Energy Consumption Analysis for

Carlisle City Council
John St. Hostel

(Image courtesy of Google Images)

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1.0 Summary

1.1 ABSTRACT

The purpose of this report is to analyse the gas data provided by the Carlisle City Council for before and after the installation of the Genius Hub system to determine the energy saved as a result (to within the greatest degree of accuracy as possible). This report found an average saving of 50% since the installation of the Genius Hub system in October 2018, at the time of writing. Note that the predicted energy savings on this site given the level of existing control (BEMS & modern TRVs on all radiators) was 25%. The 50% saving on the energy bills achieved has given the whole project a 2.1 year payback.

1.2 PROJECT INCENTIVES

John St. Homeless Hostel is frequently in high demand and has a high turnover of residents. The building has 20 ensuite bedrooms, as well as a dining hall, communal area and staff offices. Carlisle City Council (CCC) recognised the Genius Hub system as a low cost & effective energy saving measure that could be easily retrofitted with little or no disruption to the occupants of the building. The aim of this pilot project was to help the council cut energy costs while maintaining comfort levels.

1.3 FUTURE PROJECTS

The purpose of running a low-cost pilot project was to assess whether the Genius Hub system lives up to the expectations of its ease of use and energy savings. Success in these fields will lead to contracts for other buildings of the CCC's estate which have problems with:

- High energy costs
- Overheating and Underheating
- Lack of visibility of heating problems
- Existing heating systems being run for too long and causing maintenance problems

1.4 PERIOD OF ANALYSIS

The relevant dates for this installation are:

- 12/09/18 - Initial Installation
- 24/10/2018 - Tweaking Visit
    - Genius system optimized by an on-site engineer based on feedback from staff
- 19/04/2018 - Analysis of energy data from site (the winter's heating usage)

Gas data for **Oct 2017 – Aug 2018** has been compared with the data for **Sept 2018 – March 2018**.

The kWh/DegreeDay°C has been used as a way of comparing concurrent weeks in a calendar year while taking into account fluctuations in external temperature. Like 'miles per gallon', but where the type of road and driving conditions have been standardised.

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2.0 Analysis

2.1 METHODOLOGY

Explanation of degree days

Degree days are used to normalise the energy consumption of a building against fluctuations in external temperatures. The outside temperature changes day to day, month to month and to compare one month to the next or one year to the next, degree days analysis is widely accepted as the proven method to compare the heating energy usage of buildings by removing the effect of variable external temperatures as much as is possible.

The average internal temperature of a centrally heated home is 17.4°C (ONS Energy Consumption in the UK 2017 Update). Generally, a Degree Day Base Temperature of 15.5° is chosen. The average temperature takes into account the times of the day that the home is not heated which on average is less during the week but more at the weekends. This is the opposite to a workplace environment which is generally heated more during the week and less during the weekend. For most buildings, homes or offices it is widely accepted that the internal heat gain is 3°C.

Though there are no official regulations for workplace temperature, it has been assumed that the internal temperature needs to be 21-22°C for comfort levels, so for work place environments a Degree Day Base Temperature of 18° is selected to account for the higher internal temperature required in workplaces. In accommodation type environments then lower internal temperatures can be used 19-20° so a base temperature of 15.5°C can we selected. By normalising the energy use against the Degree Day Temperature this gives a comparative fuel use (kWh/°C) which in theory should be the same regardless of external temperature (i.e. the amount of kWh used should be directly proportional to the external temperature). However, in practice external factors disrupt this relationship.

A technique called Linear Regression Analysis can be used to select the best Base Temperature specifically for the building in question. This is not an exact science; the comfort of the occupants of the building and the building's usage contribute significantly to the real Base Temperature. However, the reason for calculating this is to establish at what (external) temperature that it can be assumed that no heating is required to maintain an acceptable comfort level for the users of the building. No Linear regression analysis was performed for this project as not enough data was made available. A Base Temperature of 15.5 °C was therefore used.

