Devon County Council

Building Energy Analysis

Great Moor House, Exeter

Hamson Barron Smith Limited

10th June 2017

CONTENTS

CONTROLLED DOCUMENT

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Prepared by:	Wayne Maw	Wayne Maw	15-06-17
Checked:	Ryan Skinner	Ryan Skinner	15-06-17

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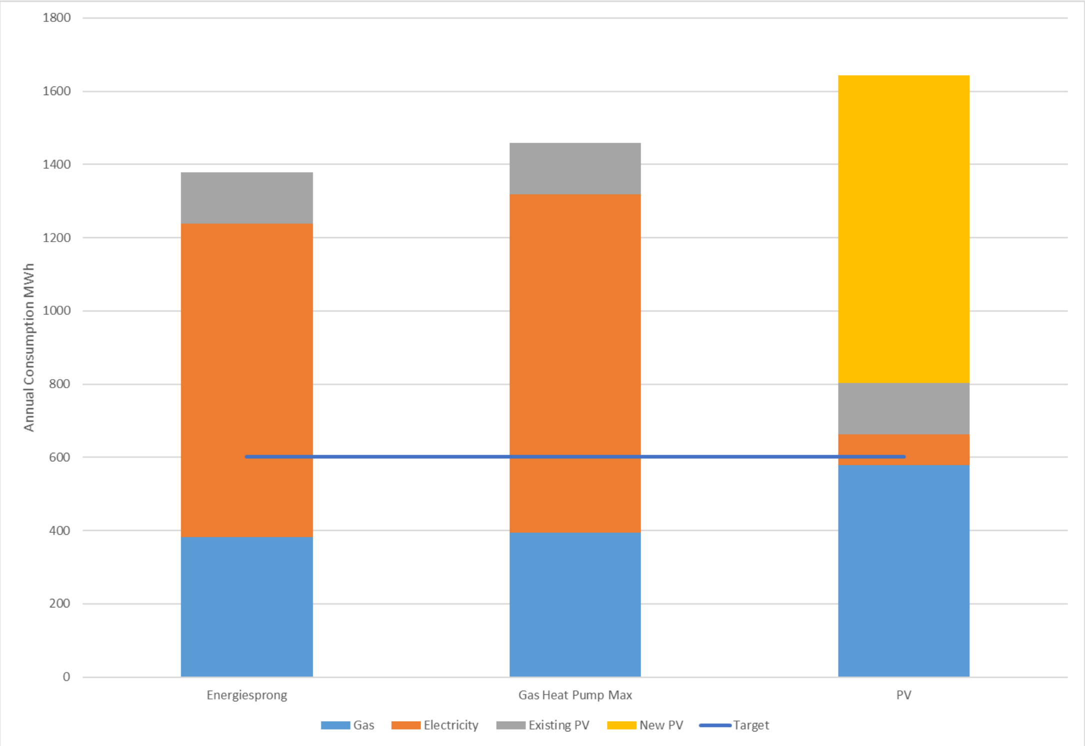
Section 1. Executive Summary

The following report was commissioned by Alastair Mumford of Devon County Council in order to investigate the feasibility of reducing the primary energy consumption of the building by 60% within the budget of £454,000. The scope of the feasibility study is to investigate a variety of suitability approaches including both building fabric and building services. The results of the building modelling exercise demonstrate that there are potentially two feasible approaches that deliver the targeted energy reduction.

Option 1: Fabric first approach using Energiesprong approach & PV

Option 2: Partial replacement of gas boiler with Gas Absorption Heat Pump & PV

The chart below shows the energy consumption impact of these approaches above and a PV installation



Due to the number of assumptions and the approximation inherent in the modelling process the results are for comparison only and will not necessarily accurately reflect the final buildings consumption and therefore decisions based on this report must reflect that the results are indicative only and no guarantees can be made over final on site consumption levels. It has been concluded that the Gas Absorption Heat Pump & PV is likely the most appropriate with the budget and recommended that further clarity in regards to all associated PV costs are required to confirm the system falls with the required budget and should a fabric first approach be desired cost data on the Energiesprong approach should also be reviewed.

