Jason Blackmore 03/06/2019

This document details an approach that can be used to incorporate solar radiance into the existing CWV calculation. The first page details the new calculation and the rest of the document provides some rationale to the approach.

CWV Calculation

To recap, the CWV calculation, is a function of the following three components:

- Wind Speed (WS_D) – Computed by taking an average of three hourly wind speed figures over the gas day
- Effective Temperature (ET_D) – Half of today's Actual Temperature (AT) + Half of yesterday's ET
- Seasonal Normal Effective Temperature $SNET_D$ – Calculated using 18 years of data from 1996/97 to 2013/14

Thus, together with the CWV parameters these are termed Composite Weather:

$$CW = I_1 ET_D + (1 - I_1) SNET_D - I_2 \max(0, WS_D - W_0) \max(0, T_0 - AT)$$

The application of cold, transition and summer cut offs is applied to CW which becomes CWV:

$$CWV = \begin{cases} V_1 + q(V_2 - V_1), & CW \geq V_2, & CWV\ Summer \\ V_1 + q(CW - V_1), & V_1 < CW < V_2, & CWV\ Transition \\ CW, & V_0 \leq CW \leq V_1, & CWV\ Normal \\ CW + I_3(CW - V_0), & CW < V_0, & CWV\ Cold \end{cases}$$

CWV+ Calculation

Solar is included in the CWV calculation as follows. The components include:

- Actual Solar (AS_D) – Computed by the sum of hourly solar radiance observations over the gas day. Same hours as temperatures used.
- Seasonal Normal Solar (SNS_D) – Sum of the hourly seasonal normal solar observations from the CCM data sets. Same hours as temperatures used.

Next, a log transformation is applied to remove scale from a highly variable seasonal measurement, thus, Solar Radiance for the Day is measured as a difference from seasonal normal:

$$SR_D = \log AS_D - \log SNS_D$$

Next, SR_D is included in the CW, CWV definition as follows:

$$CW = I_1 ET_D + (1 - I_1) SNET_D - I_2 \max(0, WS - W_0) \max(0, T_0 - AT) + S_0 SR_D$$

Where S_0 is a new parameter that is optimised in the same way as the CWV optimisation method.

Leaving CWV subject to the usual cold, transition and summer cut offs[1]:

$$CWV{+}= \begin{cases} V_1 + q(V_2 - V_1), & CW \geq V_2, & CWV\ Summer \\ V_1 + q(CW - V_1), & V_1 < CW < V_2, & CWV\ Transition \\ CW, & V_0 \leq CW \leq V_1, & CWV\ Normal \\ CW + I_3(CW - V_0), & CW < V_0, & CWV\ Cold \end{cases}$$

[1] Previously thoughts were about applying solar in the following form. SCWV=CWV+Solar Term thus CWV could differ outside its CWV maximum.

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Measuring Solar

For this design we wanted CWV+ to be higher than CWV on bright days to provide lower demand. We also wanted a result where if there was no solar effect then CWV+ = CWV.

One problem is that solar is a highly variable seasonal measurement, much higher in the summer, which is being modelled against a highly variable gas measurement, much higher in the winter. A monthly approach to the analysis would produce greater over fitting of the results and a complicated optimisation. Therefore the solar measurement used was a daily sum of hourly solar observation[2] minus its seasonal normal equivalent (which was taken from CCM datasets) and then a log of the daily solar and normal series was used, log(solar) – log(solar seasonal normal) as shown in Figure 2: Solar Radiance Transformations[3].

Figure 1 Daily Totals of Solar Radiance:

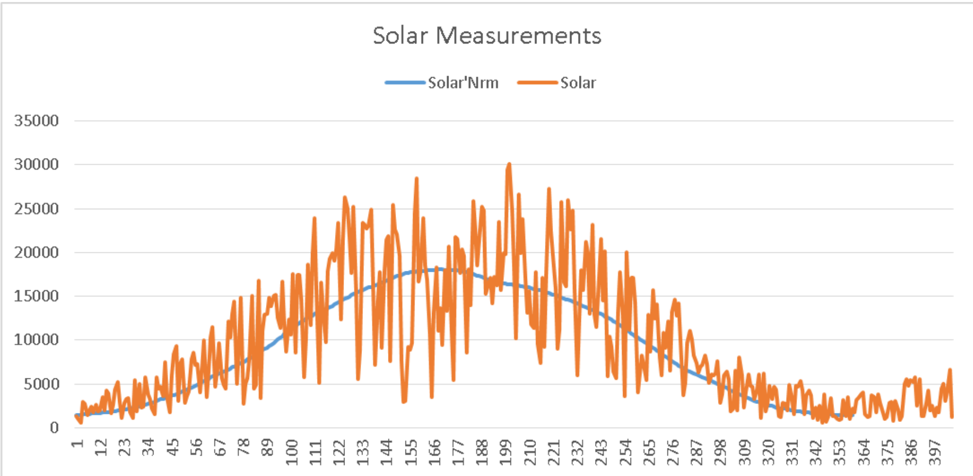
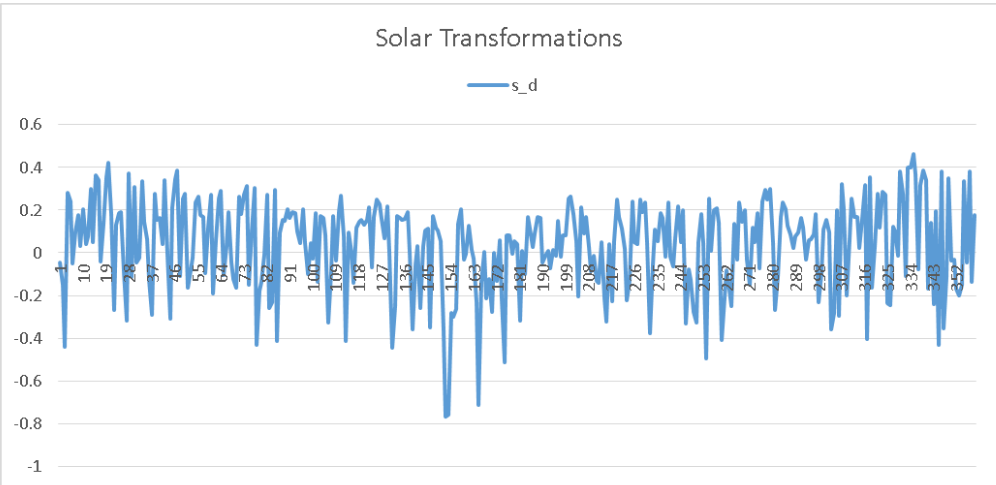


