A review of the temperature weights used in the CWV definition

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As part of a review of the CWV definition, analysis was carried out on the weights applied to temperature in the calculation of Actual Temperature (AT) and Effective Temperature (ET) within the CWV calculation. These weights currently sum to 1 across the gas day:

W_05	W_07	W_09	W_11	W_13	W_15	W_17	W_19	W_21	W_23	W_01	W_03
0.05	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.05

The lower weights assigned to overnight hours are thought to be due to less temperature sensitivity of gas demand.

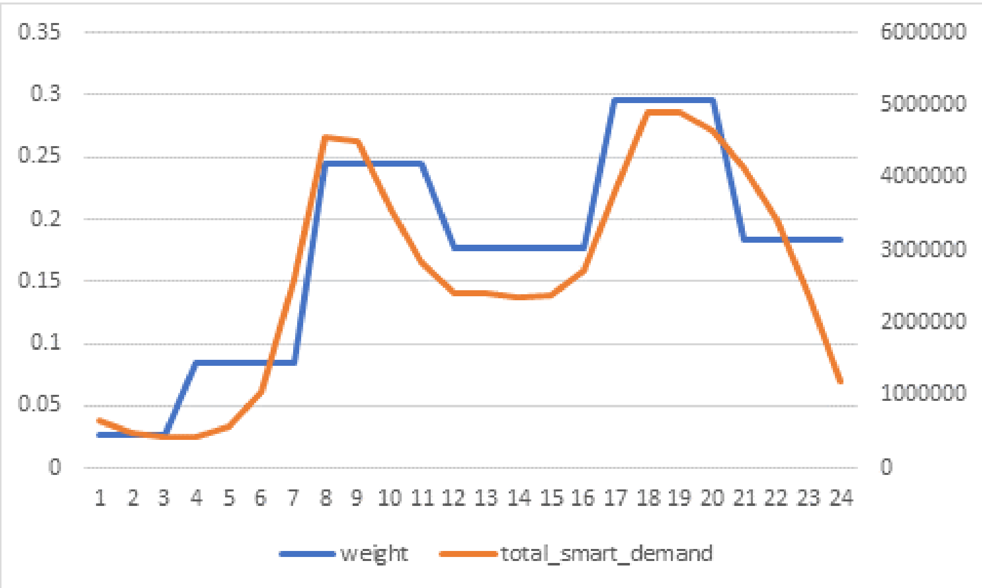
Prior expectations before the analysis were that:

1. Daily gas demands should be more affected by hours of the gas day when consumption was high.
2. Additionally, across the day gas demands would be differently affected by temperature due to customer behaviour (for example in bed, or at work).

A combination of these two impacts should be reflected in the weights.

Hourly Gas Demands

A review of hourly gas demands for a domestic customer is shown below. A morning and evening peak of consumption is shown, looking very similar to the electricity consumption profile.



Therefore it was expected that any weights should follow these periods of higher demand.

A cluster analysis was performed to identify segments across the gas day. An analysis was carried out with smart meter data. K-mean cluster technique is used for this analysis and the results are show in the following table.

Hour	0	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	3
Cluster	4	4	4	5	5	5	2	2	2	2	3	3	3	3	3	1	1	1	1	6	6	6	6	5

Clusters 1 & 2 covers the turning points during the day and divides gas day into 6 unique segments. These 6 segments cover times of the day where demand responses in a similar manner to temperature.

Next, a regression analysis was done explaining daily gas demands by average temperatures for each segments. This provides a series of temperature coefficients for each segment across the day.

These coefficients are scaled to be summed to 1, and the weights represented a relative coefficient of temperature. This is shown in the above chart (blue line).

There are clearly two peak time periods, morning peak from 7am to 10am and afternoon peak from 4pm to 7pm. While afternoon peak has higher weight than morning peak. This is also illustrated the daily routines of customers.