Section 1. Introduction

Hamson Barron Smith have been commissioned by Alastair Mumford of Devon County Council in order to conduct and energy review of Great Moor House, Exeter. The purpose of this study is to evaluate the potential for reducing the overall energy consumption by more than 60% with the proposed budget of £454,000 for this project.

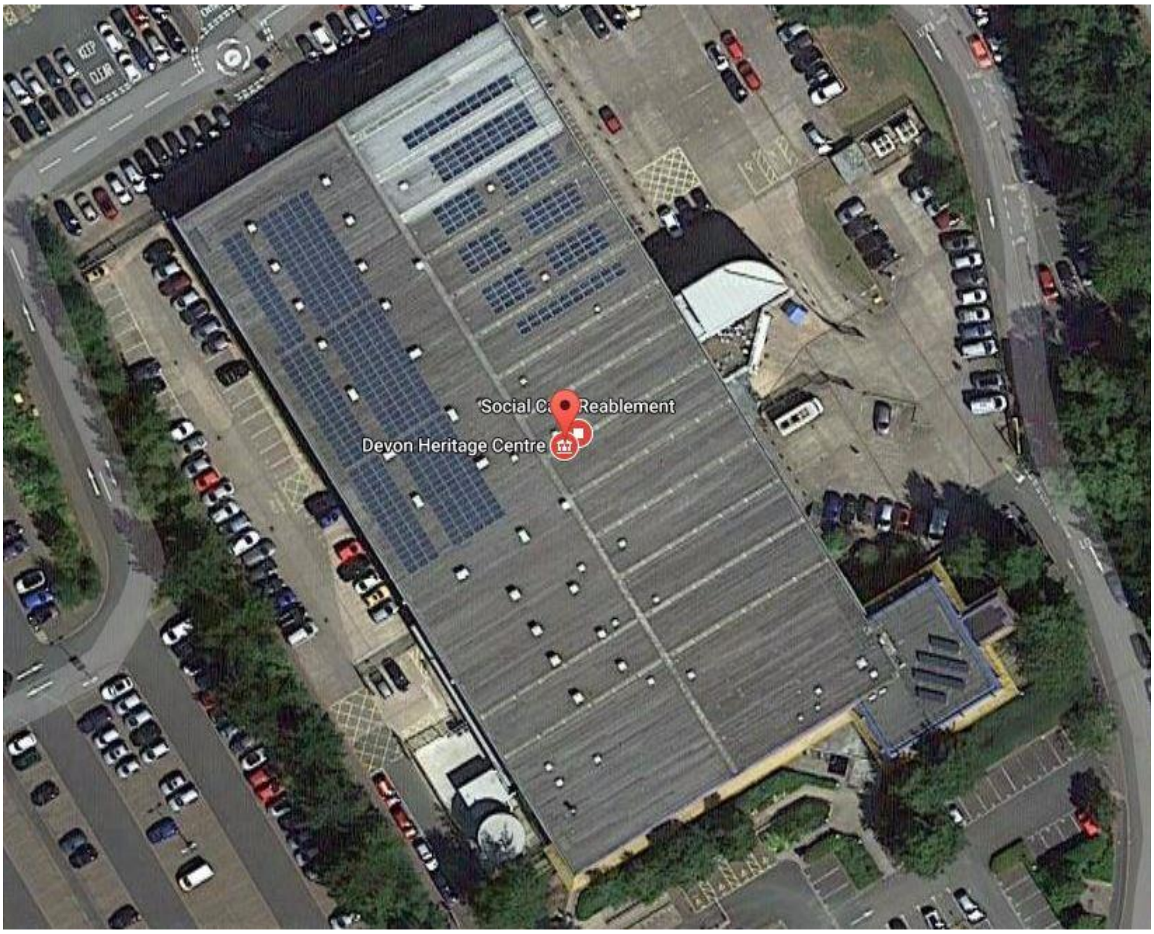
The existing building is a converted British Telecom building which is currently been used as a combination of office space and document storage. The building fabric is lightweight metal cladding for the external walls with external blockwork to the constructed extension and standing seam roof cladding. External glazing is provided to the majority of the external façade where office and reception spaces are provided.

The information for the building fabric of the building has been collected through site inspection and available floor plans. There is currently no specific data on the U-values of the building construction elements, therefore the minimum building regulation U-Values for the time of construction have been used and these have been confirmed as appropriate following a site inspection conducted by an NPS Building Surveyor.

