the current throughput factor suggests.

In 2016/17, the gas demand of a large power station connected to the High Pressure network caused an increase to the demand for the given LDZ. The result of this was an increase of 2 GWh Shrinkage Gas which compromised the ToG and OUG factors. Whilst there may be an actual increase in OUG linked to the gas flow through the High Pressure network, it would seem erroneous to attribute the ToG factor to this High Pressure demand.

GDNs believe that this particular circumstance could affect the accuracy of the SLM. In order to avoid distorting the value of ToG resulting from atypical usage patterns at large industrial connections such as Gas Fired Power Stations and Peaking Power Generation Plants, we may consider suggestions to avoid such situations occurring in the future.

8 Shrinkage Forum Review

During 2017 there have been 2 Shrinkage Forums¹⁴, facilitated by the Joint Office of Gas Transporters, with a further 2 meetings scheduled for November and December 2017. These meetings have been attended by all GDNs, various representatives from the Shipper community and other interested parties.

The purpose of these meetings is to provide an opportunity for GDNs and Gas Shippers to meet on a regular basis to review and discuss matters directly relevant to the evaluation of shrinkage to include :-

- Review of annual shrinkage forecasts
- Review of actual shrinkage performance against forecasts
- Review and recommend any projects which will improve the accuracy of the evaluation of shrinkage
- Review the output of the annual Shrinkage and Leakage Model report which is a Licence Condition for GDNs
- Review the output of the biennial Shrinkage and Leakage Smart Metering report which is a Licence Condition for GDNs

During the August 2017 Shrinkage Forum a number of points were raised by the Shipper community, as a result of discussions which took place at the prior AUGGE meeting, referencing the Energy UK Gas Retail Group Shrinkage Study in 2015. GDNs have formally responded to the Energy UK paper in November 2016 and following review still consider the responses held within to be valid. The points raised at the August 2017 Shrinkage forum are outlined below, including a response to each in turn.

1. ***“Shrinkage from CSEPs is not currently taken account of in the Shrinkage and Leakage Model (SLM) and hence should be accounted for in the UIG calculations.”***

GDNs recognise that Shrinkage from CSEPs is not calculated as part of the each GDN’s SLM return. GDNs, however, note that iGTs are responsible for reporting on Shrinkage from their networks. GDNs welcome engagement from iGTs, regarding the current methodology employed to calculate Shrinkage, through future Shrinkage forums.

2. ***“Leakage from Medium Pressure (MP) mains is included in the SLM but the leakage rates are assumed to be the same as for Low Pressure (LP) networks. This assumption is likely to be invalid and will have an impact on estimates of Shrinkage for MP mains.”***

GDNs recognise the industry’s concerns regarding the current calculation of MP Leakage and will review the calculation as part of the 2018 commitments (See section 10 below).

3. ***“Permeation of gas through PE pipelines is not included in the SLM and this may have an impact on its estimates of Shrinkage.”***

GDNs will review the calculations within the model to determine whether PE permeation is included within the current leakage rates, as part of the 2018 commitments (See Section 10 below).

4. ***“Other conclusions drawn by Imperial College are either not valid or will have no material impact on Shrinkage.”***

¹⁴ <https://www.gasgovernance.co.uk/Shrinkage>

No response required.

5. ***“Consideration should be given to carrying out further leakage tests on PE and Medium Pressure mains in order to enhance the accuracy of the SLM.”***

As per points 2 & 3 above, GDNs recognise the industry’s concern regarding PE Permeation and the current calculation of MP Leakage. Consequently, GDNs have committed to reviewing both in 2018 (See Section 10 below).

9 Joint GDN Best Practice Sessions

The GDNs made a commitment in 2017 to increase collaboration in Shrinkage related matters. The GDNs held five sessions during 2017 which have driven the following outputs:

1. Review of all inputs into the leakage model to ensure consistency of working

The GDNs reviewed all the inputs that feed into the SLM that determines our annual output position. The review focused on determining that a standard and consistent process is applied in each GDN. The areas of review included all elements of the data input process. The findings concluded that each GDN is populating SLM in a consistent way.

2. Security of Leakage Model

The GDNs have discussed best practice in securing the SLM to avoid erroneous data entry or corruption of formulae. Each GDN has a number of security measures in place. The GDNs are reviewing options to enhance the audit process of the model calculations.

3. Modification discussions

The GDNs have used the sessions to review any SLM modifications and ensure that for all proposals there is a combined and consolidated view of the best method of progression for the consumers and industry.

Over the last year the GDNs have contributed a significant amount of material for discussion and presentation at Shrinkage Forums, this has primarily come from discussion at the Joint Distribution Network best practice sessions.

4. Sharing Best Practice in Leakage Management

The Shrinkage process has been strengthened by the introduction of the joint workshops and facilitated opportunities for best practice sharing. A good example of this is in the area of Gas Conditioning. A further joint GDN meeting is planned in October to share best practice in MEG sampling, operation and maintenance of gas conditioning equipment.

10 Our Commitments

The outcome of the joint GDNs SLM review is detailed below (this expands on Table 1 contained in the Executive Summary).

Project Name: PE Permeation

Project Lead: Wales & West Utilities

Shrinkage Component: Mains and Services Leakage Calculation

Potential Shrinkage Impact Assessment Checklist:

Shrinkage Calculation Methodology	Shrinkage Baselines	Innovation
Yes	Unlikely (depends on scale)	No

Brief Overview: For the purposes of this report, PE permeation refers to the loss of natural gas through the wall of polyethylene (PE) pipes. Whilst permeation of a gas through a pipe is a known characteristic, it is generally accepted that permeation of natural gas through PE pipe walls is very small, however, it is not zero.

