Demand Estimation Sub Committee (DESC)

Seasonal Normal Review 2025:

Approach to review of CWV Formula

Demand Estimation Team

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Document Version Control

Version	Date	Reason for Change
Draft version 0.1	Jan-24	Initial draft of proposed approach for DESC review

Background

This document describes the proposed approach for reviewing and revising the parameters of the Composite Weather Variable (CWV). In accordance with Section H of the Uniform Network Code, the Demand Estimation Sub Committee (DESC) are responsible for the following obligations:

- Review the Composite Weather Variable (CWV) (H 1.4.3)
- Review the Seasonal Normal equivalent referred to as the SNCWV (H 1.5.3)

The last such CWV review was completed in Autumn 2019, with the new CWV definition being implemented on 1st October 2020. Alongside a full review of the parameters, the 2019 CWV review also added a new term to the CWV formula – Solar Radiation.

The review cycle described in this document is due to take place over Q1 – Q3 of 2024 in preparation for an implementation date of 1st October 2025, although the revised CWV definitions will be needed in the 2025 NDM analysis in April 2025. The proposed approach to reviewing the parameters is essentially the same as applied in the previous review undertaken in Autumn 2019, with the addition of another 5 Gas Years of aggregate NDM demand and weather data being available to the analysis.

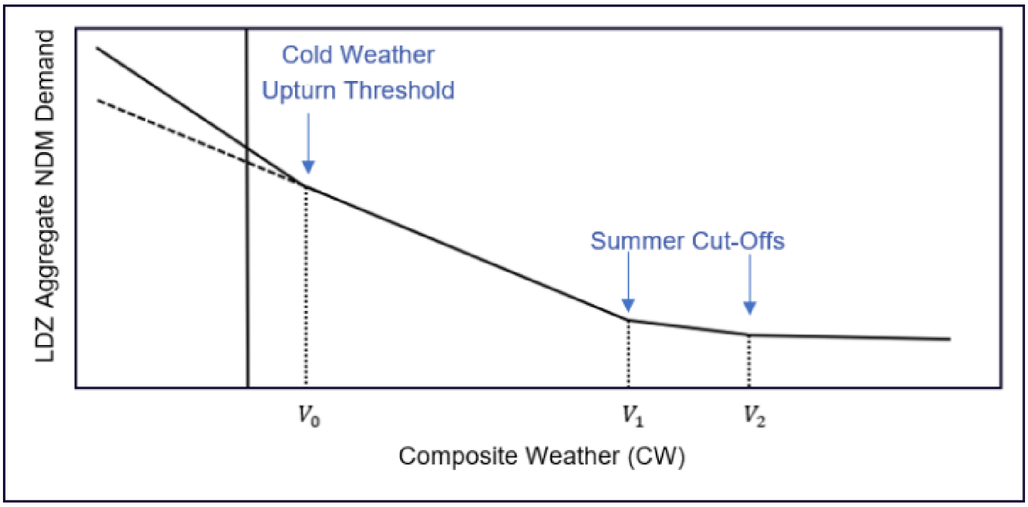
During the 5 years since 2019, we have observed some unusual trends and patterns of gas demand caused by the disruption of the global health crisis (COVID-19) along with the volatility in energy prices. These impacts will be need to be carefully considered when selecting the gas demand data for use in optimising the CWV definitions.

Definition of Composite Weather Variable

The CWV is a single measure of daily weather in each LDZ and is a function of actual temperature, wind speed, solar radiation, effective temperature, SNET, and SNES. The definition of CWV includes provision for summer cut-offs and cold weather upturn during low temperature extremes, defined such that a linear relationship applies between daily demand in the LDZ and the CWV.

The revised definitions of each CWV, implemented on 1st October 2020, include a pseudo SNET profile and a pseudo SNES profile based on aggregate NDM demand as well as weather. This is a specific feature of the revised (and previous) CWV definitions intended to beneficially alter the underlying shape of the CWV profile throughout the year and thereby help mitigate seasonal modelling bias.

Figure 1. (below) shows schematically the component parts of the definition of the CWV



The mathematical formulation of the CW (an intermediary step in the calculation) and CWV is given below.