There are a range of building services throughout the building that were observed as part of the site inspection and further detailed through heating layout drawings produced in 2002, annual commissioning reports and maintenance schedules. The systems detailed included the following

- Single room air conditioning
- Variable refrigerant volume system
- Perimeter gas fed radiators
- Air handling units
- Natural ventilation through openable windows
- Fluorescent and compact florescent lighting

The existing building has three separate Photovoltaic (PV) arrays mounted on the roof that have a combined capacity of 150 kWp. The three separate arrays are 100 kWp, 46 kWp and 4kWp and these can be observed on the image below. Details of these systems were extracted from the installations building operation and maintenance manuals that were held on site.



Please note the following disclaimers in relation to this report

- This report is for the private and confidential use of Devon County Council and must not be reproduced in whole or in part or relied upon by third parties for any use without the express written authority of Hamson Barron Smith.
- Building services have been visually inspected where exposed to view only. No internal inspections have been undertaken of plant, equipment and machinery. No inspections have been undertaken where services are covered up or hidden by the structural element or finishes. Building services have not been tested or validated.
- In view of the complexity of the building, we do not guarantee to have seen each and every system that may exist in the property – but we expect to have seen all the major systems and the majority of minor systems relating to the brief.
- There can be no guarantees of the compatibility of the systems modelled with the existing building services.
- We have not undertaken specific engineering testing or measurements. This report reflects our interpretation of the condition of the building services as apparent from the inspection.
- This report is not a certification, a warranty or guarantee and has been scoped in accordance with the instruction given and the time allowed.
- We have not tested the building fabric / systems to obtain accurate thermal performance and efficiency values. The values used are an estimate based on best practice industry data.
- The model calculations are based on standard building templates, and are not intended to be an accurate simulated estimation of energy consumption. The results are therefore an approximation – to be used for a comparative analysis of improvement measures.

Section 2. Methodology

Model

The simulation of this building has been undertaken following an initial site inspection of Great Moor House to acquire data to populate the building model including observations of the building systems in operation, utilised building fabric and to assign relevant activities to each zone of the building. The inspection of the site in addition allowed for confirmation of building dimension from the available site plans.

The model simulation was carried out using IES Virtual Environment software, version 2017. The following modules of the software have been usedw within the study;

- ModelIT – to create/edit the building model data such as geometry, site and location
- Apache – to simulate building services

Each activity zone of the building is constructed within the simulation software and assigned where relevant the following details

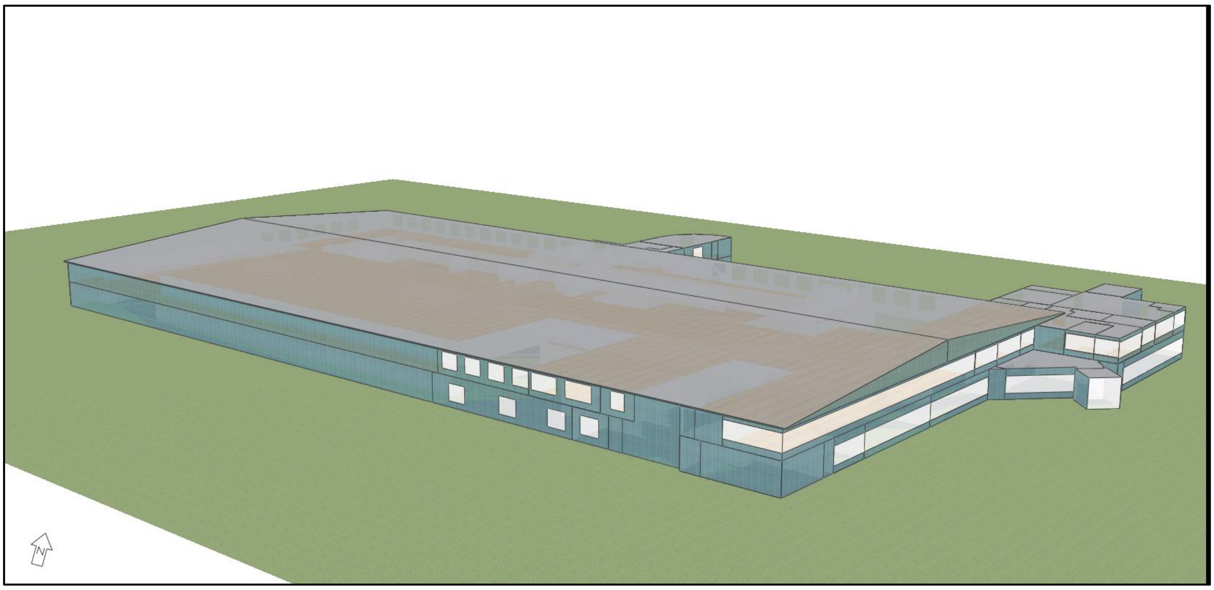
- Construction materials and U-values
- Glazing & openable windows
- Lighting systems and controls
- Heating & cooling systems and controls
- Ventilation
- Zone activity