Reason for Review: The Energy UK Gas Retail Group Shrinkage Study made reference to PE permeation and in turn provided estimated rates. Whilst the assumptions around these rates were flawed GDNs recognise that there may be a case to review permeation through polyethylene pipes to better reflect leakage within the SLM. DNV GL also responded to the Energy UK Gas Retail Group Shrinkage Study on permeation and re-iterated that the estimated rates provided in the report were flawed, however they also suggested it would be prudent to attempt to quantify the level of gas loss through permeation.

The GDNs will review the current calculations and determine if fugitive emissions resulting from PE permeation is included within current calculations. We will carry this out by consulting with industry experts to review the data from the latest leakage tests.

If it is concluded that an additional rate should be applied to the current calculations to take into account PE permeations, The GDNs will engage with manufacturers of PE pipe and consult with engineering experts to determine the impact of PE permeation within the gas distribution network.

Anticipated Baseline Impacts: If it is concluded that an additional rate is to be added to allow for PE permeation, then total leakage would increase. However it is anticipated this increase would be very small and it is unlikely that baselines would be materially affected.

Project Name: MP Leakage

Project Lead: Cadent Gas Ltd

Shrinkage Component: Medium Pressure Calculation

Potential Shrinkage Impact Assessment Checklist:

Shrinkage Calculation Methodology	Shrinkage Baselines	Innovation
Yes	Unknown	Yes

Brief Overview: Medium pressure (MP) leakage is estimated by applying the LP leakage rates at 30mbarg to the MP mains asset profile. The rationale for this is that the number of public reported escapes per km of MP main is of a similar order to that of the LP system. Therefore, it is inferred that the mains must be leaking at a similar

rate. Systems operating at higher pressures are constructed and tested to an appropriately higher level of integrity.

Reason for Review: Unlike Low Pressure mains, the calculation of leakage from Medium Pressure mains does not include an average system pressure correction. To improve the calculation a pressure related calculation of leakage may be more appropriate, which would also facilitate a mechanism for achieving and reflecting leakage reduction through effective pressure management.

GDNs intend to review the current process and engage with industry experts to review and understand if there is a better and more concise methodology to report Medium Pressure leakage. This will include considering methods to validate the current rate assumptions used within the leakage model to determine suitability together with a pressure correction factor.

Anticipated Baseline Impacts: Unknown

Project Name: Capture of Remediated Mains in the Model

Project Lead: SGN

Shrinkage Component: Low Pressure Mains Leakage

Potential Shrinkage Impact Assessment Checklist:

Shrinkage Calculation Methodology	Shrinkage Baselines	Innovation
Yes	No	No

Brief Overview: Leakage from low pressure mains is estimated by applying the leakage rates determined from the NLT programme to the mains asset records.

Currently mains leakage is calculated as:

Asset length (km) x annual leakage rate x average system pressure correction x Monoethylene Glycol correction (where applicable)

Reason for Review: In recent years, innovation within the industry has led increasingly to the use of robotics to remediate large diameter metallic mains, rather than replacing the asset. The use of robotics to anaerobically seal joints of large diameter metallic mains will reduce leakage from the asset. In order to improve the accuracy of the SLM, SGN will develop proposals to better reflect the benefits of mains remediation.

SGN are investigating the viability of applying a 'correction factor' to the existing leakage rates of individual mains assets within the model, based on a detailed remediation capture report currently being developed by DNV GL. This will provide a standardised, auditable framework to capture treated mains within our asset repository.

The proposal is to adjust the mains calculation to include a 'remediation correction factor' as outlined below:

*Asset length (km) x annual leakage rate x average system pressure correction x Monoethylene Glycol correction (where applicable) x **remediation correction (where applicable)***

SGN are currently finalising the overall remediation capture process and ensuring all associated supporting evidence (required for the above change) is available, with a view to developing an industry consultation on a modification to the SLM.

Anticipated Baseline Impacts: It is not anticipated that there will be any adjustment to the current baselines as a result of this proposed modification.

Project Name: Own Use Gas**Project Lead:** Northern Gas Networks & SGN**Shrinkage Component:** Own Use Gas Calculation**Potential Shrinkage Impact Assessment Checklist:**

Shrinkage Calculation Methodology	Shrinkage Baselines	Innovation
Yes	Yes	Yes

Brief Overview: Own Use Gas makes up approximately 2% of all Distribution Network Shrinkage and is calculated as a factor (0.0113%) of LDZ throughput. Own Use Gas is gas that is used as part of the operational requirements of the distribution networks at pressure reduction stations i.e. pre-heating.