Carlisle weather station was selected to provide the Degree Day data for this site.

2.2 THE DATA

Data has been provided for both the gas consumption prior to and after installation.

- **Data set 1 (pre-installation): Provided meter readings (kWh) and reading dates**
- **Data set 2 (post-installation): Provided only the cost of a heating period ex. VAT. The kWh used was back-calculated by subtracting the standing charge (assumed £2.65 / day) & CCL (assumed 19.80%). The actual meter readings may differ from those calculated.**

Open Date	Open Read	Close Date	Close Read	Units	Correction Factor	kWh per meter	Total kWh
01/08/2018	139474	01/09/2018	139611	137	1.022640	4361	4361
01/07/2018	139335	01/08/2018	139474	139	1.022640	4392	4392
01/06/2018	139168	01/07/2018	139335	167	1.022640	5370	5370
01/05/2018	138896	01/06/2018	139168	272	1.022640	8747	8747
01/04/2018	138505	01/05/2018	138896	391	1.022640	12479	12479
01/03/2018	137972	01/04/2018	138505	533	1.022640	17011	17011
01/02/2018	137409	01/03/2018	137972	563	1.022640	17968	17968
01/01/2018	136766	01/02/2018	137409	643	1.022640	20573	20573
01/12/2017	136182	01/01/2018	136766	584	1.022640	18592	18592
01/11/2017	135684	01/12/2017	136182	498	1.022640	15934	15934
01/10/2017	135340	01/11/2017	135684	344	1.022640	10951	10951

Figure 1 – Data set 1 (pre-installation) tabulated.

Pd.	Journal Date	Journal No	Period kWh	Daily kWh	Corrected Period kWh	No. Days	Cost Ex. CCL	CCL	Cost Inc. CCL	Standing Charge	Total cost	VAT Amount
	01/09/2018							19.80%		£2.65 / day		
7	31/10/2018	EXF000230	1871.01792	31.18363207	20756.62613	60	£ 38.65	£ 7.65	£ 46.30	£ 159.00	£ 205.30	£ 41.06
9	06/12/2018	EXF000236	8913.40008	247.5944466		36	£ 184.12	£ 36.45	£ 220.57	£ 95.40	£ 315.97	£ 63.19
9	28/12/2018	EXF000239	13993.8401	636.0836413	7610.762915	22	£ 289.06	£ 57.23	£ 346.29	£ 58.30	£ 404.59	£ 80.92
11	13/02/2019	EXF000241	13498.8084	287.2086887		47	£ 278.83	£ 55.21	£ 334.04	£ 124.55	£ 458.59	£ 91.72
12	18/03/2019	EXF000243	16599.9297	503.0281713		33	£ 342.89	£ 67.89	£ 410.78	£ 87.45	£ 498.23	£ 99.65
											£1,882.68	**£ 376.54**
Sept 2018 to Jan 2019 as at 19/03/2019				Global								
				Average	Std dev	Lower	Upper					
				341	210	131	551					
				Reliable Data								
				Average / day								
				345.9437689								

Figure 2 – Data set 2 (post-installation) tabulated.

Data set 2 (post-installation) contains values outside of its standard deviation. The cells highlighted in red highlight these values. From this, corrected values were calculated by averaging the 3 remaining reliable data points and multiplying by the number of days in that period to obtain corrected values.

The difference in % savings when the corrected values are used equates to an additional -7% savings if the corrected values were used.

In the case of this report, the corrected values were not used because it was assumed that though these outlying values may not be correct, they may be accounting for anomalies in the recording of the kWh meter readings from assumed (where the energy provider expects the old high usage) and actual meter readings (where a much lower then expected reading is taken, because of the incorrect higher consumption from the assumed readings in the previous periods).

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2.3 BEFORE GENIUS HUB INSTALLATION

When the external temperature drops the building is underheated and when it is warmer outside the building overheats. Figure 1 (below) graphs the energy used against the degree days.