Using the data inputted for each zone of the building the simulation software calculates the energy consumption of the building based on a high number of factors which include the following

- Hours of occupation
- Area activity and associated equipment
- Heating gain including solar, people and equipment
- Pre-defined heating and cooling set points
- Availability of natural light
- Efficiencies of the building systems
- Level of control of the building services.

The simulation uses the above information to determine the demand on the building services and the quantity of primary energy that would be required to service this demand.

Below is an illustration of Great Moor House as modelled within IES 2017



Assumptions

The nature of the building modelling exercise is that it becomes and approximation of the building due to the large number variables within any building. Perfect information about an existing building is rarely available and as such a number of assumptions are built into this model. The following assumptions are factored into the model for Great Moor House

- **Building activity profiles**: The assessment has been conducted using the National Calculation Methodology (NCM) activity database. The NCM profiles detail a set of fixed attributes in relation to the use of a space. The limitations to the NCM profiles are that the chosen attributes such as population density, equipment usage, heat and cooling set points are driven by the agreed format of the Building Regulations and these will not necessarily accurately reflect the use of the proposed building and therefore create a disparity in the modelled and actual energy consumed

- **Fabric U-Values:** The U-Values have been assumed to represent the minimum Building Regulation standards at the time of original construction. The limitations to these assumptions are that the actual U-Values could potentially be an improvement over the assumptions and therefore limit the heat loss from the building and in turn reduce the baseline consumption of primary energy. The assumed U-values used are as follows

Building Element	Assumed U-value W/m^{2}K
Roof	0.35
External wall	0.60
Internal Wall	1.00
Ground floor	0.58
Internal floor	1.00
Windows/glazed doors	4.368

- **Fabric air-tightness:** Currently there are no details or test certificates to identify the level of air tightness within the building. An assumed value of 25m3/h/m2 at 50 Pa based upon the Building regulations conventions appropriate for a building of this age and size has been used. The limitations to this assumption is that should the air tightness be better than assumed this would limit the loss of heat from the individual zones and require less primary energy to condition these zones.

- **Specific Fan Power:** The fan power of the ventilation and extraction systems have been assumed as 1.6 W/l/s for mechanical ventilation and 0.4 W/l/s for extract ventilation. Currently no detailed information of the fans installed is available and therefore it is not possible to accurately model the energy implications of these systems. Should the fans require less energy to operate than assumed the consumption of electrical energy with the model could be elevated.

- **Competing systems:** Where there are multiple heating systems within a single zone it is assumed that the most efficient system will provide the heating load. The limitations to this are that in air conditioned areas with supplementary radiators, the simulation will automatically use the air conditioning system (electrical energy) for the full heating load rather than the radiators (gas fuelled energy). This will skew the results to show an increased electrical energy consumption

Modelling Iterations

In order to compare the potential building improvements nine iterations of the building model were generated for comparative analysis including the modelled version of the existing building. The iterations modelled are as follows