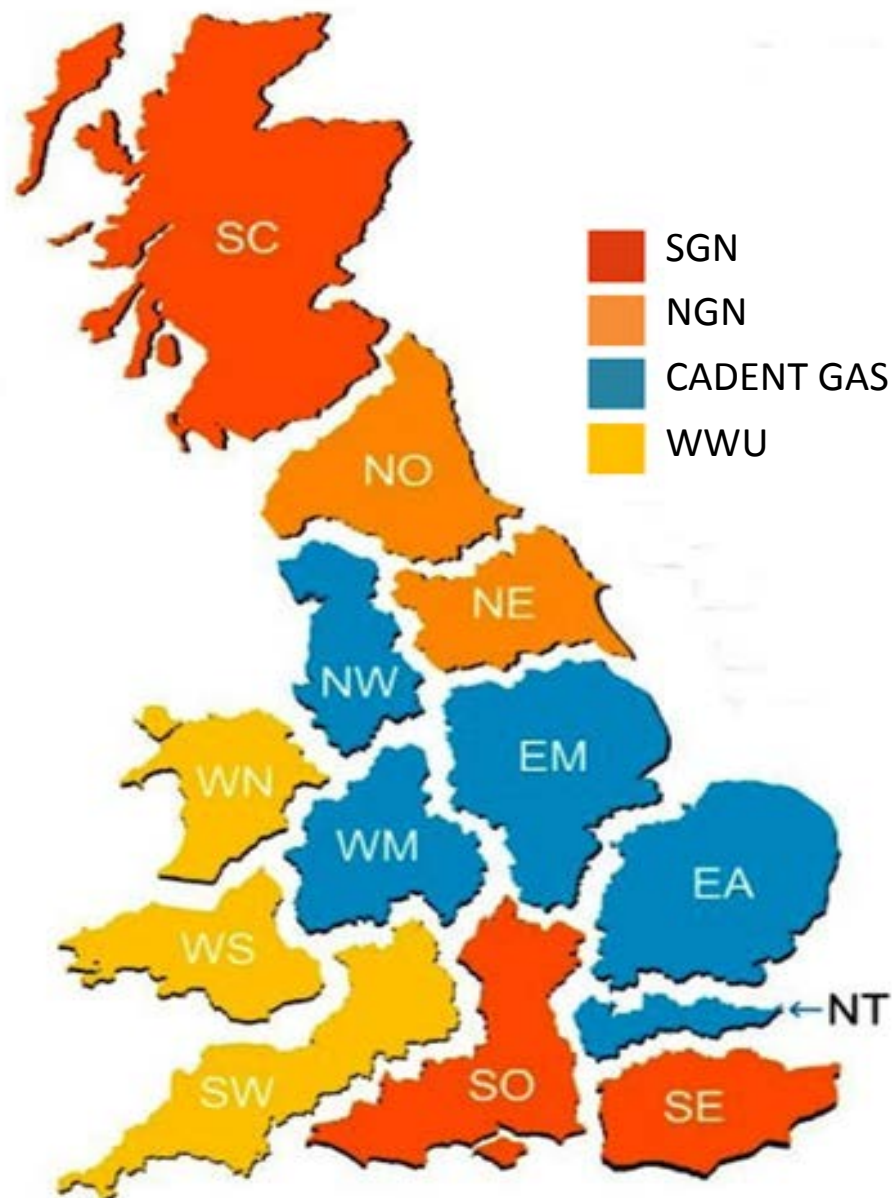
Reason for Review: Own Use Gas is driven by consumer gas demand, and by being a factor of throughput cannot be targeted for reduction by gas distribution networks. As technology evolves and more efficient equipment becomes available it is proposed to review this calculation and determine if an activity based calculation (possibly using flow and temperature data) would be more appropriate.

Anticipated Baseline Impacts: If an activity based calculation is deemed to be more appropriate then it is likely that the estimate of Shrinkage will change, resulting in a change to baselines.