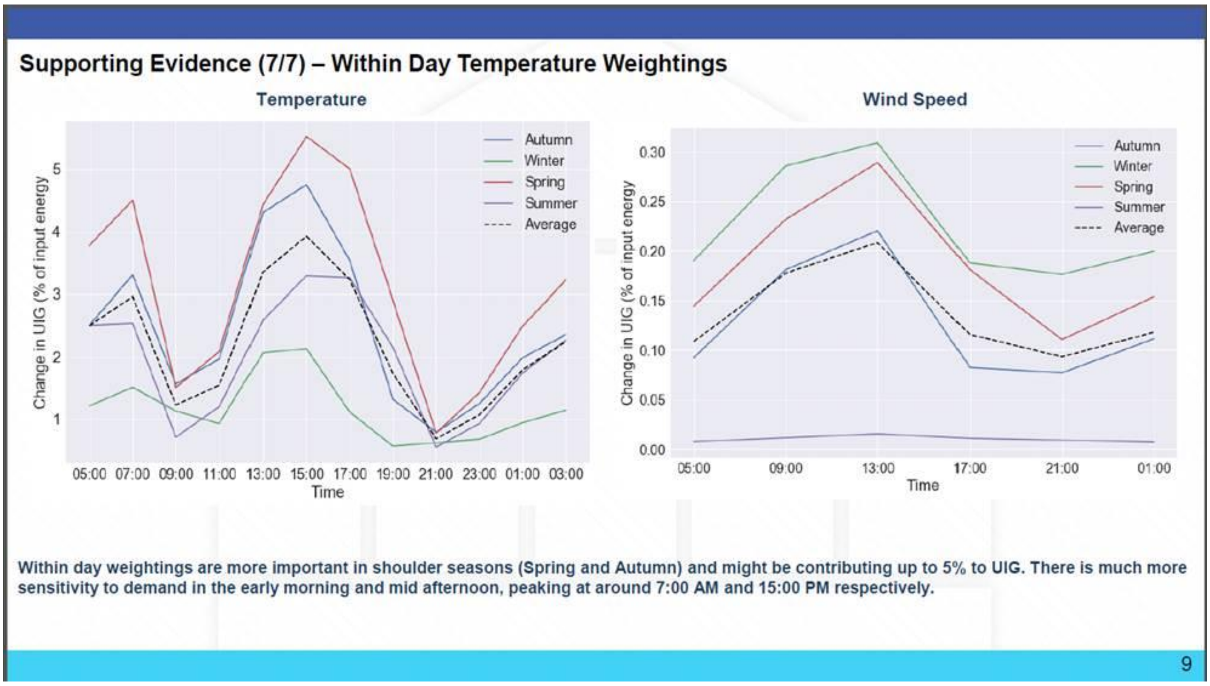
Next, the weights were applied to existing results from a CWV optimisation. The results are shown in the following table, impacts are at the 4th d.p. therefore small. It was thought if the results were robust they should improve upon any version of CWV parameters, rather than being included in the CWV optimisation process.

Year	Obs CWV	New Weights	
2010	0.9936	0.9937	0.0001
2011	0.9874	0.9868	-0.0006
2012	0.9926	0.9925	-0.0001
2013	0.9907	0.9909	0.0002
2014	0.9932	0.9932	0.0000
2015	0.9924	0.9926	0.0002
2016	0.9907	0.9907	0.0000
2017	0.9933	0.9931	-0.0002

The results suggest that improvement to the temperature weights would have little effect on the accuracy of CWV. However, for this analysis we only had hourly domestic data, where it's more appropriate to use hourly LDZ demand data (including business consumption).

UIG Task Force Analysis

The other evidence we have is from the UIG task force. Their analysis suggests "there is more sensitivity to demand in the early morning and mid- afternoon, peaking at 7:00am and 15:00pm"



We queried our results and the response has been:

"I think the BG analysis supports the weather sensitivity findings and vice versa.

The sensitivity analysis shows us which of the daily temperature measurements have the largest potential to influence demand, but the BG analysis shows us when that demand actually peaks. I'd expect to see demand peaks around 7am and 6pm as I think this would be when the majority of thermostats will fire up central heating, and the larger demands in the evening will incorporate a cooking load. But I suspect the offset pattern compared to the weather sensitivity is because it will take time for houses to cool down and for the heating to come on. If demand is sensitive to the temperature at 3-7pm, then a couple of hours delay before demand peaks feels about right. I'd be interested to see if the demand spikes are different at weekends when there could be a reduced 'coming home' effect – and trying to prove (or disprove) a temperature sensitivity /demand relationship offset would be the next step for me. "

There is another conclusion from their analysis (they graph change in UIG v Time). Where the change in UIG is high, it suggests the temperature weights used in demand estimation are inaccurate so between the hours 13,15,17,19. During the morning and evening peaks the current weights are accurate.

<u>Conclusions</u>

We believe the temperature weights are too low during the day and too high towards the end of the gas day, although our analysis so far hasn't brought this out. There are a number of ways to improve this. Inclusion of solar would provide a solution. Our analysis here investigated if the weights themselves could be refined to improve results, yet the results appeared minimal.