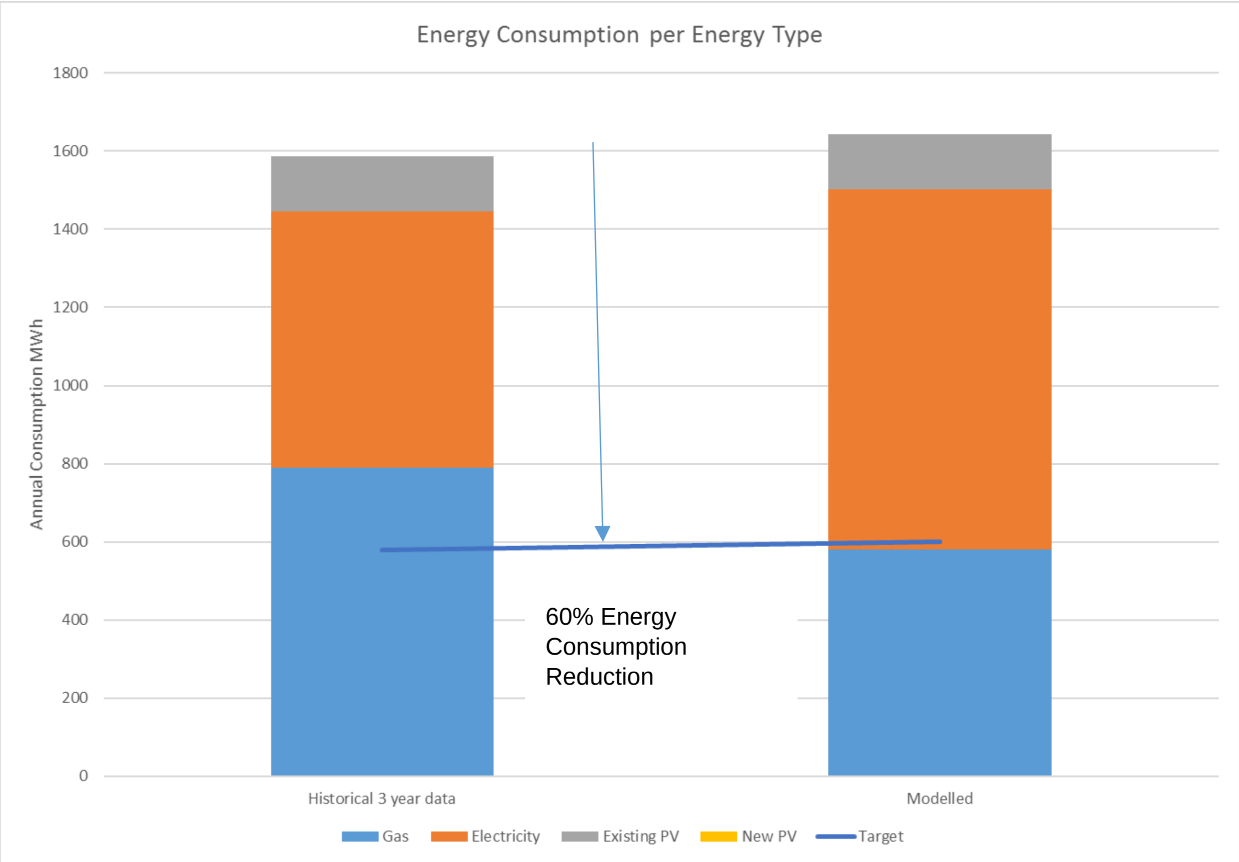
- **Version 1**: Existing building with assumptions as previously detailed
- **Version 2**: Energiesprong, which is a building cladding system with integral windows, which would create a new shell of the building. This iteration has been modelled with improved external wall U-Values of 0.3 and glazing of 1.8. In addition it has been assumed that this cladding system would improve the air tightness to at least in line with current Building Regulations of 10 m3/h/m2 at 50 Pa.
- **Version 3**: Removal and replacement of existing roof cladding with a roof system that deliver a U-value of U 0.18 W/m2K
- **Version 4**: External wall insulation render system to deliver an external wall U-Value of 0.3 W/m2K
- **Version 5**: Removal and replacement of existing external wall cladding with external wall cladding that deliver a U-value of U 0.12 W/m2K
- **Version 6:** Improvement of existing gas power boiler plant efficiencies to 95%
- **Version 7:** Replacement of standalone hot water boiler and storage with point of use hot water delivery
- **Version 8:** Installation of Gas Absorption Heat Pump to service 50% of the buildings boiler demand.
- **Version 9:** Installation of 7800 m^2 to displace 840 Mwh annually

Due to the variation between the actual building and the modelled building there is a degree of disparity between the modelled energy demands of the building and actual energy consumption, as such the iterations will demonstrate improvements over the modelled energy consumption which differ from that of the historical 3 year average energy consumption data.