Appendix A - LDZ Performance

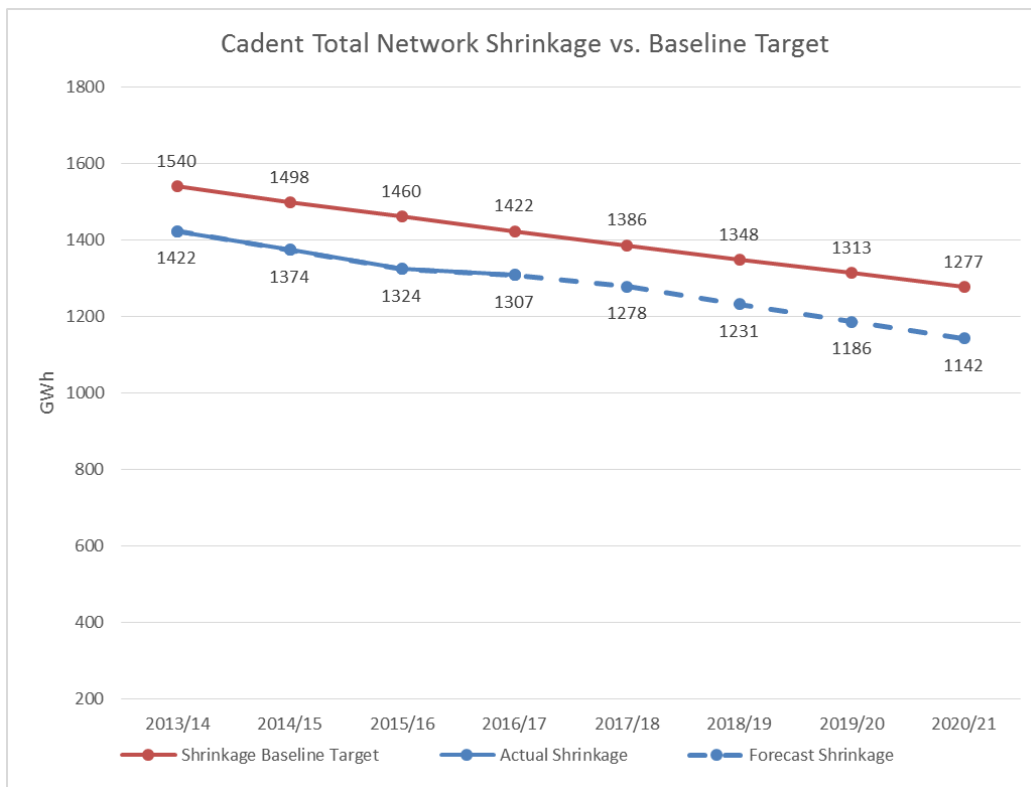
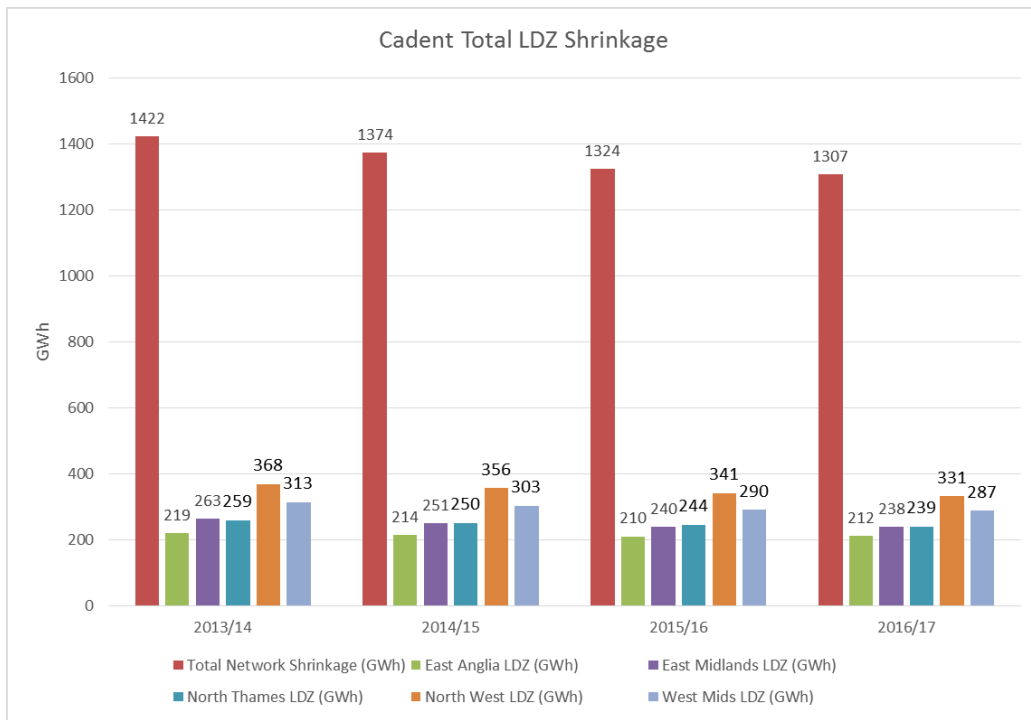
The performance breakdown contained within the following pages demonstrates the main components of Shrinkage for each Local Distribution Zone (LDZ). The introduction of these performance measures is as a result of feedback received during the 2016/17 SLM review stakeholder consultation and August 2017 Shrinkage Forum. The performance breakdown will be updated annually and published within future SLM review consultation documents.

The network map below shows the geographic location of each LDZ colour coded by network owner.



Cadent Gas Ltd

- Total Network Shrinkage was reduced by 1% in 2016/17 from 2015/16.
- Average system pressure increased by 2.8%, metallic pipe length was reduced by 4.8% and MEG saturation decreased by 3.2%.
- Total Shrinkage has been reduced by approximately 8.1% comparing 2016/17 to 2013/14.



EA LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	142 GWh (68%)	165km of Mains Replacement	144 GWh (68%)	2 GWh (1%)
MP Leakage	16 GWh (8%)	ASP increasing 1mbar to 28.1mbar MEG up 12.5%	15 GWh (7%)	-1 GWh (-6%)
Other (AGI's, OUG, Theft & Interference)	52 GWh (24%)	Demand up 3.7% AGIs & Interference up	53 GWh (25%)	1 GWh (2%)
Total	210 GWh (100%)	Replacement & ASP Largest Drivers	212 GWh (100%)	2 GWh (1%)

EM LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	141 GWh (59%)	407km of Mains Replacement	139 GWh (58%)	-2 GWh (-1%)
MP Leakage	42 GWh (18%)	ASP increasing 1.1mbar to 28.3mbar MEG down -2.4%	42 GWh (18%)	-0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	57 GWh (23%)	Demand up 3.1% AGIs & Interference down	57 GWh (24%)	0 GWh (0%)
Total	240 GWh (100%)	Replacement & ASP Largest Drivers	238 GWh (100%)	-2 GWh (-1%)

NT LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	177 GWh (73%)	372km of Mains Replacement	172 GWh (72%)	-5 GWh (-3%)
MP Leakage	21 GWh (9%)	ASP increasing 0.4mbar to 25.8mbar MEG up 2.3%	21 GWh (9%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	46 GWh (18%)	Demand up 5.1% AGIs & Interference down	46 GWh (19%)	0 GWh (0%)
Total	244 GWh (100%)	Replacement & ASP Largest Drivers	239 GWh (100%)	-5 GWh (-2%)

NW LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	263 GWh (77%)	433km of Mains Replacement	252 GWh (76%)	-11 GWh (-4%)
MP Leakage	15 GWh (4%)	ASP increasing 0.5mbar to 27.2mbar MEG down -10.5%	15 GWh (5%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	63 GWh (19%)	Demand up 0.6% AGIs & Interference down	64 GWh (19%)	1 GWh (2%)
Total	341 GWh (100%)	Replacement & ASP Largest Drivers	331 GWh (100%)	-10 GWh (-3%)