The CW is made up of an effective temperature term, a SNET term, a wind chill term, and a solar radiation term as shown:

$$\mathrm{CW_t} = I_1 * E_t + (1.0 - I_1) * S_t - I_2 * \max(0, W_t - W_0) * \max(0, T_0 - AT_t) + S_0 * SR_t$$

Incorporating summer cut-offs, transition and cold weather upturn then gives the final form of the CWV:

$CWV_t = V_1 + q * (V_2 - V_1)$	if $V_2 \leq CW_t$	(summer cut-off)
$CWV_t = V_1 + q * (CW_t - V_1)$	if $V_1 < CW_t < V_2$	(transition)
$CWV_t = CW_t$	if $V_0 \leq CW_t \leq V_1$	(normal)
$CWV_t = CW_t + l_3 * (CW_t - V_0)$	if $V_0 > CW_t$	(cold weather upturn)

Scope of Review

The scope of the analysis will focus on a fresh optimisation of the parameters used within the CWV formula.

This review will assume the current timeslots for recording Temperature, Windspeed, and Solar Radiation observations, which feed into the daily Actual Temperature (AT_t), Actual Windspeed (W_t), and Actual Solar (AS_t) calculations, will remain unchanged.

This review will not consider fundamental changes to the formula, such as introducing a new weather variable or additional terms within the formula. Although a precipitation term currently exists in the formula, and precipitation data is being collected, precipitation will not be considered for this formula review.

Parameter optimisation will look at all variables within the formula, however the following areas will also be focussed on as part of this review cycle:

- Large day-to-day movements in temperature. Preliminary work will be undertaken to assess if there is evidence to suggest that NDM allocation performs poorly when there are large day-to-day temperature changes. This analysis would potentially indicate that the current Effective temperature is too restrictive or vice versa.

- Summer cut-offs and Cold weather Up-turns – similarly, analysis will be undertaken to assess whether there is evidence to suggest that the current Cut offs, such as maximum CWV threshold, and up-turn parameters (see previous section) lead to poorer performance in NDM allocation.

Outline of Approach

In the proposed approach, there are a number of stages involved in revising the CWV definition for a particular LDZ that use demand and weather data from a number of Gas Years. At each stage the values for one or more CWV parameter is estimated. For most of these stages, a range of possible values for the parameter(s) is investigated. Regression models are derived for each Gas Year relating daily demand to CWV (on some or all non-holiday days) for each of the possible CWV parameter values.

The value(s) of the parameter(s) that produces the best fit of CWV to demand on average over the modelled Gas Years is chosen as the parameter estimate(s). If a particular Gas Year contains suspect demand or weather data, the demand model for that year may be excluded when selecting the best value(s) for the parameter estimate(s).

Due to the nature of the data used in the analysis and the industry timetable that needs to be adhered to, the analysis needs to be performed over 2 separate phases. In this document these phases shall be referred to as the **Trial Phase** and the **Production Phase**, an explanation of each is given below:

Trial Phase

The objective of the Trial phase is to establish key principles and approaches for how the main CWV optimisation analysis will be carried out during the Production phase. The work involved in revising all parameters for each LDZ is substantial, as it involves many iterations of analysis in order to find the optimum set of values which have proven themselves over a number of Gas Years. Therefore, during this investigative work only a selection of the 13 LDZs will be chosen for analysis and the results from these LDZs will be used to support the final agreements on how the calculations for all LDZs will be performed during the Production phase.

It is expected that the Trial phase analysis will be completed during Q1/Q2 of 2024

Production Phase

The objective of the Production phase is to revise the CWV parameters for all LDZs following the agreements reached at the end of the Trial phase. This phase, carried out during Q2/Q3 of 2024 will involve a significant amount of analysis with the output providing a key component of the calculations for the new Seasonal Normal Composite Weather Variable (SNCWV). The SNCWV will need to be derived during Q4 and so it is therefore not feasible to include another ‘review cycle’ of the CWV parameters within this phase. The CWV parameters output during this phase will have been derived following the earlier agreement, hence the importance of the analysis performed during the Trial phase.

Source Data

Weather Data

The CDSP currently holds a Gas industry weather history which reflects data sourced from weather service providers and has been used within day to calculate historic CWVs. This weather history is the primary source of data which will be used when performing the 2024 CWV optimisation review. As mentioned in the 'Scope of review' section, the weather variables to be considered as part of this CWV Optimisation review are Temperature, Windspeed and Solar Radiation.

The weather stations that will be used for the optimisation will be the existing Gas Industry weather stations. These stations are regularly reviewed by DESC, the latest review in July 2023 concluded that there are no anticipated upcoming station closures or issues which may cause disruption to data flows.

A full data history exists for each of the combinations of weather variable and weather station. Temperature and Windspeed Data for Yeovilton weather station has been produced by 'backing out' the bias adjustments which were performed to raw Yeovilton data to mimic Filton during period October 2018 – October 2020.