Section 3. Results

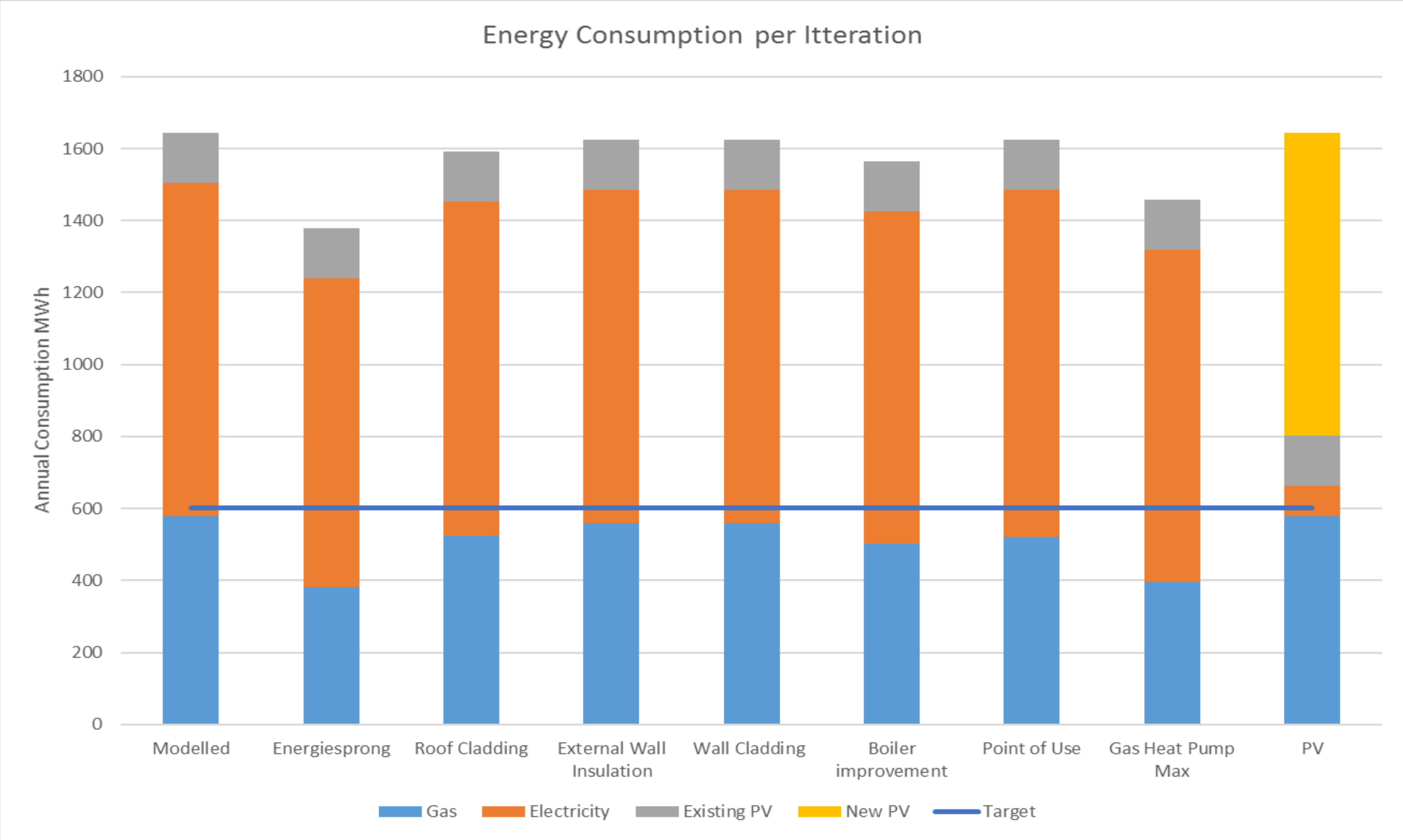
The building has been modelled using assumptions listed within the methodology. The results show that the modelled energy consumption differs from the historical 3 year average data. The modelled building has a higher electricity consumption, and a lower natural gas energy consumption, as shown in figure 1 below"..