WM LDZ Performance

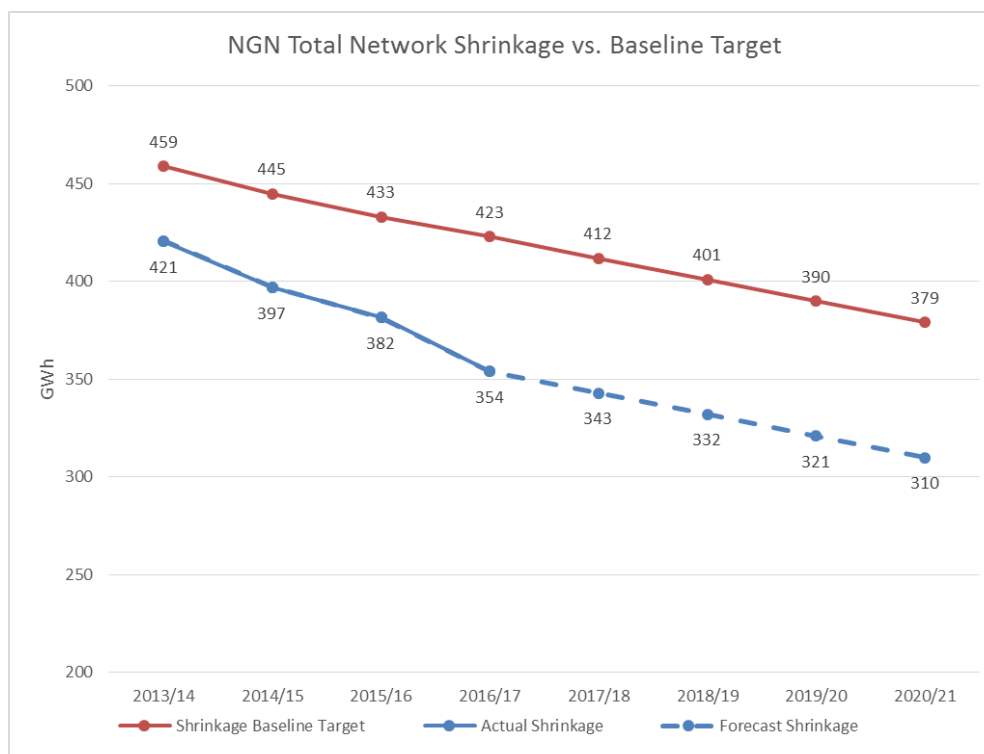
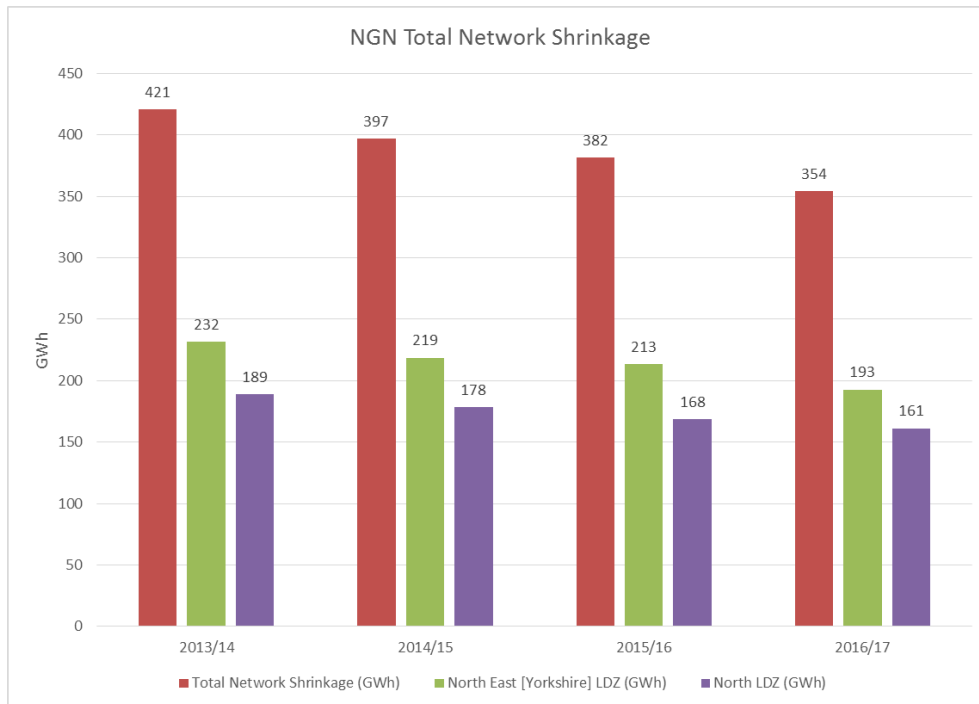
Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	218 GWh (75%)	379km of Mains Replacement	215 GWh (75%)	-3 GWh (-1%)
MP Leakage	20 GWh (7%)	ASP increasing 0.9mbar to 26.7mbar MEG up 0.9%	20 GWh (7%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	52 GWh (18%)	Demand up 3.6% AGIs & Interference up	52 GWh (18%)	0 GWh (0%)
Total	290 GWh (100%)	Replacement & ASP Largest Drivers	287 GWh (100%)	-3 GWh (-1%)

Cadent Network Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	941 GWh (71%)	1756km of Mains Replacement	922 GWh (71%)	-19 GWh (-2%)
MP Leakage	114 GWh (9%)	ASP increasing 0.7mbar to 27.2mbar MEG down -1%	113 GWh (9%)	-1 GWh (-1%)
Other (AGI's, OUG, Theft & Interference)	269 GWh (20%)	Demand up 3% AGIs & Interference down	272 GWh (20%)	3 GWh (1%)
Total	1324 GWh (100%)	Replacement & ASP Largest Drivers	1307 GWh (100%)	-17 GWh (-1%)

Northern Gas Networks

- Total Network Shrinkage was reduced by 7% in 2016/17 from 2015/16.
- Average system pressure was reduced by 3%, metallic pipe length was reduced by 5% and MEG Saturation increased by 5%.
- Average system pressure reducing by more than forecast and good performance in other shrinkage components resulted in lower than forecast total shrinkage in 2016/17.
- Total Shrinkage has been reduced by approximately 16% comparing 2016/17 to 2013/14.