The R^2 value is a measure of how tightly the data points fit the trendline. This can also be thought of as a measure of the proportionality between two variables. An R2 value of >0.95 is deemed an exceptionally accurate data set.

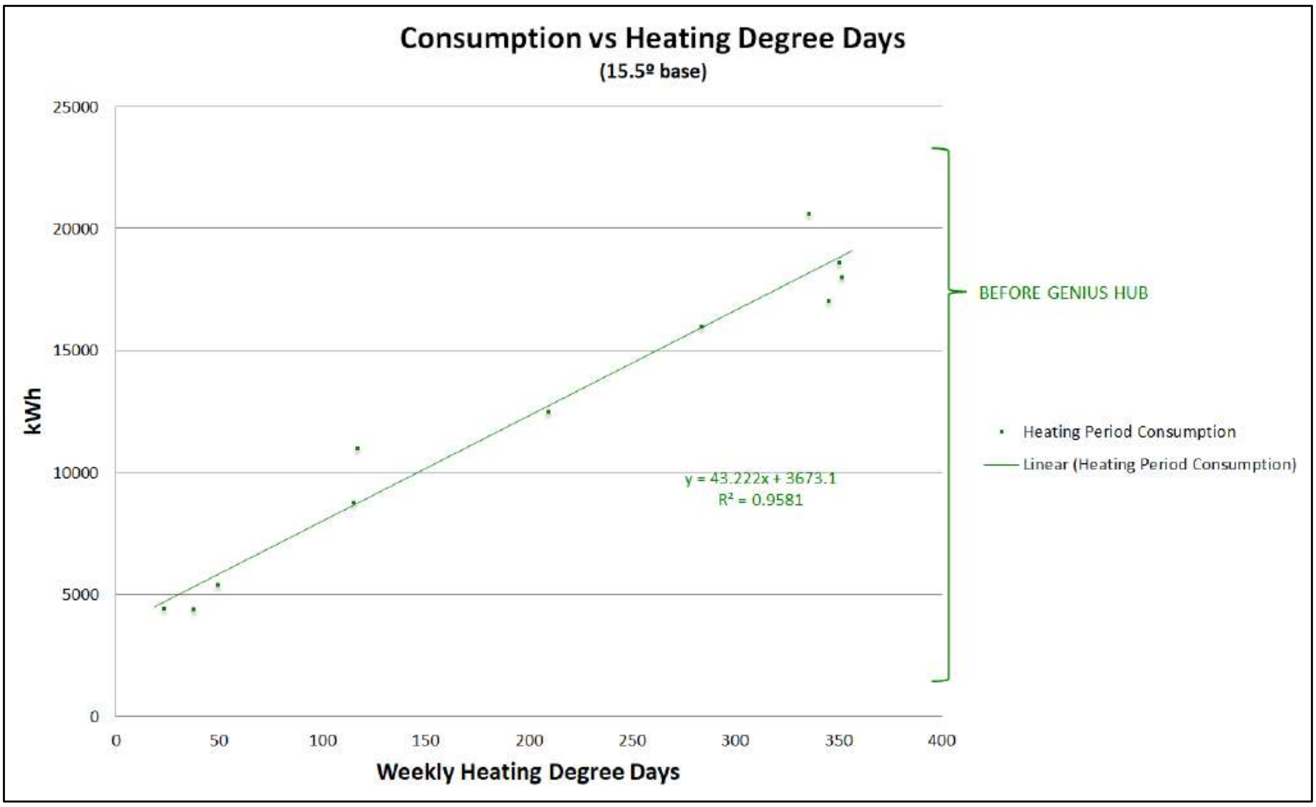

Figure 3 – Graph showing the energy consumption prior to installation of the Genius Hub system; 01/10/2017 – 12/09/17.