Figure 2: Solar Radiance after Log Transformations



[2] Same hours as used in the calculation of AT

3 In the future a Box-Cox transformation could be applied instead – a type of variance equalising transformation.

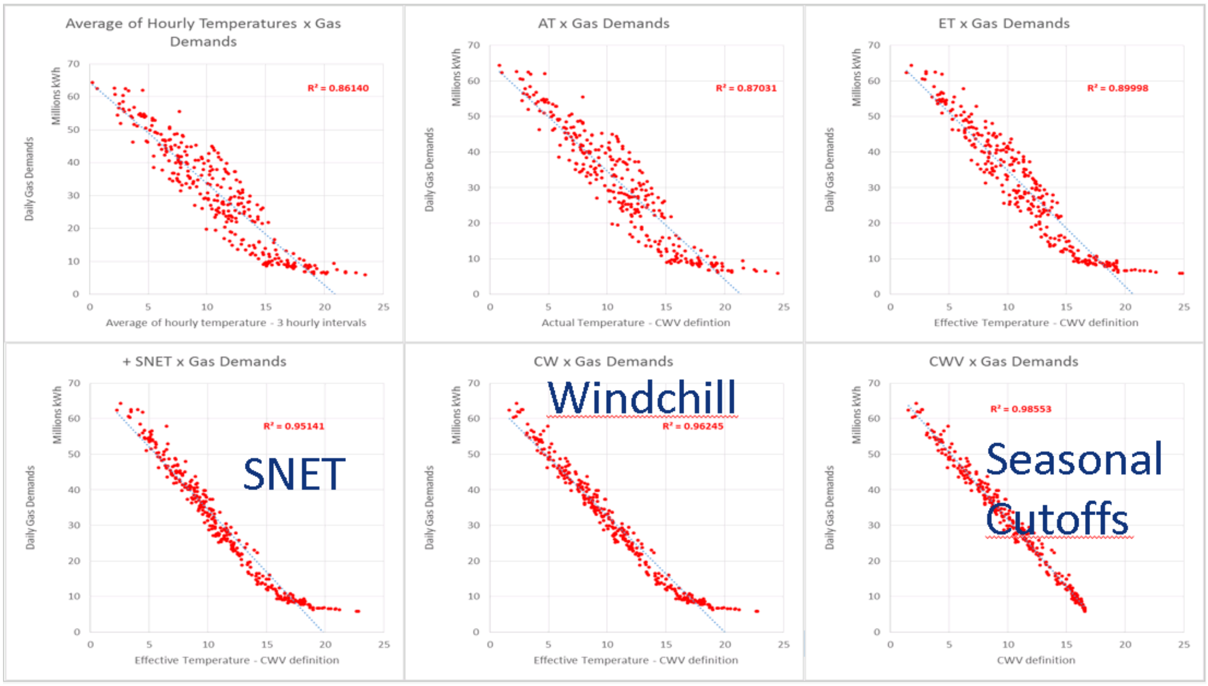
The transformation chosen attempts to produce a solar measurement which has a constant mean and variance - visually it achieves this reasonably well in Figure 2. [4]

<u>Other observations on CWV</u>

Below the components of CWV are shown against demand to highlight which parts of the CWV calculation are more or less important.

For example, the AT definition improves slightly over a simple average of hourly temperatures.

The SNET term and seasonal cut-offs are the most important part of the CWV calculation.



<u>CWV+</u>

If solar is important in explaining gas demand this would show visually as:

Actual observations below the regression line – model is over forecasting – "bright" days – CWV measured too cold.

Above the regression line – model is under forecasting – "dull" days – CWV measured too warm.

Thus an improvement in fit would be shown visually as a movement closer to the regression line within the range of CWV measurements, see chart below.

The improvements in R2 in this example 0.9863-0.9892 may be considered small, however this does explain 21% of unexplained error, so it's a significant improvement to model fit.

4 The transformation does produce a result where a summer solar impact produces the same CWV effect (and therefore same demand effect) as a winter solar impact (a linear response) – which may not be true.

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