NE LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	150 GWh (70%)	326km of Mains Replacement ASP reducing 0.9mbar to 30.1mbar MEG up 7% to 28%	135 GWh (70%)	-15 GWh (-10%)
MP Leakage	17 GWh (8%)		17 GWh (9%)	-1< GWh (-2%)
Other (AGI's, OUG, Theft & Interference)	46 GWh (22%)	Demand up 2% AGIs & Int. Down	41 GWh (21%)	-5 GWh (-11%)
Total	213 GWh (100%)	Replacement & ASP Largest Drivers	193 GWh (100%)	-20 GWh (-10%)

NO LDZ Performance

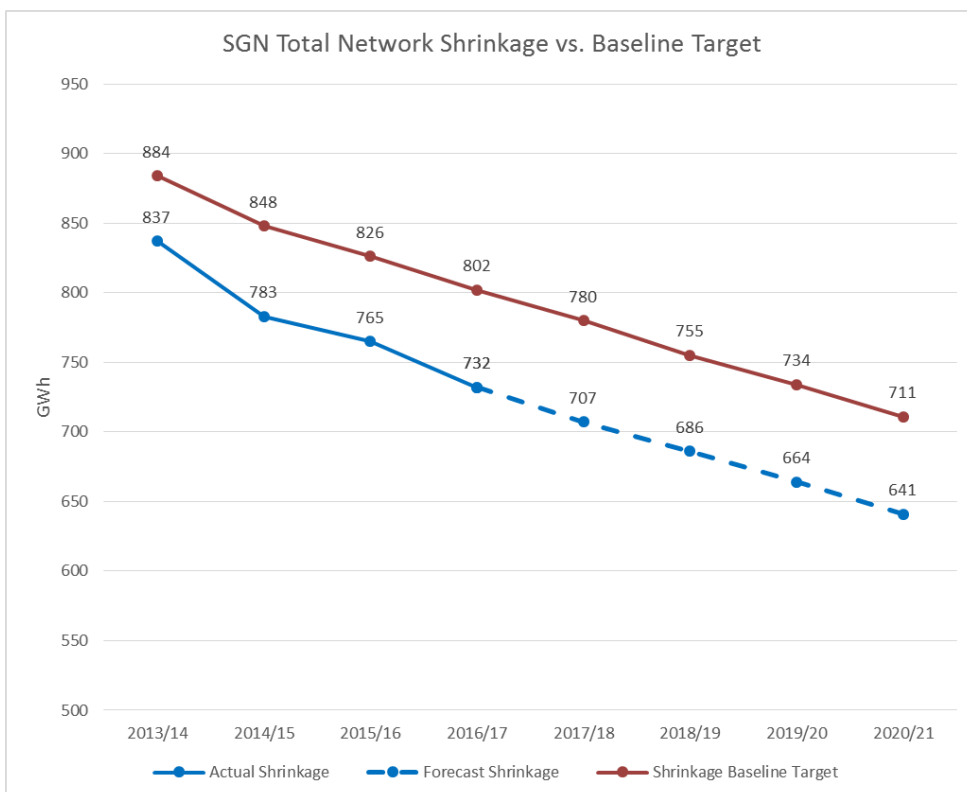
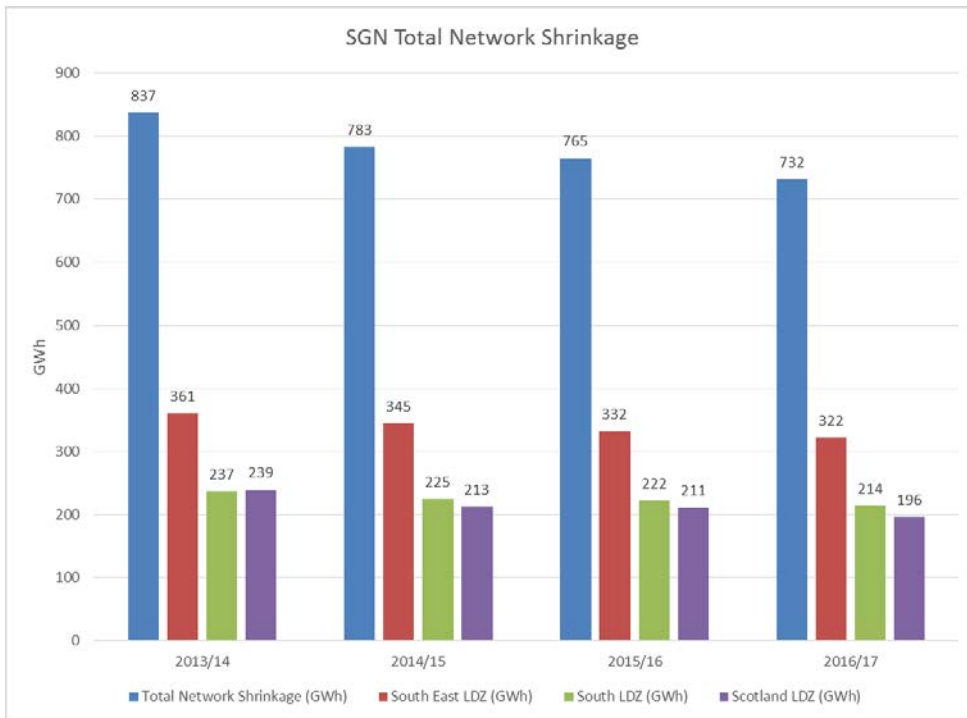
Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	122 GWh (72%)	212km of Mains Replacement ASP reducing 0.8mbar to 31.2mbar MEG up 3% to 31%	112 GWh (69%)	-10 GWh (-8%)
MP Leakage	10 GWh (6%)		9 GWh (6%)	-1< GWh (-3%)
Other (AGI's, OUG, Theft & Interference)	37 GWh (22%)	Demand up 3% AGIs & Int. Up	40 GWh (25%)	3 GWh (9%)
Total	169 GWh (100%)	Replacement & ASP Largest Drivers	161 GWh (100%)	-8 GWh (-4%)