Although data has been provided for 01/10/17 – 01/09/18, only data from concurrent months has been taken into account when calculating the energy savings.

- The *'Average Weekly Consumption / External Degree Days'* for 01/10/17 – 18/03/18 = **14.19 kWh/°C.**
- The *'Average Weekly Consumption / External Degree Days'* for 01/10/17 – 09/09/18 = **18.54 kWh/°C.**

The difference in % savings when concurrent months are not used equates to +12%.

2.4 AFTER GENIUS HUB INSTALLATION

Figure 4 (below) shows both the pre- & post-installation energy consumption against each other. It is evident that the data for post-installation is either inaccurate or there is an external factor(s) not taken into account when calculating energy consumption. It is possible that a switch from using Timer mode to Footprint mode in the first few months, or the difference between assumed and actual meter readings may be responsible for the abnormally high energy usage around ~300 degree days. This is of course conjecture; a data set with a higher resolution (day meter reading) may paint a clearer picture as to the anomalies.

Despite this, it is clear that there is at least a trend toward greater efficiency with respect to gas usage in the building, as indicated by the transparent circles. A shift in data points toward the lower right corner of the graph represents greater efficiency as less fuel is used for more degree days.

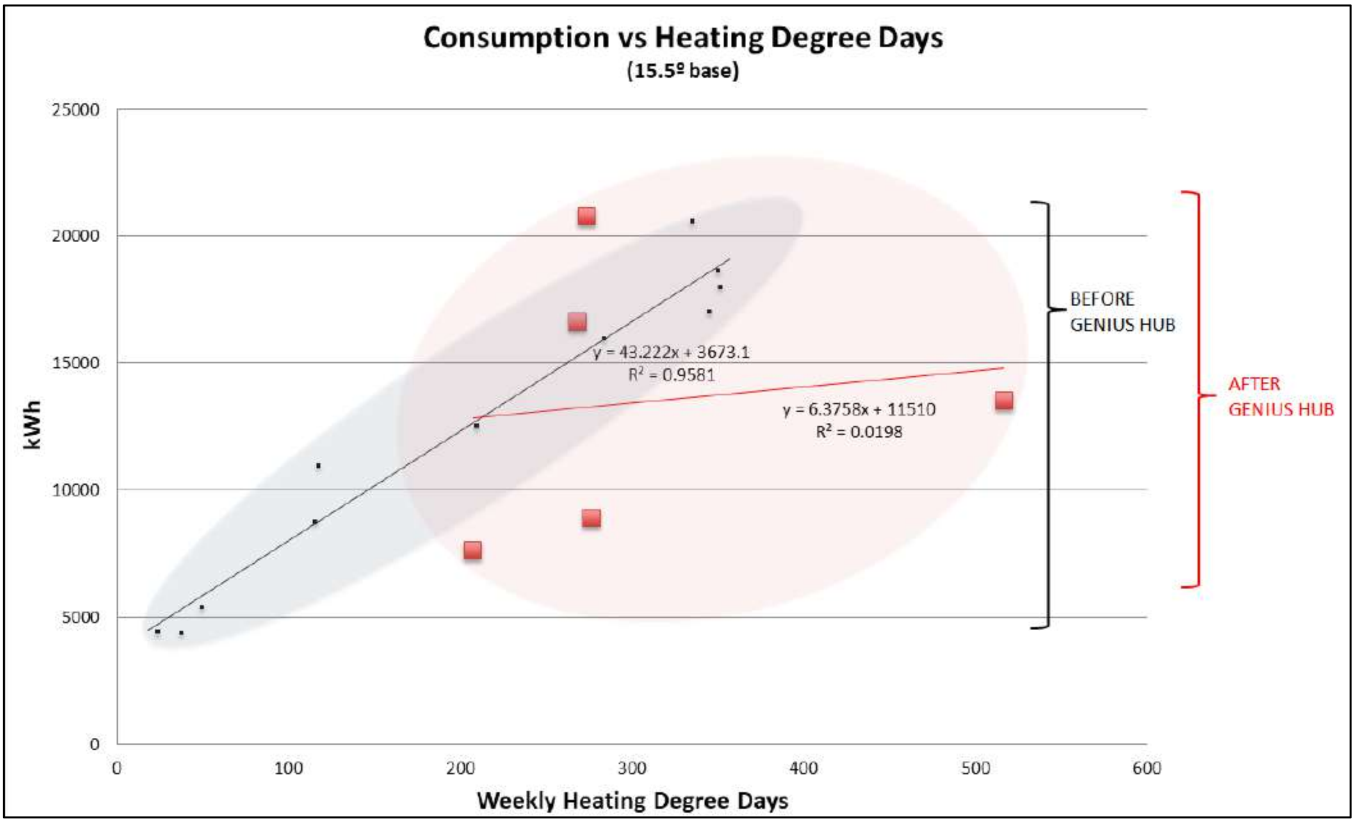

Figure 4 – Graph showing the pre-installation (black) & post-installation (red) energy consumption data. The post-install data has an R^2 value of 0.20% and should be treated with caution when drawing conclusions.

The data gas data post-installation covers the period 01/09/2018 – 18/03/2019. Therefore, when determining average energy savings, the pre-installation data for the period

01/10/2017 – 18/03/2018 was used. The *'Average Weekly Consumption / External Degree Days'* for 01/10/17 – 18/03/18 = **14.19 kWh/°C.**

The gas data was provided in select periods (detailed below) rather than weekly or monthly bills.

Period **1 after installation (01/09/2018 – 31/10/2018)**

- The *'Average Weekly Consumption / External Degree Days'* = **0.78 kWh/°C**
- **Building used 6% of the energy than the average for the first 2 months post-installation, i.e. a 94% saving.**