For completeness, the list of stations that will be used is as follows:

LDZ	Temperature	Windspeed	Solar Radiation
SC	Glasgow Bishopton	Glasgow Bishopton	Glasgow Bishopton
NO	Albemarle Barracks	Albemarle Barracks	Durham Weather Station
NW	Rostherne No 2	Rostherne No 2	Rostherne No 2
NE	Nottingham Watnall	Nottingham Watnall	Nottingham Watnall
EM	Nottingham Watnall	Nottingham Watnall	Nottingham Watnall
WM	Birmingham Winterbourne 2	Coleshill	Coleshill
WN	Rostherne No 2	Rostherne No 2	Rostherne No 2
WS	St. Athan	St. Athan	St. Athan
EA	London Heathrow	London Heathrow	London Heathrow
NT	London Heathrow	London Heathrow	London Heathrow
SE	London Heathrow	London Heathrow	London Heathrow
SO	Southampton Oceanographic Institute	Southampton Oceanographic Institute	Southampton Oceanographic Institute
SW	Yeovilton Weather Station	Yeovilton Weather Station	Yeovilton Weather Station

Demand History

As explained, the objective of the CWV formula review is to ensure a linear relationship to aggregate NDM demand in the LDZ is achieved, thus improving the accuracy of NDM allocation and the reduction of Unidentified Gas (UIG). To perform the CWV optimisation analysis, aggregate NDM demand is therefore required as a data input.

Aggregate NDM demand is calculated as below:

Total LDZ Demand - Daily Metered (DM) - Shrinkage = NDM Estimated Demand + Unidentified Gas

(NDM Estimated Demand + Unidentified Gas = 'Aggregate NDM Demand')

Monday to Thursday non-holiday daily aggregate NDM demand data for each LDZ will be used in the analysis, with the following conditions:

- Demand data that appears suspect or unusual for particular days, perhaps as a result of an incorrect DM or LDZ measurement which ultimately affects the NDM position, will be removed from the analysis. Where this happens, the removed days will be recorded.

  Example: A significant metering error was recorded in LDZ EM for period 21/04/2023 to 04/07/2023, therefore none of these Gas Days will be considered when selecting historic data

- Gas Years 2019/20 to 2022/23 have been affected by the global health crisis (Covid-19) and volatility in gas markets. As part of this review cycle, these Gas Years will be analysed independently to assess whether the relationship between CWV and aggregate demand still applies, and whether they should be included in the overall analysis.

Approach: Trial and Production phases

Trial Phase

The first stage in the Trial phase will be to select a group of LDZs on which the initial analysis will be performed and an optimisation template devised. All LDZs have a complete weather and demand history so other factors such as number of known data issues, and geographical spread will be considered.

The date range of the analysis to be performed will be [01st October 2015 to 30th September 2023]*. Once data for this period has been validated, an optimisation tool will be created in SAS which is capable of performing the optimisation calculations.

The CWV optimisation results provided will be in line with the last CWV review performed in 2019.

* Dates may be subject to change depending on outcome of analysis performed on recent Gas Years during trial phase

Production Phase

Using the optimisation routine created during the Trial phase, the Production Phase will cover the full parameter optimisation for all LDZs and is due to be completed and approved by DESC at its meeting on 08th October 2024.

In preparation for this phase, all weather and demand data will be cleansed and verified, to remove known issues such as Metering errors, or issues in calculated CWVs. The date range and number of years agreed will be used to determine the optimised CWV parameters for all LDZs.

Approach: Stages involved in revising the CWV definition

Data Import

The first step is to ensure all relevant data is available to the optimisation tool. This includes Daily aggregate NDM demand, relevant Temperature, Windspeed, and Solar Radiation observations, current pseudo-SNET values, current pseudo-SNES values, and Gas Day Holiday codes.

Measure performance of CWV in certain conditions

Statistical analysis will be performed across the optimisation period where either rapid increases or decreases in underlying temperatures have been observed.

Analysis will also be performed on Gas Days where weather is at upper or lower extremes, such as exceptionally warm Gas Days where the CWV has hit its maximum value, or exceptionally cold Gas Days where the CWV has reached the cold weather upturn threshold.

The aim of this analysis will be to assess whether there is evidence that NDM allocation performs poorly when compared to periods of stable or seasonally normal weather, and may be used to influence the ranges used during later stages of parameter optimisation.