Fig 1.0



Each of the model iterations as detailed within the methodology have produced a set of data for annual consumption. These results related to the modelled building only and are displayed within figure 2.

Figure 2.0



Energy Consumption per Itteration
1800
1600
1400
1200
1000
800
600
400
200
0
Annual Consumption MWh
Modelled
Energiesprong
Roof Cladding
External Wall Insulation
Wall Cladding
Boiler improvement
Point of Use
Gas Heat Pump Max
PV
Gas
Electricity
Existing PV
New PV
Target

Modelled building results

Technology	Gas MWh	Grid Electricity MWh	Annual total Reduction (%)	Estimated Cost	Pay Back (yrs)	Notes
Base Building	579.7	923.4	-	-	-	-
Energiesprong	382.5	857.3	17.6	-	-	No current financial details therefore payback unavailable
Roof Cladding	525.1	927.1	3.4	£550,000	More than 100 years	
Wall Render	558.1	927.1	1.2	£150,000	More than 100 years	
Wall Cladding	556.1	926.5	1.3	£280,000	More than 100 years	
High efficiency Boilers	502.7	923.7	5.2	-		Discounted as doesn't reach the target threshold
Point of Use Water Heater	552.2	963.3	1.2	-	-	Discounted due to anticipated demand from catering areas
Gas Absorption Heat Pump	395.6	923.7	12.3	£130,000	42 years	
PV Array	579.7	83.37	55.9	-	-	

The previous results above show the range modelled outcomes for the proposed approaches. The payback for these approaches have been calculated on gas consumption reduction only due the currently unknown variables in relation to this sites PV. In order to maximise a system designed to service the full electrical load of the building through PV it is likely that battery time shifting of the PV generation would be required. Correspondence with Flexisolar Ltd has indicated that this is a viable proposition for this building based on current consumption levels, however notes that this could have a potential impact on grid service revenues available.

It has been indicated that the expansion of the PV installation is to be funded through a purchase agreement to minimise the cost implications to the building owners. Within this report we are unable to provide payback details due to the variety of factors including battery storage, infrastructure upgrades, available grants and quantity of PV required for the in use building.

The payback has been based on the unit cost of £0.01824 per unit of gas as per example billing provided. Cost implications have been provided by indicative manufacturers quotes and building surveyor estimations.

As previously noted there is a variation between the modelled building and the historical 3 year data consumption figures with as much as 33% increase in electrical demand within he modelled building when compared to the historical data.

Section 4. Conclusion

Based on the building simulation outputs it can be concluded that there are potentially two of the proposed building improvements that could deliver the 60% reduction in primary energy consumed. As can be seen within the results output Version 1 Energiesprong and version 8 Gas Absorption Heat Pump deliver an overall consumption reduction of greater than 10% if either of these approaches are combined with the additional PV installation, this results in reduction in energy of greater than 60%.

The third option that is potential viable is the use of the additional PC array and high efficiency boilers however as noted the disparity results in a 61% reduction and due to the disparity between the modelled building and the historical 3 year data this option has been discounted.

As outlined within the introduction the budget for these improvement works £454,000 and that the target is reduce the energy consumption by 60% within this budget. While Energiesprong does deliver a calculated reduction in line with the project target when combined with PV, due to the primarily domestic use of this approach and lack of clarity on overall costs it is not possible to conclude that this approach would deliver the required savings within the specified budget, however should a fabric first approach be preferred this is potentially an option.

Version 8 of the modelling using Gas Absorption Heat Pump & PV does deliver the target energy consumption and based on indicative costs this approach would fall within the cost parameters of the project. There however would need to be some clarification of the costs involved to deliver the level of PV to offset the electrical consumption of the building to confirm the project falls within the required £454,000 target.

Section 5. Recommendations

To progress the conclusion of this report we would recommend that detailed cost implications of the Energiesprong approach be sourced in order to confirm if this approach is valid within the stated budget. Additionally it is recommend that the quantity of PV is established for the actual building activity rather than a modelled version. This could result in a smaller PV array that services the electrical demand of the building and any associated costs relating to this including battery storage, infrastructure upgrades and available grants are included in order to establish that either of these proposed solutions fit within the required budget.