NGN Network Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	272 GWh (71%)	537km of Mains Replacement ASP reducing 0.8mbar to 30.6mbar MEG up 5% to 30%	247 GWh (70%)	-25 GWh (-9%)
MP Leakage	27 GWh (7%)		26 GWh (7%)	-1 GWh (-2%)
Other (AGI's, OUG, Theft & Interference)	83 GWh (22%)	Demand up 2% AGIs & Int. Down	81 GWh (23%)	-2 GWh (-2%)
Total	382 GWh (100%)	Replacement & ASP Largest Drivers	354 GWh (100%)	-28 GWh (-7%)

SGN

- Total Network Shrinkage was reduced by 4% in 2016/17 from 2015/16.
- Average system pressure was reduced by 0.6%, metallic pipe length was reduced by 4.6% and MEG Saturation increased by 7%.
- Total Shrinkage has been reduced by approximately 13% comparing 2016/17 to 2013/14.



SE LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	268 GWh (81%)	427km of Mains Replacement ASP reducing 0.2mbar to 26.31mbar MEG up 6%	255 GWh (79%)	-13 GWh (-10%)
MP Leakage	15 GWh (5%)		15 GWh (5%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	49 GWh (14%)	Demand up 7.5% AGIs & Interference Down	52 GWh (16%)	3 GWh (6%)
Total	332 GWh (100%)	Replacement & ASP Largest Drivers	322 GWh (100%)	-10 GWh (-3%)

SO LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	147 GWh (66%)	200km of Mains Replacement ASP reducing 0.1mbar to 26.57mbar	142 GWh (66%)	-5 GWh (-3%)
MP Leakage	28 GWh (13%)		28 GWh (13%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	47 GWh (21%)	Demand up 7.5% AGIs up & Interference Down	44 GWh (21%)	-3 GWh (-6%)
Total	222 GWh (100%)	Replacement & ASP Largest Drivers	214 GWh (100%)	-8 GWh (-4%)