Pseudo SNET and SNES optimisation

- Derive a pseudo-SNET from aggregate NDM demand data using 3-Frequency Fourier series. The Pseudo-SNET is calculated from [8] years [2015/16 to 2022/23] of autoregressive models of the following form, derived using non-holiday days with $ET_{min} < ET < ET_{max}$

$$D = a - \sum_{i=1}^{3} bi\ \sin\left(\frac{2id\pi}{365}\right) - \sum_{i=1}^{3} bi\ \cos\left(\frac{2id\pi}{365}\right) + d\ \mathrm{ET} + e\ \mathrm{WC} + f\mathrm{FRI} + g\mathrm{SAT} + h\mathrm{SUN} + \ \mu$$

- For each year's model, scale the bi and ci parameters by dividing by the sum of the Fourier series parameters (b1+b2+b3+c1+c2+c3). Take the mean of these 8 sets of scaled parameters to produce an average Fourier series. A "pseudo SNET" is derived from this average Fourier series by adding the mean ET and scaling the averaged parameters so that the pseudo SNET has a similar range and mean to the mean daily ET profile over the analysis period. The value for 29th February is derived from the average of the 28th February and March 1st values.

  Note that the limits ET_{min} and ET_{max} are constants that vary by LDZ and are chosen to select most of the non-holiday days that do not fall within the cold weather upturn or warm weather flattening off periods.

- The pseudo-SNES is calculated similarly to the SNET, with an additional variable, $f\mathrm{Solar}$. For each of the Gas Years, an autoregressive demand model of the following form is derived using non-holiday days (excl. 29th Feb) with $ET_{min} < ET < ET_{max}$:

$$D = a - \sum_{i=1}^{3} bi\ \sin\left(\frac{2id\pi}{365}\right) - \sum_{i=1}^{3} bi\ \cos\left(\frac{2id\pi}{365}\right) + d\ \mathrm{ET} + e\ \mathrm{WC} + f\mathrm{Solar} + g\mathrm{FRI} + h\mathrm{SAT} + i\mathrm{SUN} + \ \mu$$

Parameter Optimisation

- Once a suitable profile for the SNET and SNES have been derived, optimisation can then be performed on all parameters.

  A reminder of the parameters and what each represents can be found below:

  > y – The weighting factor applied in the Effective temperature calculation for Gas Day 'D' between D-1's Temperature and D's Actual Temperature
  >
  > I_1 – A weighting factor applied between the Effective Temperature and the SNET for Gas Day 'D' in the CW calculation
  >
  > I_2 – A constant applied to the 'Windchill' factor of the CW Calculation
  >
  > I_3 – A constant used to scale the magnitude of the Cold Weather Upturn
  >
  > V_o – The CW boundary between 'Cold Weather Upturn' and 'Normal' phases
  >
  > V_1 – The CW boundary between 'Normal' and 'Transition' phases
  >
  > V_2 – The CW boundary for the 'Summer cut-off' (Max CWV)
  >
  > q – A constant used to determine the magnitude of the 'Transition' phase and 'Summer cut-off'
  >
  > W_0 – A constant used to set a minimum Wind Speed threshold for the 'Windchill' effect
  >
  > T_0 – A constant used to set a maximum Temperature threshold for the 'Windchill' effect
  >
  > S_0 – A constant used to scale the magnitude of Solar Radiation

- Derive the 1 in 20 peak CWV from all available weather data (64 gas years from 01/10/1960 to 30/09/2023) and estimate indicative 1 in 20 peak demands for each Gas Year from Monday to Thursday non-holiday demand model parameters. Compare the fit and indicative peak demands for the revised CWV with the existing CWV.

2024 Indicative Timeline for CWV Formula Review

Phase	Approx Dates	Interaction / Decisions	Made by
Approach to Optimisation	Q1 2024	Review the proposed approach to be taken for Optimisation	DESC
Approach to Optimisation	Q1 2024	Approve the approach to Optimisation	DESC
Optimisation - Trial Phase	Q1 / Q2 2024	Based on approved approach: Prepare data (weather / demand) as necessary Undertake initial analysis on agreed LDZs and parameters	Xoserve Demand Estimation Team
Optimisation - Trial Phase	Q1 / Q2 2024	Review the outputs from the initial analysis and provide recommendation to DESC	Xoserve Demand Estimation Team
Optimisation - Trial Phase	July 2024	DESC to review and agree preferred options for full optimisation	DESC
Full Optimisation - Production Phase	Q3 2024	Complete analysis of 13 LDZs as per DESC agreed performed options	Xoserve Demand Estimation Team
Full Optimisation - Production Phase	Q3 2024	Prepare output and provide recommendations to DESC	Xoserve Demand Estimation Team
Full Optimisation - Production Phase	October 2024	DESC to review and approve revised CWV Parameters	DESC