Appendix

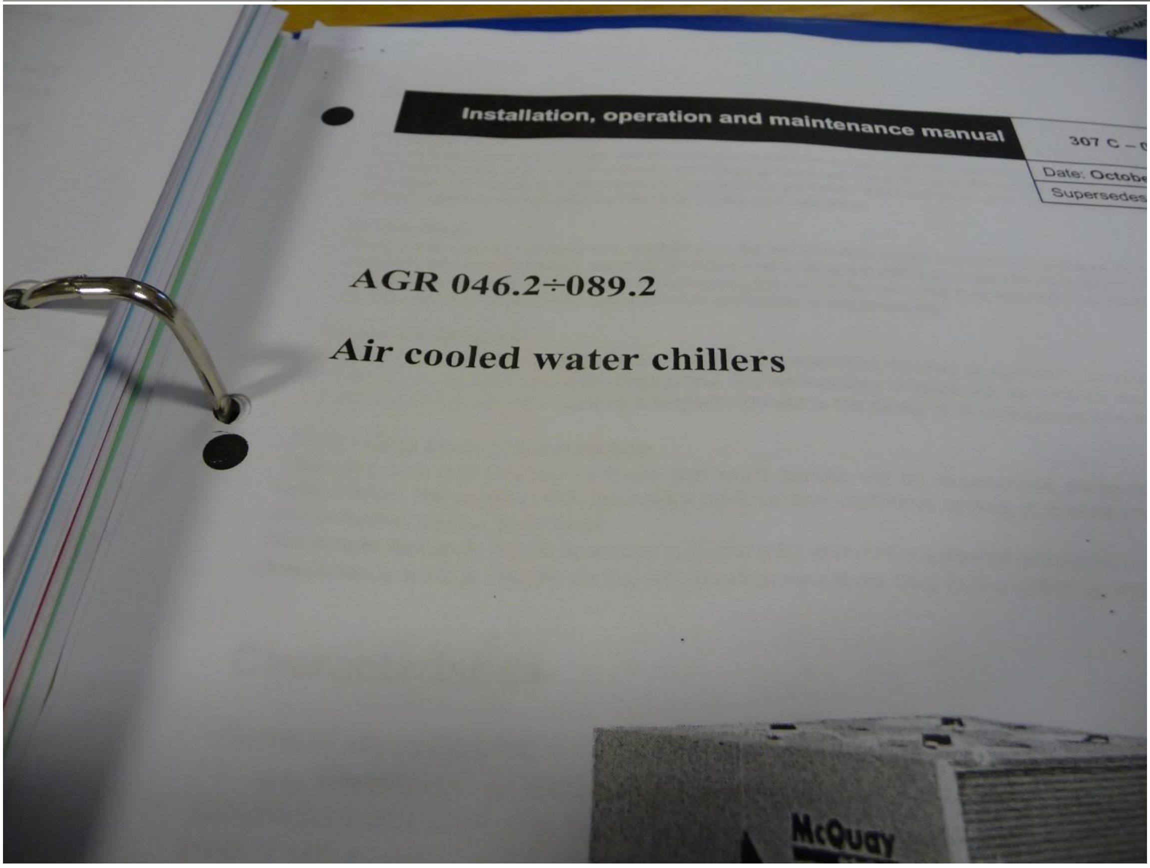
On site plant equipment photographs


DAIKIN EUROPE N.V.
DEVON COUNTY COUNCIL EQUIPMENT
DO NOT REMOVE
800008181
AC3


BOILER No 1
remeha


BEAUMONT
This appliance must be installed in accordance with the manufacturers instructions and the regulations in force and only used in a suitably ventilated location. Read the instructions fully before installing or using this appliance.
V SERIES WATER HEATER
BEAUMONT V - VE100
DEVON COUNTY COUNCIL EQUIPMENT
200002487
DOMESTIC HOT
WATER HEATER


MCC7
BMS SECTION
DANGER 230 VOLTS
LIVE WITH MAIN SUPPLY
ISOLATOR IN OFF POSITION


Installation, operation and maintenance manual
AGR 046.2÷089.2
Air cooled water chillers
McQuay