SC LDZ Performance

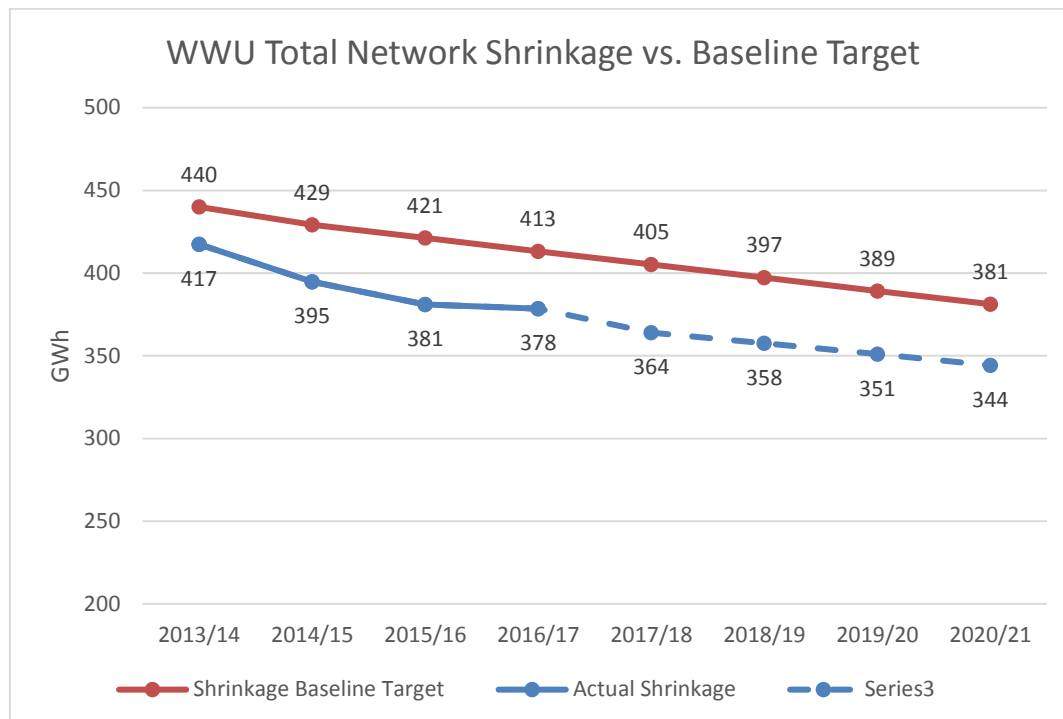
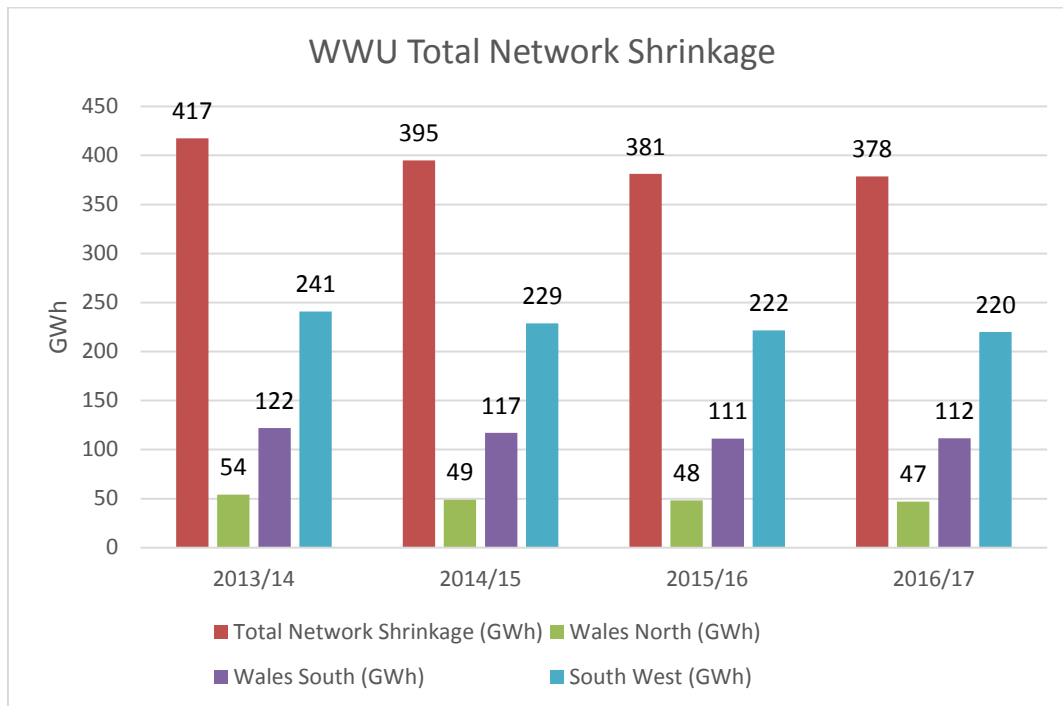
Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	139 GWh (66%)	280km of Mains Replacement ASP reducing 0.2mbar to 26.47mbar MEG up 7%	130 GWh (66%)	-9 GWh (-7%)
MP Leakage	16 GWh (8%)		16 GWh (8%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	56 GWh (26%)	Demand up 4% AGIs & Interference Down	50 GWh (26%)	-6 GWh (-11%)
Total	211 GWh (100%)	Replacement & ASP Largest Drivers	196 GWh (100%)	-15 GWh (-7%)

SGN Network Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	554 GWh (72%)	907km of Mains Replacement ASP reducing 0.2mbar to 26.53mbar MEG up 8%	527 GWh (72%)	-27 GWh (-5%)
MP Leakage	59 GWh (8%)		59 GWh (8%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	152 GWh (20%)	Demand up 2% AGIs & Interference Down	146 GWh (20%)	-6 GWh (-4%)
Total	765 GWh (100%)	Replacement & ASP Largest Drivers	732 GWh (100%)	-33 GWh (-4%)

Wales & West Utilities

- Total Network Shrinkage was reduced by 1% in 2016/17 from 2015/16.
- Average system pressure increased by 3% and metallic pipe length was reduced by 4.5%.
- Total Shrinkage has been reduced by approximately 9% comparing 2016/17 to 2013/14.



WN LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	22 GWh (46%)	Mains & Services Replacement/ASP	21 GWh (45%)	-1 GWh (-5%)
MP Leakage	3 GWh (6%)		3 GWh (6%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	23 GWh (48%)	No Change	23 GWh (49%)	0 GWh (0%)
Total	48 GWh (100%)		47 GWh (100%)	-1 GWh (-2%)

WS LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	71 GWh (64%)	Mains & Services Replacement/ASP	70 GWh (63%)	-1 GWh (-1%)
MP Leakage	10 GWh (9%)		10 GWh (9%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	30 GWh (27%)	Increase in demand – Power station	32 GWh (29%)	2 GWh (7%)
Total	111 GWh (100%)		112 GWh (100%)	1 GWh (0.3%)

SW LDZ Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	163 GWh (73%)	Mains & Services Replacement/ASP	161 GWh (73%)	-2 GWh (-1%)
MP Leakage	19 GWh (9%)		19 GWh (9%)	0 GWh (0%)
Other (AGI's, OUG, Theft & Interference)	39 GWh (18%)	No Change	40 GWh (18%)	0 GWh (0%)
Total	222 GWh (100%)		220 GWh (100%)	-2 GWh (-1%)

WWU Network Performance

Component	2015-16	Drivers of Change	2016-17	Difference
LP Leakage	257 GWh (67%)	471km of Mains Replacement Average System Pressure (ASP) increased 1 mbar	252 GWh (67%)	-5 GWh (-2%)
MP Leakage	33 GWh (9%)		32 GWh (8%)	-1 GWh (-3%)
Other (AGI's, OUG, Theft & Interference)	91 GWh (24%)	Demand in South Wales increased - large power station connected	94 GWh (25%)	3 GWh (3%)
Total	381 GWh (100%)		378 GWh (100%)	-3 GWh (-1%)