Period **2 after installation (31/10/2018 – 06/12/2018)**

- The *'Average Weekly Consumption / External Degree Days'* = **6.27 kWh/°C**
- **Building used 34% of the energy than the average for the following 2 months, i.e. a 66% saving.**

Period **3 after installation (06/12/2018 – 28/12/2018)**

- The *'Average Weekly Consumption / External Degree Days'* = **21.50 kWh/°C**
- **Building used 152% of the energy than the average for the following 3 weeks, i.e. an increase of 52%.**

Period **4 after installation (28/12/2018 – 13/02/2019)**

- The *'Average Weekly Consumption / External Degree Days'* = **3.89 kWh/°C**
- **Building used 27% of the energy than the average for the following 2 months. i.e. a 73% saving.**

Period **5 after installation (13/02/2019 – 18/03/2019)**

- The *'Average Weekly Consumption / External Degree Days'* = **13.15 kWh/°C**
- **Building used 93% of the energy than the average for the following month, i.e. a 7% saving.**

2.5 AVERAGE SAVINGS TO DATE:

From the data provided, this report finds an average saving of 50% for the time period being monitored. It is likely that this figure will not be entirely accurate as the data provided is not of especially high resolution - however lengths have been taken in the calculations above to mitigate any discrepancies and take a worst case approach.

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3.0 Qualification Of Report

In accordance with the BREEAM education manual, an experienced energy specialist, using an approved energy modelling software tool, carried out the assessment. The energy specialist overseeing this report (Alasdair Woodbridge) has a masters degree in Mechanical Engineering specialising in Environmental Engineering, accreditation under the 'On Construction Domestic Energy Assessor and Code for Sustainable Homes Assessor' schemes, membership no. STRO006549, plus 8 years' experience working on projects were carbon reduction has been a core part of the design.

The approved energy modelling software tool is FSAP2012, for which the energy specialist has accreditation as an energy assessor.

It must be noted that all recommended solutions using proprietary and recognised building materials are unbiased and impartial offered as potential exemplification only.

